# Table of Contents

**Summary of GDB** ................................................. 1  
Free Software ................................................. 1  
Free Software Needs Free Documentation ................................................. 1  
Contributors to GDB ............................................. 3  

1 **A Sample GDB Session** ......................... 7  

2 **Getting In and Out of GDB** ............ 11  
2.1 Invoking GDB .................................................. 11  
2.1.1 Choosing Files ........................................... 12  
2.1.2 Choosing Modes ........................................... 13  
2.1.3 What GDB Does During Startup ........................................... 16  
2.2 Quitting GDB .................................................... 17  
2.3 Shell Commands .............................................. 17  
2.4 Logging Output ............................................... 18  

3 **GDB Commands** .............................. 19  
3.1 Command Syntax .............................................. 19  
3.2 Command Completion ......................................... 19  
3.3 Getting Help .................................................. 22  

4 **Running Programs Under GDB** .......... 25  
4.1 Compiling for Debugging ................................. 25  
4.2 Starting your Program ....................................... 26  
4.3 Your Program’s Arguments ............................. 30  
4.4 Your Program’s Environment ............................ 30  
4.5 Your Program’s Working Directory ..................... 31  
4.6 Your Program’s Input and Output .................. 32  
4.7 Debugging an Already-running Process ............. 32  
4.8 Killing the Child Process ................................. 33  
4.9 Debugging Multiple Inferiors and Programs .......... 33  
4.10 Debugging Programs with Multiple Threads ........ 36  
4.11 Debugging Forks ............................................ 39  
4.12 Setting a Bookmark to Return to Later ............ 42  
4.12.1 A Non-obvious Benefit of Using Checkpoints ...... 43
5 Stopping and Continuing ................. 45
  5.1 Breakpoints, Watchpoints, and Catchpoints ............... 45
     5.1.1 Setting Breakpoints ................................... 46
     5.1.2 Setting Watchpoints ..................................... 52
     5.1.3 Setting Catchpoints .................................... 55
     5.1.4 Deleting Breakpoints .................................... 59
     5.1.5 Disabling Breakpoints ................................... 59
     5.1.6 Break Conditions ....................................... 60
     5.1.7 Breakpoint Command Lists .............................. 62
     5.1.8 Dynamic Printf ......................................... 63
     5.1.9 How to save breakpoints to a file ...................... 65
     5.1.10 Static Probe Points ..................................... 65
     5.1.11 “Cannot insert breakpoints” ............................ 67
     5.1.12 “Breakpoint address adjusted...” ...................... 67
  5.2 Continuing and Stepping ..................... 68
  5.3 Skipping Over Functions and Files .............. 71
  5.4 Signals ..................................................... 73
  5.5 Stopping and Starting Multi-thread Programs ............. 75
     5.5.1 All-Stop Mode ........................................... 76
     5.5.2 Non-Stop Mode ........................................... 77
     5.5.3 Background Execution ................................... 78
     5.5.4 Thread-Specific Breakpoints ............................ 79
     5.5.5 Interrupted System Calls .............................. 80
     5.5.6 Observer Mode .......................................... 80

6 Running programs backward .................. 83

7 Recording Inferior’s Execution and Replaying It ............. 85

8 Examining the Stack ............................ 93
  8.1 Stack Frames .............................................. 93
  8.2 Backtraces ............................................... 94
  8.3 Management of Frame Filters ...................... 97
  8.4 Selecting a Frame ........................................ 99
  8.5 Information About a Frame ............................ 100
## 12 C Preprocessor Macros

- 12.1 Commands to Set Tracepoints
  - 12.1.1 Create and Delete Tracepoints
  - 12.1.2 Enable and Disable Tracepoints
  - 12.1.3 Tracepoint Passcounts
  - 12.1.4 Tracepoint Conditions
  - 12.1.5 Trace State Variables
  - 12.1.6 Tracepoint Action Lists
  - 12.1.7 Listing Tracepoints
  - 12.1.8 Listing Static Tracepoint Markers
  - 12.1.9 Starting and Stopping Trace Experiments
  - 12.1.10 Tracepoint Restrictions

## 13 Tracepoints

- 13.2 Using the Collected Data
  - 13.2.1 \texttt{tfind n}
  - 13.2.2 \texttt{tdump}
  - 13.2.3 \texttt{save tracepoints filename}

## 13.3 Convenience Variables for Tracepoints

## 13.4 Using Trace Files

## 14 Debugging Programs That Use Overlays

- 14.1 How Overlays Work
- 14.2 Overlay Commands
- 14.3 Automatic Overlay Debugging
- 14.4 Overlay Sample Program

## 15 Using \texttt{gdb} with Different Languages

- 15.1 Switching Between Source Languages
  - 15.1.1 List of Filename Extensions and Languages
  - 15.1.2 Setting the Working Language
  - 15.1.3 Having \texttt{gdb} Infer the Source Language
- 15.2 Displaying the Language
- 15.3 Type and Range Checking
  - 15.3.1 An Overview of Type Checking
  - 15.3.2 An Overview of Range Checking
- 15.4 Supported Languages
  - 15.4.1 C and C++
    - 15.4.1.1 C and C++ Operators
    - 15.4.1.2 C and C++ Constants
    - 15.4.1.3 C++ Expressions
    - 15.4.1.4 C and C++ Defaults
    - 15.4.1.5 C and C++ Type and Range Checks
    - 15.4.1.6 \texttt{gdb} and C
    - 15.4.1.7 \texttt{gdb} Features for C++
    - 15.4.1.8 Decimal Floating Point format
15.4.2 D .............................................................. 197
15.4.3 Go .............................................................. 197
15.4.4 Objective-C .................................................... 198
  15.4.4.1 Method Names in Commands ......................... 198
  15.4.4.2 The Print Command With Objective-C .......... 198
15.4.5 OpenCL C .................................................. 199
  15.4.5.1 OpenCL C Datatypes ................................. 199
  15.4.5.2 OpenCL C Expressions .............................. 199
  15.4.5.3 OpenCL C Operators ................................. 199
15.4.6 Fortran .................................................... 199
  15.4.6.1 Fortran Operators and Expressions ............... 199
  15.4.6.2 Fortran Defaults .................................... 199
  15.4.6.3 Special Fortran Commands .......................... 200
15.4.7 Pascal ..................................................... 200
15.4.8 Modula-2 .................................................. 200
  15.4.8.1 Operators .............................................. 200
  15.4.8.2 Built-in Functions and Procedures ............... 201
  15.4.8.3 Constants ............................................. 202
  15.4.8.4 Modula-2 Types ..................................... 203
  15.4.8.5 Modula-2 Defaults ................................... 205
  15.4.8.6 Deviations from Standard Modula-2 .............. 205
  15.4.8.7 Modula-2 Type and Range Checks ................. 205
  15.4.8.8 The Scope Operators :: and ...................... 205
  15.4.8.9 GDB and Modula-2 .................................... 206
15.4.9 Ada ......................................................... 206
  15.4.9.1 Introduction .......................................... 206
  15.4.9.2 Omissions from Ada ................................. 207
  15.4.9.3 Additions to Ada ..................................... 208
  15.4.9.4 Stopping at the Very Beginning ................. 209
  15.4.9.5 Ada Exceptions ....................................... 210
  15.4.9.6 Extensions for Ada Tasks .......................... 210
  15.4.9.7 Tasking Support when Debugging Core Files ...... 213
  15.4.9.8 Tasking Support when using the Ravenscar Profile .......... 213
  15.4.9.9 Known Peculiarities of Ada Mode ............... 214
15.5 Unsupported Languages ...................................... 215

16 Examining the Symbol Table ....................... 217
17  Altering Execution .................................. 225
  17.1 Assignment to Variables .......................... 225
  17.2 Continuing at a Different Address .................. 226
  17.3 Giving your Program a Signal ......................... 227
  17.4 Returning from a Function .......................... 228
  17.5 Calling Program Functions .......................... 229
  17.6 Patching Programs .................................. 230
  17.7 Compiling and injecting code in GDB ................. 230
    17.7.1 Compilation options for the compile command .... 232
    17.7.2 Caveats when using the compile command ......... 232
    17.7.3 Compiler search for the compile command ......... 234

18  GDB Files ............................................. 237
  18.1 Commands to Specify Files ......................... 237
  18.2 File Caching ...................................... 245
  18.3 Debugging Information in Separate Files ............ 246
  18.4 Debugging information in a special section ........... 249
  18.5 Index Files Speed Up GDB .......................... 250
  18.6 Errors Reading Symbol Files ........................ 251
  18.7 GDB Data Files .................................... 252

19  Specifying a Debugging Target ....................... 253
  19.1 Active Targets ..................................... 253
  19.2 Commands for Managing Targets ...................... 253
  19.3 Choosing Target Byte Order .......................... 255

20  Debugging Remote Programs ............................ 257
  20.1 Connecting to a Remote Target ....................... 257
  20.2 Sending files to a remote system ..................... 259
  20.3 Using the gdbserver Program ........................ 259
    20.3.1 Running gdbserver .............................. 259
      20.3.1.1 Attaching to a Running Program ............... 260
      20.3.1.2 Multi-Process Mode for gdbserver ............ 261
      20.3.1.3 TCP port allocation lifecycle of gdbserver .... 261
      20.3.1.4 Other Command-Line Arguments for gdbserver ... 261
    20.3.2 Connecting to gdbserver ........................ 262
    20.3.3 Monitor Commands for gdbserver .................... 262
    20.3.4 Tracepoints support in gdbserver .................. 263
  20.4 Remote Configuration ............................... 264
  20.5 Implementing a Remote Stub .......................... 270
    20.5.1 What the Stub Can Do for You .................... 271
    20.5.2 What You Must Do for the Stub .................... 272
    20.5.3 Putting it All Together .......................... 273
21 Configuration-Specific Information .... 275

21.1 Native ......................................................... 275
  21.1.1 HP-UX ...................................................... 275
  21.1.2 BSD libkvm Interface ............................... 275
  21.1.3 SVR4 Process Information ......................... 275
  21.1.4 Features for Debugging DJGPP Programs .......... 277
  21.1.5 Features for Debugging MS Windows PE Executables .. 279
    21.1.5.1 Support for DLLs without Debugging Symbols ..... 281
    21.1.5.2 DLL Name Prefixes ................................. 281
    21.1.5.3 Working with Minimal Symbols ...................... 281
  21.1.6 Commands Specific to GNU Hurd Systems ............ 282
  21.1.7 Darwin .................................................. 284

21.2 Embedded Operating Systems .......................... 285

21.3 Embedded Processors ..................................... 285
  21.3.1 ARM ....................................................... 285
  21.3.2 Renesas M32R/SDI ....................................... 287
  21.3.3 M68k ....................................................... 287
  21.3.4 MicroBlaze ............................................... 287
  21.3.5 MIPS Embedded ........................................... 288
  21.3.6 PowerPC Embedded ....................................... 290
  21.3.7 Atmel AVR ............................................... 291
  21.3.8 CRIS ....................................................... 291
  21.3.9 Renesas Super-H ......................................... 291

21.4 Architectures ............................................... 292
  21.4.1 AArch64 ................................................... 292
  21.4.2 x86 Architecture-specific Issues .................... 292
    21.4.2.1 Intel(R) Memory Protection Extensions (MPX) .... 292
  21.4.3 Alpha ...................................................... 293
  21.4.4 MIPS ....................................................... 293
  21.4.5 HPPA ....................................................... 295
  21.4.6 Cell Broadband Engine SPU architecture ............ 295
  21.4.7 PowerPC ................................................... 296
  21.4.8 Nios II .................................................... 296

22 Controlling GDB .............................................. 297

22.1 Prompt ....................................................... 297
22.2 Command Editing ........................................... 297
22.3 Command History .......................................... 298
22.4 Screen Size ................................................ 299
22.5 Numbers ..................................................... 300
22.6 Configuring the Current ABI .............................. 301
22.7 Automatically loading associated files .................. 302
  22.7.1 Automatically loading init file in the current directory .. 304
  22.7.2 Automatically loading thread debugging library .......... 304
  22.7.3 Security restriction for auto-loading .................. 305
  22.7.4 Displaying files tried for auto-load ................... 306
22.8 Optional Warnings and Messages .......................... 307
22.9 Optional Messages about Internal Happenings .......... 308


22.10 Other Miscellaneous Settings ........................................... 313

23 Extending GDB ............................................................. 315
23.1 Canned Sequences of Commands ..................................... 315
  23.1.1 User-defined Commands ........................................... 315
  23.1.2 User-defined Command Hooks .................................. 317
  23.1.3 Command Files ..................................................... 318
  23.1.4 Commands for Controlled Output ............................... 319
  23.1.5 Controlling auto-loading native GDB scripts ................. 321
23.2 Extending GDB using Python ........................................... 321
  23.2.1 Python Commands .................................................. 322
   23.2.2 Python API ....................................................... 323
      23.2.2.1 Basic Python ............................................... 323
      23.2.2.2 Exception Handling ....................................... 326
      23.2.2.3 Values From Inferior ...................................... 327
      23.2.2.4 Types In Python ............................................ 332
      23.2.2.5 Pretty Printing API ........................................ 336
      23.2.2.6 Selecting Pretty-Printers ................................ 337
      23.2.2.7 Writing a Pretty-Printer .................................. 338
      23.2.2.8 Type Printing API .......................................... 340
      23.2.2.9 Filtering Frames ............................................. 341
      23.2.2.10 Decorating Frames ......................................... 343
      23.2.2.11 Writing a Frame Filter .................................... 346
      23.2.2.12 Unwinding Frames in Python ............................... 350
      23.2.2.13 Xmethods In Python ........................................ 352
      23.2.2.14 Xmethod API ................................................ 353
      23.2.2.15 Writing an Xmethod ........................................ 354
      23.2.2.16 Inferiors In Python ........................................ 357
      23.2.2.17 Events In Python ........................................... 358
      23.2.2.18 Threads In Python .......................................... 361
      23.2.2.19 Commands In Python ........................................ 362
      23.2.2.20 Parameters In Python ....................................... 366
      23.2.2.21 Writing new convenience functions ....................... 368
      23.2.2.22 Program Spaces In Python ................................ 369
      23.2.2.23 Objfiles In Python ......................................... 370
      23.2.2.24 Accessing inferior stack frames from Python .......... 372
      23.2.2.25 Accessing blocks from Python ............................ 375
      23.2.2.26 Python representation of Symbols ....................... 377
      23.2.2.27 Symbol table representation in Python .................. 380
      23.2.2.28 Manipulating line tables using Python .................. 381
      23.2.2.29 Manipulating breakpoints using Python ................. 382
      23.2.2.30 Finish Breakpoints ........................................ 385
      23.2.2.31 Python representation of lazy strings .................. 386
      23.2.2.32 Python representation of architectures ................. 387
  23.2.3 Python Auto-loading .............................................. 387
  23.2.4 Python modules ................................................... 388
     23.2.4.1 gdb.printing ............................................... 388
     23.2.4.2 gdb.types ................................................... 389
# 23.3 Extending GDB using Guile

## 23.3.1 Guile Introduction

## 23.3.2 Guile Commands

## 23.3.3 Guile API

### 23.3.3.1 Basic Guile

### 23.3.3.2 Guile Configuration

### 23.3.3.3 GDB Scheme Data Types

### 23.3.3.4 Guile Exception Handling

### 23.3.3.5 Values From Inferior In Guile

### 23.3.3.6 Arithmetic In Guile

### 23.3.3.7 Types In Guile

### 23.3.3.8 Guile Pretty Printing API

### 23.3.3.9 Selecting Guile Pretty-Printers

### 23.3.3.10 Writing a Guile Pretty-Printer

### 23.3.3.11 Commands In Guile

### 23.3.3.12 Parameters In Guile

### 23.3.3.13 Program Spaces In Guile

### 23.3.3.14 Objfiles In Guile

### 23.3.3.15 Accessing inferior stack frames from Guile.

### 23.3.3.16 Accessing blocks from Guile.

### 23.3.3.17 Guile representation of Symbols.

### 23.3.3.18 Symbol table representation in Guile.

### 23.3.3.19 Manipulating breakpoints using Guile

### 23.3.3.20 Guile representation of lazy strings.

### 23.3.3.21 Guile representation of architectures

### 23.3.3.22 Disassembly In Guile

### 23.3.3.23 I/O Ports in Guile

### 23.3.3.24 Memory Ports in Guile

### 23.3.3.25 Iterators In Guile

### 23.3.4 Guile Auto-loading

### 23.3.5 Guile Modules

#### 23.3.5.1 Guile Printing Module

#### 23.3.5.2 Guile Types Module

### 23.4 Auto-loading extensions

#### 23.4.1 The ‘objfile-gdb.ext’ file

#### 23.4.2 The .debug_gdb_scripts section

##### 23.4.2.1 Script File Entries

##### 23.4.2.2 Script Text Entries

#### 23.4.3 Which flavor to choose?

### 23.5 Multiple Extension Languages

#### 23.5.1 Python comes first

### 23.6 Creating new spellings of existing commands

---

# 24 Command Interpreters
25 GDB Text User Interface ............................... 449
   25.1 TUI Overview ......................................... 449
   25.2 TUI Key Bindings ..................................... 450
   25.3 TUI Single Key Mode ................................ 451
   25.4 TUI-specific Commands ............................... 451
   25.5 TUI Configuration Variables ......................... 453

26 Using GDB under GNU Emacs ......................... 455

27 The GDB/MI Interface ................................. 457
   Function and Purpose .................................... 457
   Notation and Terminology ................................ 457
   27.3 GDB/MI General Design ............................... 457
      27.3.1 Context management ............................. 458
         27.3.1.1 Threads and Frames ........................... 458
         27.3.1.2 Language .................................. 459
         27.3.2 Asynchronous command execution and non-stop mode 459
         27.3.3 Thread groups ................................ 460
   27.4 GDB/MI Command Syntax .............................. 460
      27.4.1 GDB/MI Input Syntax ............................. 461
      27.4.2 GDB/MI Output Syntax ......................... 461
   27.5 GDB/MI Compatibility with CLI ...................... 463
   27.6 GDB/MI Development and Front Ends ................. 463
   27.7 GDB/MI Output Records ................................ 464
      27.7.1 GDB/MI Result Records .......................... 464
      27.7.2 GDB/MI Stream Records ......................... 464
      27.7.3 GDB/MI Async Records ........................... 465
      27.7.4 GDB/MI Breakpoint Information ................. 468
      27.7.5 GDB/MI Frame Information ...................... 470
      27.7.6 GDB/MI Thread Information ...................... 470
      27.7.7 GDB/MI Ada Exception Information ............... 471
   27.8 Simple Examples of GDB/MI Interaction .............. 471
   27.9 GDB/MI Command Description Format ................. 472
   27.10 GDB/MI Breakpoint Commands ....................... 472
   27.11 GDB/MI Catchpoint Commands ....................... 482
      27.11.1 Shared Library GDB/MI Catchpoints ............. 482
      27.11.2 Ada Exception GDB/MI Catchpoints ............. 483
   27.12 GDB/MI Program Context ............................ 485
   27.13 GDB/MI Thread Commands ............................ 487
   27.14 GDB/MI Ada Tasking Commands ...................... 489
   27.15 GDB/MI Program Execution .......................... 490
   27.16 GDB/MI Stack Manipulation Commands ............... 497
   27.17 GDB/MI Variable Objects ........................... 502
   27.18 GDB/MI Data Manipulation .......................... 513
   27.19 GDB/MI Tracepoint Commands ....................... 522
   27.20 GDB/MI Symbol Query Commands ..................... 527
   27.21 GDB/MI File Commands .............................. 527
27.22 GDB/MI Target Manipulation Commands
27.23 GDB/MI File Transfer Commands
27.24 Ada Exceptions GDB/MI Commands
27.25 GDB/MI Support Commands
27.26 Miscellaneous GDB/MI Commands

28 GDB Annotations
28.1 What is an Annotation?
28.2 The Server Prefix
28.3 Annotation for GDB Input
28.4 Errors
28.5 Invalidation Notices
28.6 Running the Program
28.7 Displaying Source

29 JIT Compilation Interface
29.1 JIT Declarations
29.2 Registering Code
29.3 Unregistering Code
29.4 Custom Debug Info
29.4.1 Using JIT Debug Info Readers
29.4.2 Writing JIT Debug Info Readers

30 In-Process Agent
30.1 In-Process Agent Protocol
30.1.1 IPA Protocol Objects
30.1.2 IPA Protocol Commands

31 Reporting Bugs in GDB
31.1 Have You Found a Bug?
31.2 How to Report Bugs

32 Command Line Editing
32.1 Introduction to Line Editing
32.2 Readline Interaction
32.2.1 Readline Bare Essentials
32.2.2 Readline Movement Commands
32.2.3 Readline Killing Commands
32.2.4 Readline Arguments
32.2.5 Searching for Commands in the History
32.3 Readline Init File
32.3.1 Readline Init File Syntax
32.3.2 Conditional Init Constructs
32.3.3 Sample Init File
32.4 Bindable Readline Commands
32.4.1 Commands For Moving
### 32.4.2 Commands For Manipulating The History .................. 574
### 32.4.3 Commands For Changing Text .............................. 576
### 32.4.4 Killing And Yanking .................................. 577
### 32.4.5 Specifying Numeric Arguments ........................... 578
### 32.4.6 Letting Readline Type For You .................................. 578
### 32.4.7 Keyboard Macros ........................................... 579
### 32.4.8 Some Miscellaneous Commands ............................. 579

### 32.5 Readline vi Mode ............................................. 581

### 33 Using History Interactively ................................. 583
#### 33.1 History Expansion ........................................ 583
##### 33.1.1 Event Designators .................................... 583
##### 33.1.2 Word Designators .................................... 584
##### 33.1.3 Modifiers .............................................. 584

### Appendix A In Memoriam ........................................ 587

### Appendix B Formatting Documentation ........................... 589

### Appendix C Installing GDB ....................................... 591
#### C.1 Requirements for Building GDB .............................. 591
#### C.2 Invoking the GDB ‘configure’ Script ........................ 592
#### C.3 Compiling GDB in Another Directory ........................ 593
#### C.4 Specifying Names for Hosts and Targets .................... 594
#### C.5 ‘configure’ Options ........................................ 595
#### C.6 System-wide configuration and settings ...................... 596
##### C.6.1 Installed System-wide Configuration Scripts ............. 596

### Appendix D Maintenance Commands .............................. 597

### Appendix E GDB Remote Serial Protocol ..................... 607
#### E.1 Overview ..................................................... 607
#### E.2 Packets ...................................................... 608
#### E.3 Stop Reply Packets .......................................... 618
#### E.4 General Query Packets ...................................... 621
#### E.5 Architecture-Specific Protocol Details ..................... 643
##### E.5.1 ARM-specific Protocol Details ........................... 643
###### E.5.1.1 ARM Breakpoint Kinds ................................ 643
##### E.5.2 MIPS-specific Protocol Details .......................... 643
###### E.5.2.1 MIPS Register Packet Format ......................... 643
##### E.5.2.2 MIPS Breakpoint Kinds ................................ 644
#### E.6 Tracepoint Packets ........................................... 644
##### E.6.1 Relocate instruction reply packet ......................... 650
#### E.7 Host I/O Packets ............................................ 651
#### E.8 Interrupts ..................................................... 653
#### E.9 Notification Packets .......................................... 653
E.10 Remote Protocol Support for Non-Stop Mode ............... 655
E.11 Packet Acknowledgment .................................. 656
E.12 Examples .................................................... 656
E.13 File-I/O Remote Protocol Extension ....................... 657
  E.13.1 File-I/O Overview .................................. 657
  E.13.2 Protocol Basics ...................................... 657
  E.13.3 The $F$ Request Packet .............................. 658
  E.13.4 The $F$ Reply Packet ............................... 658
  E.13.5 The 'Ctrl-C' Message ................................ 659
  E.13.6 Console I/O .......................................... 659
  E.13.7 List of Supported Calls .............................. 660
    open ....................................................... 660
    close .................................................... 661
    read ...................................................... 661
    write ..................................................... 662
    lseek ..................................................... 662
    rename .................................................. 662
    unlink ................................................... 663
    stat/fstat ............................................... 664
    gettimeofday .......................................... 664
    isatty .................................................... 664
    system .................................................... 665
  E.13.8 Protocol-specific Representation of Datatypes ....... 665
    Integral Datatypes ...................................... 665
    Pointer Values .......................................... 665
    Memory Transfer ........................................ 666
    struct stat ............................................... 666
    struct timeval ......................................... 667
  E.13.9 Constants .............................................. 667
    Open Flags ............................................... 667
    mode_t Values .......................................... 667
    Errno Values ............................................ 667
    lseek Flags ............................................... 668
    Limits .................................................... 668
  E.13.10 File-I/O Examples ................................. 668
E.14 Library List Format ....................................... 669
E.15 Library List Format for SVR4 Targets ...................... 670
E.16 Memory Map Format ....................................... 670
E.17 Thread List Format ...................................... 671
E.18 Traceframe Info Format .................................. 672
E.19 Branch Trace Format ..................................... 672
E.20 Branch Trace Configuration Format ......................... 673
<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Appendix M GNU Free Documentation License</td>
<td>723</td>
</tr>
<tr>
<td>Concept Index</td>
<td>731</td>
</tr>
<tr>
<td>Command, Variable, and Function Index</td>
<td>745</td>
</tr>
</tbody>
</table>
Summary of GDB

The purpose of a debugger such as GDB is to allow you to see what is going on “inside” another program while it executes—or what another program was doing at the moment it crashed.

GDB can do four main kinds of things (plus other things in support of these) to help you catch bugs in the act:

- Start your program, specifying anything that might affect its behavior.
- Make your program stop on specified conditions.
- Examine what has happened, when your program has stopped.
- Change things in your program, so you can experiment with correcting the effects of one bug and go on to learn about another.

You can use GDB to debug programs written in C and C++. For more information, see Section 15.4 [Supported Languages], page 191. For more information, see Section 15.4.1 [C and C++], page 191.

Support for D is partial. For information on D, see Section 15.4.2 [D], page 197.

Support for Modula-2 is partial. For information on Modula-2, see Section 15.4.8 [Modula-2], page 200.

Support for OpenCL C is partial. For information on OpenCL C, see Section 15.4.5 [OpenCL C], page 199.

Debugging Pascal programs which use sets, subranges, file variables, or nested functions does not currently work. GDB does not support entering expressions, printing values, or similar features using Pascal syntax.

GDB can be used to debug programs written in Fortran, although it may be necessary to refer to some variables with a trailing underscore.

GDB can be used to debug programs written in Objective-C, using either the Apple/NeXT or the GNU Objective-C runtime.

Free Software

GDB is free software, protected by the GNU General Public License (GPL). The GPL gives you the freedom to copy or adapt a licensed program—but every person getting a copy also gets with it the freedom to modify that copy (which means that they must get access to the source code), and the freedom to distribute further copies. Typical software companies use copyrights to limit your freedoms; the Free Software Foundation uses the GPL to preserve these freedoms.

Fundamentally, the General Public License is a license which says that you have these freedoms and that you cannot take these freedoms away from anyone else.

Free Software Needs Free Documentation

The biggest deficiency in the free software community today is not in the software—it is the lack of good free documentation that we can include with the free software. Many of our most important programs do not come with free reference manuals and free introductory
texts. Documentation is an essential part of any software package; when an important free software package does not come with a free manual and a free tutorial, that is a major gap. We have many such gaps today.

Consider Perl, for instance. The tutorial manuals that people normally use are non-free. How did this come about? Because the authors of those manuals published them with restrictive terms—no copying, no modification, source files not available—which exclude them from the free software world.

That wasn’t the first time this sort of thing happened, and it was far from the last. Many times we have heard a GNU user eagerly describe a manual that he is writing, his intended contribution to the community, only to learn that he had ruined everything by signing a publication contract to make it non-free.

Free documentation, like free software, is a matter of freedom, not price. The problem with the non-free manual is not that publishers charge a price for printed copies—that in itself is fine. (The Free Software Foundation sells printed copies of manuals, too.) The problem is the restrictions on the use of the manual. Free manuals are available in source code form, and give you permission to copy and modify. Non-free manuals do not allow this.

The criteria of freedom for a free manual are roughly the same as for free software. Redistribution (including the normal kinds of commercial redistribution) must be permitted, so that the manual can accompany every copy of the program, both on-line and on paper.

Permission for modification of the technical content is crucial too. When people modify the software, adding or changing features, if they are conscientious they will change the manual too—so they can provide accurate and clear documentation for the modified program. A manual that leaves you no choice but to write a new manual to document a changed version of the program is not really available to our community.

Some kinds of limits on the way modification is handled are acceptable. For example, requirements to preserve the original author’s copyright notice, the distribution terms, or the list of authors, are ok. It is also no problem to require modified versions to include notice that they were modified. Even entire sections that may not be deleted or changed are acceptable, as long as they deal with nontechnical topics (like this one). These kinds of restrictions are acceptable because they don’t obstruct the community’s normal use of the manual.

However, it must be possible to modify all the technical content of the manual, and then distribute the result in all the usual media, through all the usual channels. Otherwise, the restrictions obstruct the use of the manual, it is not free, and we need another manual to replace it.

Please spread the word about this issue. Our community continues to lose manuals to proprietary publishing. If we spread the word that free software needs free reference manuals and free tutorials, perhaps the next person who wants to contribute by writing documentation will realize, before it is too late, that only free manuals contribute to the free software community.

If you are writing documentation, please insist on publishing it under the GNU Free Documentation License or another free documentation license. Remember that this decision requires your approval—you don’t have to let the publisher decide. Some commercial publishers will use a free license if you insist, but they will not propose the option; it is up
Summary of GDB

You can encourage commercial publishers to sell more free, copylefted manuals and tutorials by buying them, and particularly by buying copies from the publishers that paid for their writing or for major improvements. Meanwhile, try to avoid buying non-free documentation at all. Check the distribution terms of a manual before you buy it, and insist that whoever seeks your business must respect your freedom. Check the history of the book, and try to reward the publishers that have paid or pay the authors to work on it.


Contributors to GDB

Richard Stallman was the original author of GDB, and of many other GNU programs. Many others have contributed to its development. This section attempts to credit major contributors. One of the virtues of free software is that everyone is free to contribute to it; with regret, we cannot actually acknowledge everyone here. The file ‘ChangeLog’ in the GDB distribution approximates a blow-by-blow account.

Changes much prior to version 2.0 are lost in the mists of time.

Plea: Additions to this section are particularly welcome. If you or your friends (or enemies, to be evenhanded) have been unfairly omitted from this list, we would like to add your names!

So that they may not regard their many labors as thankless, we particularly thank those who shepherded GDB through major releases: Andrew Cagney (releases 6.3, 6.2, 6.1, 6.0, 5.3, 5.2, 5.1 and 5.0); Jim Blandy (release 4.18); Jason Molenda (release 4.17); Stan Shebs (release 4.14); Fred Fish (releases 4.16, 4.15, 4.13, 4.12, 4.11, 4.10, and 4.9); Stu Grossman and John Gilmore (releases 4.8, 4.7, 4.6, 4.5, and 4.4); John Gilmore (releases 4.3, 4.2, 4.1, 4.0, and 3.9); Jim Kingdon (releases 3.5, 3.4, and 3.3); and Randy Smith (releases 3.2, 3.1, and 3.0).

Richard Stallman, assisted at various times by Peter TerMaat, Chris Hanson, and Richard Mlynarik, handled releases through 2.8.

Michael Tiemann is the author of most of the GNU C++ support in GDB, with significant additional contributions from Per Bothner and Daniel Berlin. James Clark wrote the GNU C++ demangler. Early work on C++ was by Peter TerMaat (who also did much general update work leading to release 3.0).

GDB uses the BFD subroutine library to examine multiple object-file formats; BFD was a joint project of David V. Henkel-Wallace, Rich Pixley, Steve Chamberlain, and John Gilmore.

David Johnson wrote the original COFF support; Pace Willison did the original support for encapsulated COFF.

Brent Benson of Harris Computer Systems contributed DWARF 2 support.

Adam de Boor and Bradley Davis contributed the ISI Optimum V support. Per Bothner, Noboyuki Hikichi, and Alessandro Forin contributed MIPS support. Jean-Daniel Fekete contributed Sun 386i support. Chris Hanson improved the HP9000 support. Noboyuki

Andreas Schwab contributed M68K gnu/Linux support.

Rich Schaefer and Peter Schauer helped with support of SunOS shared libraries.

Jay Fenlason and Roland McGrath ensured that gdb and GAS agree about several machine instruction sets.

Patrick Duval, Ted Goldstein, Vikram Koka and Glenn Engel helped develop remote debugging. Intel Corporation, Wind River Systems, AMD, and ARM contributed remote debugging modules for the i960, VxWorks, A29K UDI, and RDI targets, respectively.

Brian Fox is the author of the readline libraries providing command-line editing and command history.

Andrew Beers of SUNY Buffalo wrote the language-switching code, the Modula-2 support, and contributed the Languages chapter of this manual.

Fred Fish wrote most of the support for Unix System Vr4. He also enhanced the command-completion support to cover C++ overloaded symbols.

Hitachi America (now Renesas America), Ltd. sponsored the support for H8/300, H8/500, and Super-H processors.

NEC sponsored the support for the v850, Vr4xxx, and Vr5xxx processors.

Mitsubishi (now Renesas) sponsored the support for D10V, D30V, and M32R/D processors.

Toshiba sponsored the support for the TX39 Mips processor.

Matsushita sponsored the support for the MN10200 and MN10300 processors.

Fujitsu sponsored the support for SPARClite and FR30 processors.

Kung Hsu, Jeff Law, and Rick Sladkey added support for hardware watchpoints.

Michael Snyder added support for tracepoints.

Stu Grossman wrote gdbserver.

Jim Kingdon, Peter Schauer, Ian Taylor, and Stu Grossman made nearly innumerable bug fixes and cleanups throughout gdb.

The following people at the Hewlett-Packard Company contributed support for the PA-RISC 2.0 architecture, HP-UX 10.20, 10.30, and 11.0 (narrow mode), HP’s implementation of kernel threads, HP’s aC++ compiler, and the Text User Interface (nee Terminal User Interface): Ben Krepp, Richard Title, John Bishop, Susan Macchia, Kathy Mann, Satish Pai, India Paul, Steve Rehrauer, and Elena Zannoni. Kim Haase provided HP-specific information in this manual.

DJ Delorie ported gdb to MS-DOS, for the DJGPP project. Robert Hoehne made significant contributions to the DJGPP port.
Cygnum Solutions has sponsored GDB maintenance and much of its development since 1991. Cygnus engineers who have worked on GDB fulltime include Mark Alexander, Jim Blandy, Per Bothner, Kevin Buettner, Edith Epstein, Chris Taylor, Fred Fish, Martin Hunt, Jim Ingham, John Gilmore, Stu Grossman, Kung Hsu, Jim Kindon, John Metzler, Fernando Nasser, Geoffrey Noer, Dawn Perchik, Rich Pixley, Zdenek Radouch, Keith Seitz, Stan Shebs, David Taylor, and Elena Zannoni. In addition, Dave Brolley, Ian Carmichael, Steve Chamberlain, Nick Clifton, JT Conklin, Stan Cox, DJ Delorie, Ulrich Drepper, Frank Eigler, Doug Evans, Sean Fagan, David Henkel-Wallace, Richard Henderson, Jeff Holcomb, Jeff Law, Jim Lemke, Tom Lord, Bob Manson, Michael Meissner, Jason Merrill, Catherine Moore, Drew Moseley, Ken Raeburn, Gavin Romig-Koch, Rob Savoye, Jamie Smith, Mike Stump, Ian Taylor, Angela Thomas, Michael Tiemann, Tom Tromey, Ron Unrau, Jim Wilson, and David Zuhn have made contributions both large and small.

Andrew Cagney, Fernando Nasser, and Elena Zannoni, while working for Cygnus Solutions, implemented the original GDB/MI interface.

Jim Blandy added support for preprocessor macros, while working for Red Hat.

Andrew Cagney designed GDB’s architecture vector. Many people including Andrew Cagney, Stephane Carrez, Randolph Chung, Nick Duffek, Richard Henderson, Mark Kettenis, Grace Sainsbury, Kei Sakamoto, Yoshinori Sato, Michael Snyder, Andreas Schwab, Jason Thorpe, Corinna Vinschen, Ulrich Weigand, and Elena Zannoni, helped with the migration of old architectures to this new framework.

Andrew Cagney completely re-designed and re-implemented GDB’s unwinder framework, this consisting of a fresh new design featuring frame IDs, independent frame sniffers, and the sentinel frame. Mark Kettenis implemented the DwarF 2 unwinder, Jeff Johnston the libunwind unwinder, and Andrew Cagney the dummy, sentinel, tramp, and trad unwinders. The architecture-specific changes, each involving a complete rewrite of the architecture’s frame code, were carried out by Jim Blandy, Joel Brobecker, Kevin Buettner, Andrew Cagney, Stephane Carrez, Randolph Chung, Orjan Friberg, Richard Henderson, Daniel Jacobowitz, Jeff Johnston, Mark Kettenis, Theodore A. Roth, Kei Sakamoto, Yoshinori Sato, Michael Snyder, Corinna Vinschen, and Ulrich Weigand.

Christian Zankel, Ross Morley, Bob Wilson, and Maxim Grigoriev from Tensilica, Inc. contributed support for Xtensa processors. Others who have worked on the Xtensa port of GDB in the past include Steve Tjiang, John Newlin, and Scott Foehner.

Michael Eager and staff of Xilinx, Inc., contributed support for the Xilinx MicroBlaze architecture.
1 A Sample GDB Session

You can use this manual at your leisure to read all about GDB. However, a handful of commands are enough to get started using the debugger. This chapter illustrates those commands.

In this sample session, we emphasize user input like this: input, to make it easier to pick out from the surrounding output.

One of the preliminary versions of GNU m4 (a generic macro processor) exhibits the following bug: sometimes, when we change its quote strings from the default, the commands used to capture one macro definition within another stop working. In the following short m4 session, we define a macro foo which expands to 0000; we then use the m4 built-in defn to define bar as the same thing. However, when we change the open quote string to <QUOTE> and the close quote string to <UNQUOTE>, the same procedure fails to define a new synonym baz:

$ cd gnu/m4
$ ./m4
define(foo,0000)

foo
0000
define(bar,defn('foo'))

bar
0000
changequote(<QUOTE>,<UNQUOTE>)

define(baz,defn(<QUOTE>foo<UNQUOTE>))
baz
Ctrl-d
m4: End of input: 0: fatal error: EOF in string

Let us use GDB to try to see what is going on.

$ gdb m4
GDB is free software and you are welcome to distribute copies
of it under certain conditions; type "show copying" to see
the conditions.
There is absolutely no warranty for GDB; type "show warranty"
for details.

GDB 7.10.50.20150918-cvs, Copyright 1999 Free Software Foundation, Inc...
(gdb)
GDB reads only enough symbol data to know where to find the rest when needed; as a result, the first prompt comes up very quickly. We now tell GDB to use a narrower display width than usual, so that examples fit in this manual.

(gdb) set width 70
We need to see how the m4 built-in changequote works. Having looked at the source, we know the relevant subroutine is m4_changequote, so we set a breakpoint there with the GDB break command.

(gdb) break m4_changequote
Breakpoint 1 at 0x62f4: file builtin.c, line 879.

Using the run command, we start m4 running under GDB control; as long as control does not reach the m4_changequote subroutine, the program runs as usual:
To trigger the breakpoint, we call \texttt{changequote}. GDB suspends execution of \texttt{m4}, displaying information about the context where it stops.

\begin{Verbatim}
\texttt{changequote(<QUOTE>,<UNQUOTE>)}
\end{Verbatim}

Breakpoint 1, m4\_changequote (argc=3, argv=0x33c70)  
879 at builtin.c:879

\begin{Verbatim}
879 if (bad\_argc(TOKEN\_DATA\_TEXT(argv[0]),argc,1,3))
\end{Verbatim}

Now we use the command \texttt{n} (\texttt{next}) to advance execution to the next line of the current function.

\begin{Verbatim}
\texttt{n}
\end{Verbatim}

\begin{Verbatim}
882 set\_quotes((argc >= 2) ? TOKEN\_DATA\_TEXT(argv[1])\
: nil,
\end{Verbatim}

\texttt{set\_quotes} looks like a promising subroutine. We can go into it by using the command \texttt{s} (\texttt{step}) instead of \texttt{next}. \texttt{step} goes to the next line to be executed in \texttt{any} subroutine, so it steps into \texttt{set\_quotes}.

\begin{Verbatim}
\texttt{s}
\end{Verbatim}

\begin{Verbatim}
set\_quotes (lq=0x34c78 "<QUOTE>", rq=0x34c88 "<UNQUOTE>")
\end{Verbatim}

\begin{Verbatim}
\texttt{s}
\end{Verbatim}

\begin{Verbatim}
set\_quotes (lq=0x34c78 "<QUOTE>", rq=0x34c88 "<UNQUOTE>")
at input.c:530
\end{Verbatim}

\begin{Verbatim}
530 if (lquote != def\_lquote)
\end{Verbatim}

The display that shows the subroutine where \texttt{m4} is now suspended (and its arguments) is called a stack frame display. It shows a summary of the stack. We can use the \texttt{backtrace} command (which can also be spelled \texttt{bt}), to see where we are in the stack as a whole: the \texttt{backtrace} command displays a stack frame for each active subroutine.

\begin{Verbatim}
\texttt{bt}
\end{Verbatim}

\begin{Verbatim}
#0 set\_quotes (lq=0x34c78 "<QUOTE>", rq=0x34c88 "<UNQUOTE>")
at input.c:530
#1 0x6344 in m4\_changequote (argc=3, argv=0x33c70)
at builtin.c:882
#2 0x8174 in expand\_macro (sym=0x33320) at macro.c:242
#3 0x7a88 in expand\_token (obs=0x0, t=209696, td=0xf7fffa30)
at macro.c:71
#4 0x79dc in expand\_input () at macro.c:40
#5 0x2930 in main (argc=0, argv=0xf7fffb20) at m4.c:195
\end{Verbatim}

We step through a few more lines to see what happens. The first two times, we can use \texttt{s}; the next two times we use \texttt{n} to avoid falling into the \texttt{xstrdup} subroutine.

\begin{Verbatim}
\texttt{s}
\end{Verbatim}

\begin{Verbatim}
0x3b5c 532 if (rquote != def\_rquote)
\end{Verbatim}

\begin{Verbatim}
\texttt{s}
\end{Verbatim}

\begin{Verbatim}
0x3b80 535 lquote = (lq == nil || *lq == '\0') ? \\
def\_lquote : xstrdup(lq);
\end{Verbatim}

\begin{Verbatim}
\texttt{n}
\end{Verbatim}

\begin{Verbatim}
536 rquote = (rq == nil || *rq == '\0') ? def\_rquote\\
xstrdup(rq);
\end{Verbatim}

\begin{Verbatim}
\texttt{n}
\end{Verbatim}

\begin{Verbatim}
538 len\_lquote = strlen(rquote);
\end{Verbatim}
The last line displayed looks a little odd; we can examine the variables \texttt{lquote} and \texttt{rquote} to see if they are in fact the new left and right quotes we specified. We use the command \texttt{p (print)} to see their values.

\begin{verbatim}
(gdb) p lquote
$1 = 0x35d40 "<QUOTE>"
(gdb) p rquote
$2 = 0x35d50 "<UNQUOTE>"
\end{verbatim}

\texttt{lquote} and \texttt{rquote} are indeed the new left and right quotes. To look at some context, we can display ten lines of source surrounding the current line with the \texttt{l (list)} command.

\begin{verbatim}
(gdb) l
533                   xfree(rquote);
534
535       lquote = (lq == nil || *lq == '\0') ? def_lquote:
536       : xstrdup (lq);
537
538       rquote = (rq == nil || *rq == '\0') ? def_rquote:
539       : xstrdup (rq);
540 }
541 void
\end{verbatim}

Let us step past the two lines that set \texttt{len_lquote} and \texttt{len_rquote}, and then examine the values of those variables.

\begin{verbatim}
(gdb) n
539       len_rquote = strlen(lquote);
(gdb) n
540 }
(gdb) p len_lquote
$3 = 9
(gdb) p len_rquote
$4 = 7
\end{verbatim}

That certainly looks wrong, assuming \texttt{len_lquote} and \texttt{len_rquote} are meant to be the lengths of \texttt{lquote} and \texttt{rquote} respectively. We can set them to better values using the \texttt{p} command, since it can print the value of any expression—and that expression can include subroutine calls and assignments.

\begin{verbatim}
(gdb) p len_lquote=strlen(lquote)
$5 = 7
(gdb) p len_rquote=strlen(rquote)
$6 = 9
\end{verbatim}

Is that enough to fix the problem of using the new quotes with the \texttt{m4} built-in \texttt{defn}? We can allow \texttt{m4} to continue executing with the \texttt{c (continue)} command, and then try the example that caused trouble initially:

\begin{verbatim}
(gdb) c
Continuing.

define(baz,defn(<QUOTE>foo<UNQUOTE>))
\end{verbatim}

\texttt{baz}
0000
Success! The new quotes now work just as well as the default ones. The problem seems to have been just the two typos defining the wrong lengths. We allow m4 exit by giving it an EOF as input:

```
Ctrl-d
Program exited normally.
```

The message ‘Program exited normally.’ is from GDB; it indicates m4 has finished executing. We can end our GDB session with the GDB quit command.

```
(gdb) quit
```
Chapter 2: Getting In and Out of GDB

This chapter discusses how to start GDB, and how to get out of it. The essentials are:

- type ‘gdb’ to start GDB.
- type quit or Ctrl-d to exit.

2.1 Invoking GDB

Invoke GDB by running the program gdb. Once started, GDB reads commands from the terminal until you tell it to exit.

You can also run gdb with a variety of arguments and options, to specify more of your debugging environment at the outset.

The command-line options described here are designed to cover a variety of situations; in some environments, some of these options may effectively be unavailable.

The most usual way to start GDB is with one argument, specifying an executable program:

gdb program

You can also start with both an executable program and a core file specified:

gdb program core

You can, instead, specify a process ID as a second argument, if you want to debug a running process:

gdb program 1234

would attach GDB to process 1234 (unless you also have a file named ‘1234’; GDB does check for a core file first).

Taking advantage of the second command-line argument requires a fairly complete operating system; when you use GDB as a remote debugger attached to a bare board, there may not be any notion of “process”, and there is often no way to get a core dump. GDB will warn you if it is unable to attach or to read core dumps.

You can optionally have gdb pass any arguments after the executable file to the inferior using --args. This option stops option processing.

gdb --args gcc -O2 -c foo.c

This will cause gdb to debug gcc, and to set gcc’s command-line arguments (see Section 4.3 [Arguments], page 30) to ‘-02 -c foo.c’.

You can run gdb without printing the front material, which describes GDB’s non-warranty, by specifying --silent (or -q/--quiet):

gdb --silent

You can further control how GDB starts up by using command-line options. GDB itself can remind you of the options available.

Type

gdb --help

to display all available options and briefly describe their use (‘gdb --h’ is a shorter equivalent).

All options and command line arguments you give are processed in sequential order. The order makes a difference when the ‘-x’ option is used.
2.1.1 Choosing Files

When GDB starts, it reads any arguments other than options as specifying an executable file and core file (or process ID). This is the same as if the arguments were specified by the ‘-se’ and ‘-c’ (or ‘-p’) options respectively. (GDB reads the first argument that does not have an associated option flag as equivalent to the ‘-se’ option followed by that argument; and the second argument that does not have an associated option flag, if any, as equivalent to the ‘-c’/’-p’ option followed by that argument.) If the second argument begins with a decimal digit, GDB will first attempt to attach to it as a process, and if that fails, attempt to open it as a corefile. If you have a corefile whose name begins with a digit, you can prevent GDB from treating it as a pid by prefixing it with ‘./’, e.g. ‘./12345’.

If GDB has not been configured to included core file support, such as for most embedded targets, then it will complain about a second argument and ignore it.

Many options have both long and short forms; both are shown in the following list. GDB also recognizes the long forms if you truncate them, so long as enough of the option is present to be unambiguous. (If you prefer, you can flag option arguments with ‘--’ rather than ‘-’, though we illustrate the more usual convention.)

-symbols file
-s file   Read symbol table from file file.
-exec file
-e file   Use file file as the executable file to execute when appropriate, and for examining pure data in conjunction with a core dump.
-se file  Read symbol table from file file and use it as the executable file.
-core file
-c file   Use file file as a core dump to examine.
-pid number
-p number  Connect to process ID number, as with the attach command.
-command file
-x file   Execute commands from file file. The contents of this file is evaluated exactly as the source command would. See Section 23.1.3 [Command files], page 318.
-eval-command command
-ex command
-Execute a single GDB command.

This option may be used multiple times to call multiple commands. It may also be interleaved with ‘-command’ as required.

gdb -ex 'target sim' -ex 'load' \
    -x setbreakpoints -ex 'run' a.out

-init-command file
-ix file   Execute commands from file file before loading the inferior (but after loading gdbinit files). See Section 2.1.3 [Startup], page 16.

-init-eval-command command
-ix command
-Execute a single GDB command before loading the inferior (but after loading gdbinit files). See Section 2.1.3 [Startup], page 16.
-directory directory
-d directory
Add directory to the path to search for source and script files.

-r
-readnow Read each symbol file's entire symbol table immediately, rather than the default, which is to read it incrementally as it is needed. This makes startup slower, but makes future operations faster.

2.1.2 Choosing Modes
You can run GDB in various alternative modes—for example, in batch mode or quiet mode.

-\texttt{-nx}
-\texttt{-n} Do not execute commands found in any initialization file. There are three init files, loaded in the following order:

\texttt{`system.gdbinit'}
This is the system-wide init file. Its location is specified with the -\texttt{--with-system-gdbinit} configure option (see Section C.6 [System-wide configuration], page 596). It is loaded first when GDB starts, before command line options have been processed.

\texttt{`~/.gdbinit'}
This is the init file in your home directory. It is loaded next, after `\texttt{system.gdbinit}', and before command options have been processed.

\texttt{`/./gdbinit'}
This is the init file in the current directory. It is loaded last, after command line options other than -\texttt{x} and -\texttt{ex} have been processed. Command line options -\texttt{x} and -\texttt{ex} are processed last, after `\texttt{./gdbinit}' has been loaded.

For further documentation on startup processing, See Section 2.1.3 [Startup], page 16. For documentation on how to write command files, See Section 23.1.3 [Command Files], page 318.

-\texttt{-nh} Do not execute commands found in `\texttt{~/.gdbinit}', the init file in your home directory. See Section 2.1.3 [Startup], page 16.

-\texttt{-quiet}
-\texttt{-silent}
-q
“Quiet”. Do not print the introductory and copyright messages. These messages are also suppressed in batch mode.

-\texttt{-batch} Run in batch mode. Exit with status 0 after processing all the command files specified with `-\texttt{x}' (and all commands from initialization files, if not inhibited with `-\texttt{n}'). Exit with nonzero status if an error occurs in executing the GDB commands in the command files. Batch mode also disables pagination, sets unlimited terminal width and height see Section 22.4 [Screen Size], page 299, and acts as if set confirm off were in effect (see Section 22.8 [Messages/Warnings], page 307).
Batch mode may be useful for running GDB as a filter, for example to download and run a program on another computer; in order to make this more useful, the message

\[\text{Program exited normally.}\]

(which is ordinarily issued whenever a program running under GDB control terminates) is not issued when running in batch mode.

\textbf{-batch-silent}

Run in batch mode exactly like ‘-batch’, but totally silently. All GDB output to stdout is prevented (stderr is unaffected). This is much quieter than ‘-silent’ and would be useless for an interactive session.

This is particularly useful when using targets that give ‘Loading section’ messages, for example.

Note that targets that give their output via GDB, as opposed to writing directly to stdout, will also be made silent.

\textbf{-return-child-result}

The return code from GDB will be the return code from the child process (the process being debugged), with the following exceptions:

- GDB exits abnormally. E.g., due to an incorrect argument or an internal error. In this case the exit code is the same as it would have been without ‘-return-child-result’.
- The user quits with an explicit value. E.g., ‘quit 1’.
- The child process never runs, or is not allowed to terminate, in which case the exit code will be -1.

This option is useful in conjunction with ‘-batch’ or ‘-batch-silent’, when GDB is being used as a remote program loader or simulator interface.

\textbf{-nowindows}

\textbf{-nw}

“No windows”. If GDB comes with a graphical user interface (GUI) built in, then this option tells GDB to only use the command-line interface. If no GUI is available, this option has no effect.

\textbf{-windows}

\textbf{-w}

If GDB includes a GUI, then this option requires it to be used if possible.

\textbf{-cd directory}

Run GDB using directory as its working directory, instead of the current directory.

\textbf{-data-directory directory}

\textbf{-D directory}

Run GDB using directory as its data directory. The data directory is where GDB searches for its auxiliary files. See Section 18.7 [Data Files], page 252.

\textbf{-fullname}

\textbf{-f}

GNU Emacs sets this option when it runs GDB as a subprocess. It tells GDB to output the full file name and line number in a standard, recognizable fashion each time a stack frame is displayed (which includes each time your program
stops). This recognizable format looks like two ‘\032’ characters, followed by the file name, line number and character position separated by colons, and a newline. The Emacs-to-GDB interface program uses the two ‘\032’ characters as a signal to display the source code for the frame.

**-annotate level**
This option sets the *annotation level* inside GDB. Its effect is identical to using ‘*set annotate level*’ (see Chapter 28 [Annotations], page 545). The annotation level controls how much information GDB prints together with its prompt, values of expressions, source lines, and other types of output. Level 0 is the normal, level 1 is for use when GDB is run as a subprocess of GNU Emacs, level 3 is the maximum annotation suitable for programs that control GDB, and level 2 has been deprecated.

The annotation mechanism has largely been superseded by GDB/MI (see Chapter 27 [GDB/MI], page 457).

**--args**
Change interpretation of command line so that arguments following the executable file are passed as command line arguments to the inferior. This option stops option processing.

**-baud bps**
**-b bps**
Set the line speed (baud rate or bits per second) of any serial interface used by GDB for remote debugging.

**-l timeout**
Set the timeout (in seconds) of any communication used by GDB for remote debugging.

**-tty device**
**-t device**
Run using device for your program’s standard input and output.

**-tui**
Activate the *Text User Interface* when starting. The Text User Interface manages several text windows on the terminal, showing source, assembly, registers and GDB command outputs (see Chapter 25 [GDB Text User Interface], page 449). Do not use this option if you run GDB from Emacs (see Chapter 26 [Using GDB under GNU Emacs], page 455).

**-interpreter interp**
Use the interpreter interp for interface with the controlling program or device. This option is meant to be set by programs which communicate with GDB using it as a back end. See Chapter 24 [Command Interpreters], page 447.

‘**--interpreter=mi**’ (or ‘**--interpreter=mi2**’) causes GDB to use the GDB/MI interface (see Chapter 27 [The GDB/MI Interface], page 457) included since GDB version 6.0. The previous GDB/MI interface, included in GDB version 5.3 and selected with ‘**--interpreter=mi1**’, is deprecated. Earlier GDB/MI interfaces are no longer supported.

**-write**
Open the executable and core files for both reading and writing. This is equivalent to the ‘*set write on*’ command inside GDB (see Section 17.6 [Patching], page 230).
-statistics
This option causes GDB to print statistics about time and memory usage after it completes each command and returns to the prompt.

-version
This option causes GDB to print its version number and no-warranty blurb, and exit.

-configuration
This option causes GDB to print details about its build-time configuration parameters, and then exit. These details can be important when reporting GDB bugs (see Chapter 31 [GDB Bugs], page 557).

### 2.1.3 What GDB Does During Startup

Here’s the description of what GDB does during session startup:

1. Sets up the command interpreter as specified by the command line (see Section 2.1.2 [Mode Options], page 13).

2. Reads the system-wide init file (if ‘--with-system-gdbinit’ was used when building GDB; see Section C.6 [System-wide configuration and settings], page 596) and executes all the commands in that file.

3. Reads the init file (if any) in your home directory\(^1\) and executes all the commands in that file.

4. Executes commands and command files specified by the ‘-iex’ and ‘-ix’ options in their specified order. Usually you should use the ‘-ex’ and ‘-x’ options instead, but this way you can apply settings before GDB init files get executed and before inferior gets loaded.

5. Processes command line options and operands.

6. Reads and executes the commands from init file (if any) in the current working directory as long as ‘set auto-load local-gdbinit’ is set to ‘on’ (see Section 22.7.1 [Init File in the Current Directory], page 304). This is only done if the current directory is different from your home directory. Thus, you can have more than one init file, one generic in your home directory, and another, specific to the program you are debugging, in the directory where you invoke GDB.

7. If the command line specified a program to debug, or a process to attach to, or a core file, GDB loads any auto-loaded scripts provided for the program or for its loaded shared libraries. See Section 22.7 [Auto-loading], page 302.

If you wish to disable the auto-loading during startup, you must do something like the following:

```bash
$ gdb -iex "set auto-load python-scripts off" myprogram
```

Option ‘-ex’ does not work because the auto-loading is then turned off too late.

8. Executes commands and command files specified by the ‘-ex’ and ‘-x’ options in their specified order. See Section 23.1.3 [Command Files], page 318, for more details about GDB command files.

9. Reads the command history recorded in the history file. See Section 22.3 [Command History], page 298, for more details about the command history and the files where GDB records it.

\(^1\) On DOS/Windows systems, the home directory is the one pointed to by the HOME environment variable.
Init files use the same syntax as command files (see Section 23.1.3 [Command Files], page 318) and are processed by GDB in the same way. The init file in your home directory can set options (such as ‘set complaints’) that affect subsequent processing of command line options and operands. Init files are not executed if you use the ‘-nx’ option (see Section 2.1.2 [Choosing Modes], page 13).

To display the list of init files loaded by gdb at startup, you can use `gdb --help`.

The GDB init files are normally called ‘.gdbinit’. The DJGPP port of GDB uses the name ‘gdb.ini’, due to the limitations of file names imposed by DOS filesystems. The Windows port of GDB uses the standard name, but if it finds a ‘gdb.ini’ file in your home directory, it warns you about that and suggests to rename the file to the standard name.

### 2.2 Quitting GDB

```plaintext
quit [expression]
```

To exit GDB, use the quit command (abbreviated q), or type an end-of-file character (usually Ctrl-d). If you do not supply expression, GDB will terminate normally; otherwise it will terminate using the result of expression as the error code.

An interrupt (often Ctrl-c) does not exit from GDB, but rather terminates the action of any GDB command that is in progress and returns to GDB command level. It is safe to type the interrupt character at any time because GDB does not allow it to take effect until a time when it is safe.

If you have been using GDB to control an attached process or device, you can release it with the `detach` command (see Section 4.7 [Debugging an Already-running Process], page 32).

### 2.3 Shell Commands

If you need to execute occasional shell commands during your debugging session, there is no need to leave or suspend GDB; you can just use the shell command.

```plaintext
shell command-string
```

Invoke a standard shell to execute command-string. Note that no space is needed between `!` and command-string. If it exists, the environment variable SHELL determines which shell to run. Otherwise GDB uses the default shell (‘/bin/sh’ on Unix systems, ‘COMMAND.COM’ on MS-DOS, etc.).

The utility make is often needed in development environments. You do not have to use the shell command for this purpose in GDB:

```plaintext
make make-args
```

Execute the make program with the specified arguments. This is equivalent to ‘shell make make-args’.
2.4 Logging Output

You may want to save the output of GDB commands to a file. There are several commands to control GDB’s logging.

set logging on
   Enable logging.

set logging off
   Disable logging.

set logging file file
   Change the name of the current logfile. The default logfile is ‘gdb.txt’.

set logging overwrite [on|off]
   By default, GDB will append to the logfile. Set overwrite if you want set logging on to overwrite the logfile instead.

set logging redirect [on|off]
   By default, GDB output will go to both the terminal and the logfile. Set redirect if you want output to go only to the log file.

show logging
   Show the current values of the logging settings.
3 GDB Commands

You can abbreviate a GDB command to the first few letters of the command name, if that abbreviation is unambiguous; and you can repeat certain GDB commands by typing just RET. You can also use the TAB key to get GDB to fill out the rest of a word in a command (or to show you the alternatives available, if there is more than one possibility).

3.1 Command Syntax

A GDB command is a single line of input. There is no limit on how long it can be. It starts with a command name, which is followed by arguments whose meaning depends on the command name. For example, the command step accepts an argument which is the number of times to step, as in ‘step 5’. You can also use the step command with no arguments. Some commands do not allow any arguments.

GDB command names may always be truncated if that abbreviation is unambiguous. Other possible command abbreviations are listed in the documentation for individual commands. In some cases, even ambiguous abbreviations are allowed; for example, s is specially defined as equivalent to step even though there are other commands whose names start with s. You can test abbreviations by using them as arguments to the help command.

A blank line as input to GDB (typing just RET) means to repeat the previous command. Certain commands (for example, run) will not repeat this way; these are commands whose unintentional repetition might cause trouble and which you are unlikely to want to repeat. User-defined commands can disable this feature; see Section 23.1.1 [Define], page 315.

The list and x commands, when you repeat them with RET, construct new arguments rather than repeating exactly as typed. This permits easy scanning of source or memory.

GDB can also use RET in another way: to partition lengthy output, in a way similar to the common utility more (see Section 22.4 [Screen Size], page 299). Since it is easy to press one RET too many in this situation, GDB disables command repetition after any command that generates this sort of display.

Any text from a # to the end of the line is a comment; it does nothing. This is useful mainly in command files (see Section 23.1.3 [Command Files], page 318).

The Ctrl-o binding is useful for repeating a complex sequence of commands. This command accepts the current line, like RET, and then fetches the next line relative to the current line from the history for editing.

3.2 Command Completion

GDB can fill in the rest of a word in a command for you, if there is only one possibility; it can also show you what the valid possibilities are for the next word in a command, at any time. This works for GDB commands, GDB subcommands, and the names of symbols in your program.

Press the TAB key whenever you want GDB to fill out the rest of a word. If there is only one possibility, GDB fills in the word, and waits for you to finish the command (or press RET to enter it). For example, if you type

(gdb) info bre TAB

GDB fills in the rest of the word ‘breakpoints’, since that is the only info subcommand beginning with ‘bre’:
You can either press RET at this point, to run the \texttt{info breakpoints} command, or backspace and enter something else, if ‘breakpoints’ does not look like the command you expected. (If you were sure you wanted \texttt{info breakpoints} in the first place, you might as well just type RET immediately after ‘info bre’, to exploit command abbreviations rather than command completion).

If there is more than one possibility for the next word when you press TAB, \texttt{gdb} sounds a bell. You can either supply more characters and try again, or just press TAB a second time; \texttt{gdb} displays all the possible completions for that word. For example, you might want to set a breakpoint on a subroutine whose name begins with ‘make_’, but when you type \texttt{b make TAB} \texttt{gdb} just sounds the bell. Typing TAB again displays all the function names in your program that begin with those characters, for example:

\begin{verbatim}
(gdb) b make_ TAB
GDB sounds bell; press TAB again, to see:
make_a_section_from_file     make_environ
make_abs_section             make_function_type
make_blockvector             make_pointer_type
make_cleanup                 make_reference_type
make_command                 make_symbol_completion_list
(gdb) b make_
\end{verbatim}

After displaying the available possibilities, \texttt{gdb} copies your partial input (‘b make_’ in the example) so you can finish the command.

If you just want to see the list of alternatives in the first place, you can press \texttt{M-?} rather than pressing TAB twice. \texttt{M-?} means \texttt{META ?}. You can type this either by holding down a key designated as the \texttt{META} shift on your keyboard (if there is one) while typing ?, or as \texttt{ESC} followed by ?.

If the number of possible completions is large, \texttt{gdb} will print as much of the list as it has collected, as well as a message indicating that the list may be truncated.

\begin{verbatim}
(gdb) b mTABTAB
main
<... the rest of the possible completions ...>
*** List may be truncated, max-completions reached. ***
(gdb) b m
\end{verbatim}

This behavior can be controlled with the following commands:

\texttt{set max-completions limit}
\texttt{set max-completions unlimited}

Set the maximum number of completion candidates. \texttt{GDB} will stop looking for more completions once it collects this many candidates. This is useful when completing on things like function names as collecting all the possible candidates can be time consuming. The default value is 200. A value of zero disables tab-completion. Note that setting either no limit or a very large limit can make completion slow.

\texttt{show max-completions}

Show the maximum number of candidates that \texttt{GDB} will collect and show during completion.

Sometimes the string you need, while logically a “word”, may contain parentheses or other characters that \texttt{GDB} normally excludes from its notion of a word. To permit word
completion to work in this situation, you may enclose words in ’ (single quote marks) in GDB commands.

The most likely situation where you might need this is in typing the name of a C++ function. This is because C++ allows function overloading (multiple definitions of the same function, distinguished by argument type). For example, when you want to set a breakpoint you may need to distinguish whether you mean the version of name that takes an int parameter, name(int), or the version that takes a float parameter, name(float). To use the word-completion facilities in this situation, type a single quote ’ at the beginning of the function name. This alerts GDB that it may need to consider more information than usual when you press TAB or M-? to request word completion:

```gdb
(gdb) b 'bubble( M-
  bubble(double,double) bubble(int,int)
(gdb) b 'bubble(
```

In some cases, GDB can tell that completing a name requires using quotes. When this happens, GDB inserts the quote for you (while completing as much as it can) if you do not type the quote in the first place:

```
(gdb) b bub TAB
```

GDB alters your input line to the following, and rings a bell:

```
(gdb) b 'bubble(
```

In general, GDB can tell that a quote is needed (and inserts it) if you have not yet started typing the argument list when you ask for completion on an overloaded symbol.

For more information about overloaded functions, see Section 15.4.1.3 [C++ Expressions], page 194. You can use the command set overload-resolution off to disable overload resolution; see Section 15.4.1.7 [GDB Features for C++], page 195.

When completing in an expression which looks up a field in a structure, GDB also tries\(^1\) to limit completions to the field names available in the type of the left-hand-side:

```
(gdb) p gdb_stdout.M-
magic to_fputs to_rewind
to_data to_isatty to_write
to_delete to_put to_write_async_safe
to_flush to_read
```

This is because the gdb_stdout is a variable of the type struct ui_file that is defined in GDB sources as follows:

```c
struct ui_file
{
    int *magic;
    ui_file_flush_ftype *to_flush;
    ui_file_write_ftype *to_write;
    ui_file_write_async_safe_ftype *to_write_async_safe;
    ui_file_fputs_ftype *to_fputs;
    ui_file_read_ftype *to_read;
    ui_file_delete_ftype *to_delete;
    ui_file_isatty_ftype *to_isatty;
    ui_file_rewind_ftype *to_rewind;
    ui_file_put_ftype *to_put;
    void *to_data;
}
```

---

\(^1\) The completer can be confused by certain kinds of invalid expressions. Also, it only examines the static type of the expression, not the dynamic type.
3.3 Getting Help

You can always ask GDB itself for information on its commands, using the command `help`.

```
(gdb) help
List of classes of commands:

aliases -- Aliases of other commands
breakpoints -- Making program stop at certain points
data -- Examining data
files -- Specifying and examining files
internals -- Maintenance commands
obscure -- Obscure features
running -- Running the program
stack -- Examining the stack
status -- Status inquiries
support -- Support facilities
tracepoints -- Tracing of program execution without
               stopping the program
user-defined -- User-defined commands
```

Type "help" followed by a class name for a list of
commands in that class.
Type "help" followed by command name for full
documentation.
Command name abbreviations are allowed if unambiguous.

```
(gdb)
```

```
(gdb) help status
Status inquiries.

List of commands:

info -- Generic command for showing things
        about the program being debugged
show -- Generic command for showing things
        about the debugger
```

Type "help" followed by command name for full
documentation.
Command name abbreviations are allowed if unambiguous.

```
(gdb)
```

```
(gdb) help command
With a command name as help argument, GDB displays a short paragraph on
how to use that command.
```

```
apropos args
The `apropos` command searches through all of the GDB commands, and their documentation, for the regular expression specified in `args`. It prints out all matches found. For example:

```
apropos alias
```

results in:

```
alias -- Define a new command that is an alias of an existing command
aliases -- Aliases of other commands
d -- Delete some breakpoints or auto-display expressions
del -- Delete some breakpoints or auto-display expressions
delete -- Delete some breakpoints or auto-display expressions
```

complete args
The `complete args` command lists all the possible completions for the beginning of a command. Use `args` to specify the beginning of the command you want completed. For example:

```
complete i
```

results in:

```
if
ignore
info
inspext
```

This is intended for use by GNU Emacs.

In addition to `help`, you can use the GDB commands `info` and `show` to inquire about the state of your program, or the state of GDB itself. Each command supports many topics of inquiry; this manual introduces each of them in the appropriate context. The listings under `info` and under `show` in the Command, Variable, and Function Index point to all the sub-commands. See [Command and Variable Index], page 745.

info
This command (abbreviated `i`) is for describing the state of your program. For example, you can show the arguments passed to a function with `info args`, list the registers currently in use with `info registers`, or list the breakpoints you have set with `info breakpoints`. You can get a complete list of the `info` sub-commands with `help info`.

set
You can assign the result of an expression to an environment variable with `set`. For example, you can set the GDB prompt to a $-sign with `set prompt $`.

show
In contrast to `info`, `show` is for describing the state of GDB itself. You can change most of the things you can `show`, by using the related command `set`; for example, you can control what number system is used for displays with `set radix`, or simply inquire which is currently in use with `show radix`.

To display all the settable parameters and their current values, you can use `show` with no arguments; you may also use `info set`. Both commands produce the same display.

Here are several miscellaneous `show` subcommands, all of which are exceptional in lacking corresponding `set` commands:
show version
Show what version of GDB is running. You should include this information in GDB bug-reports. If multiple versions of GDB are in use at your site, you may need to determine which version of GDB you are running; as GDB evolves, new commands are introduced, and old ones may wither away. Also, many system vendors ship variant versions of GDB, and there are variant versions of GDB in GNU/Linux distributions as well. The version number is the same as the one announced when you start GDB.

show copying
info copying
Display information about permission for copying GDB.

show warranty
info warranty
Display the GNU “NO WARRANTY” statement, or a warranty, if your version of GDB comes with one.

show configuration
Display detailed information about the way GDB was configured when it was built. This displays the optional arguments passed to the ‘configure’ script and also configuration parameters detected automatically by configure. When reporting a GDB bug (see Chapter 31 [GDB Bugs], page 557), it is important to include this information in your report.
Chapter 4: Running Programs Under GDB

4 Running Programs Under GDB

When you run a program under GDB, you must first generate debugging information when you compile it.

You may start GDB with its arguments, if any, in an environment of your choice. If you are doing native debugging, you may redirect your program’s input and output, debug an already running process, or kill a child process.

4.1 Compiling for Debugging

In order to debug a program effectively, you need to generate debugging information when you compile it. This debugging information is stored in the object file; it describes the data type of each variable or function and the correspondence between source line numbers and addresses in the executable code.

To request debugging information, specify the ‘-g’ option when you run the compiler.

Programs that are to be shipped to your customers are compiled with optimizations, using the ‘-O’ compiler option. However, some compilers are unable to handle the ‘-g’ and ‘-O’ options together. Using those compilers, you cannot generate optimized executables containing debugging information.

GCC, the GNU C/C++ compiler, supports ‘-g’ with or without ‘-O’, making it possible to debug optimized code. We recommend that you always use ‘-g’ whenever you compile a program. You may think your program is correct, but there is no sense in pushing your luck. For more information, see Chapter 11 [Optimized Code], page 155.

Older versions of the GNU C compiler permitted a variant option ‘-gg’ for debugging information. GDB no longer supports this format; if your GNU C compiler has this option, do not use it.

GDB knows about preprocessor macros and can show you their expansion (see Chapter 12 [Macros], page 159). Most compilers do not include information about preprocessor macros in the debugging information if you specify the ‘-g’ flag alone. Version 3.1 and later of GCC, the GNU C compiler, provides macro information if you are using the DWARF debugging format, and specify the option ‘-g3’.

See Section “Options for Debugging Your Program or GCC” in Using the GNU Compiler Collection (GCC), for more information on GCC options affecting debug information.

You will have the best debugging experience if you use the latest version of the DWARF debugging format that your compiler supports. DWARF is currently the most expressive and best supported debugging format in GDB.
### 4.2 Starting your Program

`run`  
Use the `run` command to start your program under GDB. You must first specify the program name with an argument to GDB (see Chapter 2 [Getting In and Out of GDB], page 11), or by using the `file` or `exec-file` command (see Section 18.1 [Commands to Specify Files], page 237).

If you are running your program in an execution environment that supports processes, `run` creates an inferior process and makes that process run your program. In some environments without processes, `run` jumps to the start of your program. Other targets, like `remote`, are always running. If you get an error message like this one:

```
The "remote" target does not support "run".
Try "help target" or "continue".
```

then use `continue` to run your program. You may need `load` first (see [load], page 255).

The execution of a program is affected by certain information it receives from its superior. GDB provides ways to specify this information, which you must do before starting your program. (You can change it after starting your program, but such changes only affect your program the next time you start it.) This information may be divided into four categories:

The **arguments**.

Specify the arguments to give your program as the arguments of the `run` command. If a shell is available on your target, the shell is used to pass the arguments, so that you may use normal conventions (such as wildcard expansion or variable substitution) in describing the arguments. In Unix systems, you can control which shell is used with the `SHELL` environment variable. If you do not define `SHELL`, GDB uses the default shell (`/bin/sh`). You can disable use of any shell with the `set startup-with-shell` command (see below for details).

The **environment**.

Your program normally inherits its environment from GDB, but you can use the GDB commands `set environment` and `unset environment` to change parts of the environment that affect your program. See Section 4.4 [Your Program’s Environment], page 30.

The **working directory**.

Your program inherits its working directory from GDB. You can set the GDB working directory with the `cd` command in GDB. See Section 4.5 [Your Program’s Working Directory], page 31.

The **standard input and output**.

Your program normally uses the same device for standard input and standard output as GDB is using. You can redirect input and output in the `run` command line, or you can use the `tty` command to set a different device for your program. See Section 4.6 [Your Program’s Input and Output], page 32.

**Warning:** While input and output redirection work, you cannot use pipes to pass the output of the program you are debugging to another program; if you attempt this, GDB is likely to wind up debugging the wrong program.
When you issue the `run` command, your program begins to execute immediately. See Chapter 5 [Stopping and Continuing], page 45, for discussion of how to arrange for your program to stop. Once your program has stopped, you may call functions in your program, using the print or call commands. See Chapter 10 [Examining Data], page 113.

If the modification time of your symbol file has changed since the last time gdb read its symbols, gdb discards its symbol table, and reads it again. When it does this, gdb tries to retain your current breakpoints.

`start`  The name of the main procedure can vary from language to language. With C or C++, the main procedure name is always `main`, but other languages such as Ada do not require a specific name for their main procedure. The debugger provides a convenient way to start the execution of the program and to stop at the beginning of the main procedure, depending on the language used.

The `start` command does the equivalent of setting a temporary breakpoint at the beginning of the main procedure and then invoking the `run` command.

Some programs contain an elaboration phase where some startup code is executed before the main procedure is called. This depends on the languages used to write your program. In C++, for instance, constructors for static and global objects are executed before main is called. It is therefore possible that the debugger stops before reaching the main procedure. However, the temporary breakpoint will remain to halt execution.

Specify the arguments to give to your program as arguments to the `start` command. These arguments will be given verbatim to the underlying `run` command. Note that the same arguments will be reused if no argument is provided during subsequent calls to `start` or `run`.

It is sometimes necessary to debug the program during elaboration. In these cases, using the `start` command would stop the execution of your program too late, as the program would have already completed the elaboration phase. Under these circumstances, insert breakpoints in your elaboration code before running your program.

```
set exec-wrapper wrapper
show exec-wrapper
unset exec-wrapper
```

When `exec-wrapper` is set, the specified wrapper is used to launch programs for debugging. gdb starts your program with a shell command of the form `exec wrapper program`. Quoting is added to `program` and its arguments, but not to `wrapper`, so you should add quotes if appropriate for your shell. The wrapper runs until it executes your program, and then gdb takes control.

You can use any program that eventually calls execve with its arguments as a wrapper. Several standard Unix utilities do this, e.g. env and nohup. Any Unix shell script ending with `exec "$@"` will also work.

For example, you can use env to pass an environment variable to the debugged program, without setting the variable in your shell’s environment:

```
(gdb) set exec-wrapper env 'LD_PRELOAD=libtest.so'
(gdb) run
```
This command is available when debugging locally on most targets, excluding DJGPP, Cygwin, MS Windows, and QNX Neutrino.

**set startup-with-shell**
**set startup-with-shell on**
**set startup-with-shell off**
**show set startup-with-shell**

On Unix systems, by default, if a shell is available on your target, GDB uses it to start your program. Arguments of the `run` command are passed to the shell, which does variable substitution, expands wildcard characters and performs redirection of I/O. In some circumstances, it may be useful to disable such use of a shell, for example, when debugging the shell itself or diagnosing startup failures such as:

```
(gdb) run
Starting program: ./a.out
During startup program terminated with signal SIGSEGV, Segmentation fault.
```

which indicates the shell or the wrapper specified with `exec-wrapper` crashed, not your program. Most often, this is caused by something odd in your shell’s non-interactive mode initialization file—such as `.cshrc` for C-shell, `$ .zshenv` for the Z shell, or the file specified in the `BASH_ENV` environment variable for BASH.

**set auto-connect-native-target**
**set auto-connect-native-target on**
**set auto-connect-native-target off**
**show auto-connect-native-target**

By default, if not connected to any target yet (e.g., with `target remote`), the `run` command starts your program as a native process under GDB, on your local machine. If you’re sure you don’t want to debug programs on your local machine, you can tell GDB to not connect to the native target automatically with the `set auto-connect-native-target off` command.

If `on`, which is the default, and if GDB is not connected to a target already, the `run` command automatically connects to the native target, if one is available.

If `off`, and if GDB is not connected to a target already, the `run` command fails with an error:

```
(gdb) run
Don't know how to run. Try "help target".
```

If GDB is already connected to a target, GDB always uses it with the `run` command.

In any case, you can explicitly connect to the native target with the `target native` command. For example,

```
(gdb) set auto-connect-native-target off
(gdb) run
Don't know how to run. Try "help target".
(gdb) target native
(gdb) run
Starting program: ./a.out
[Inferior 1 (process 10421) exited normally]`
In case you connected explicitly to the native target, GDB remains connected even if all inferiors exit, ready for the next run command. Use the disconnect command to disconnect.

Examples of other commands that likewise respect the auto-connect-native-target setting: attach, info proc, info os.

**set disable-randomization**

This option (enabled by default in GDB) will turn off the native randomization of the virtual address space of the started program. This option is useful for multiple debugging sessions to make the execution better reproducible and memory addresses reusable across debugging sessions.

This feature is implemented only on certain targets, including GNU/Linux. On GNU/Linux you can get the same behavior using

```
(gdb) set exec-wrapper setarch 'uname -m' -R
```

**set disable-randomization off**

Leave the behavior of the started executable unchanged. Some bugs rear their ugly heads only when the program is loaded at certain addresses. If your bug disappears when you run the program under GDB, that might be because GDB by default disables the address randomization on platforms, such as GNU/Linux, which do that for stand-alone programs. Use **set disable-randomization off** to try to reproduce such elusive bugs.

On targets where it is available, virtual address space randomization protects the programs against certain kinds of security attacks. In these cases the attacker needs to know the exact location of a concrete executable code. Randomizing its location makes it impossible to inject jumps misusing a code at its expected addresses.

Prelinking shared libraries provides a startup performance advantage but it makes addresses in these libraries predictable for privileged processes by having just unprivileged access at the target system. Reading the shared library binary gives enough information for assembling the malicious code misusing it. Still even a prelinked shared library can get loaded at a new random address just requiring the regular relocation process during the startup. Shared libraries not already prelinked are always loaded at a randomly chosen address.

Position independent executables (PIE) contain position independent code similar to the shared libraries and therefore such executables get loaded at a randomly chosen address upon startup. PIE executables always load even already prelinked shared libraries at a random address. You can build such executable using **gcc -fPIE -pie**.

Heap (malloc storage), stack and custom mmap areas are always placed randomly (as long as the randomization is enabled).

**show disable-randomization**

Show the current setting of the explicit disable of the native randomization of the virtual address space of the started program.
4.3 Your Program’s Arguments

The arguments to your program can be specified by the arguments of the run command. They are passed to a shell, which expands wildcard characters and performs redirection of I/O, and thence to your program. Your SHELL environment variable (if it exists) specifies what shell GDB uses. If you do not define SHELL, GDB uses the default shell (’/bin/sh’ on Unix).

On non-Unix systems, the program is usually invoked directly by GDB, which emulates I/O redirection via the appropriate system calls, and the wildcard characters are expanded by the startup code of the program, not by the shell.

run with no arguments uses the same arguments used by the previous run, or those set by the set args command.

set args Specify the arguments to be used the next time your program is run. If set args has no arguments, run executes your program with no arguments. Once you have run your program with arguments, using set args before the next run is the only way to run it again without arguments.

show args Show the arguments to give your program when it is started.

4.4 Your Program’s Environment

The environment consists of a set of environment variables and their values. Environment variables conventionally record such things as your user name, your home directory, your terminal type, and your search path for programs to run. Usually you set up environment variables with the shell and they are inherited by all the other programs you run. When debugging, it can be useful to try running your program with a modified environment without having to start GDB over again.

path directory Add directory to the front of the PATH environment variable (the search path for executables) that will be passed to your program. The value of PATH used by GDB does not change. You may specify several directory names, separated by whitespace or by a system-dependent separator character (’;’ on Unix, ’;’ on MS-DOS and MS-Windows). If directory is already in the path, it is moved to the front, so it is searched sooner.

You can use the string ‘$cwd’ to refer to whatever is the current working directory at the time GDB searches the path. If you use ‘.’ instead, it refers to the directory where you executed the path command. GDB replaces ‘.’ in the directory argument (with the current path) before adding directory to the search path.

show paths Display the list of search paths for executables (the PATH environment variable).

show environment [varname] Print the value of environment variable varname to be given to your program when it starts. If you do not supply varname, print the names and values of all environment variables to be given to your program. You can abbreviate environment as env.
set environment varname [=value]
Set environment variable varname to value. The value changes for your program (and the shell GDB uses to launch it), not for GDB itself. The value may be any string; the values of environment variables are just strings, and any interpretation is supplied by your program itself. The value parameter is optional; if it is eliminated, the variable is set to a null value.

For example, this command:

```plaintext
set env USER = foo
```

tells the debugged program, when subsequently run, that its user is named ‘foo’. (The spaces around ‘=’ are used for clarity here; they are not actually required.)

Note that on Unix systems, GDB runs your program via a shell, which also inherits the environment set with `set environment`. If necessary, you can avoid that by using the ‘env’ program as a wrapper instead of using `set environment`. See [set exec-wrapper], page 27, for an example doing just that.

unset environment varname
Remove variable varname from the environment to be passed to your program. This is different from `set env varname =`; `unset environment` removes the variable from the environment, rather than assigning it an empty value.

**Warning:** On Unix systems, GDB runs your program using the shell indicated by your SHELL environment variable if it exists (or `/bin/sh` if not). If your SHELL variable names a shell that runs an initialization file when started non-interactively—such as ‘.cshrc’ for C-shell, ‘.zshenv’ for the Z shell, or the file specified in the ‘BASH_ENV’ environment variable for BASH—any variables you set in that file affect your program. You may wish to move setting of environment variables to files that are only run when you sign on, such as ‘.login’ or ‘.profile’.

### 4.5 Your Program’s Working Directory

Each time you start your program with `run`, it inherits its working directory from the current working directory of GDB. The GDB working directory is initially whatever it inherited from its parent process (typically the shell), but you can specify a new working directory in GDB with the `cd` command.

The GDB working directory also serves as a default for the commands that specify files for GDB to operate on. See Section 18.1 [Commands to Specify Files], page 237.

```plaintext
cd [directory]
```
Set the GDB working directory to directory. If not given, directory uses ‘~’.

```plaintext
pwd
```
Print the GDB working directory.

It is generally impossible to find the current working directory of the process being debugged (since a program can change its directory during its run). If you work on a system where GDB is configured with the ‘/proc’ support, you can use the `info proc` command (see Section 21.1.3 [SVR4 Process Information], page 275) to find out the current working directory of the debuggee.
4.6 Your Program’s Input and Output

By default, the program you run under GDB does input and output to the same terminal that GDB uses. GDB switches the terminal to its own terminal modes to interact with you, but it records the terminal modes your program was using and switches back to them when you continue running your program.

`info terminal`

Displays information recorded by GDB about the terminal modes your program is using.

You can redirect your program’s input and/or output using shell redirection with the `run` command. For example,

```
run > outfile
```

starts your program, diverting its output to the file ‘outfile’.

Another way to specify where your program should do input and output is with the `tty` command. This command accepts a file name as argument, and causes this file to be the default for future `run` commands. It also resets the controlling terminal for the child process, for future `run` commands. For example,

```
tty /dev/ttyb
```

directs that processes started with subsequent `run` commands default to do input and output on the terminal ‘/dev/ttyb’ and have that as their controlling terminal.

An explicit redirection in `run` overrides the `tty` command’s effect on the input/output device, but not its effect on the controlling terminal.

When you use the `tty` command or redirect input in the `run` command, only the input for your program is affected. The input for GDB still comes from your terminal. `tty` is an alias for `set inferior-tty`.

You can use the `show inferior-tty` command to tell GDB to display the name of the terminal that will be used for future runs of your program.

```
set inferior-tty /dev/ttyb
```

Set the tty for the program being debugged to /dev/ttyb.

```
show inferior-tty
```

Show the current tty for the program being debugged.

4.7 Debugging an Already-running Process

`attach process-id`

This command attaches to a running process—one that was started outside GDB. (`info files` shows your active targets.) The command takes as argument a process ID. The usual way to find out the process-id of a Unix process is with the `ps` utility, or with the `jobs -l` shell command.

`attach` does not repeat if you press `RET` a second time after executing the command.

To use `attach`, your program must be running in an environment which supports processes; for example, `attach` does not work for programs on bare-board targets that lack an operating system. You must also have permission to send the process a signal.
When you use `attach`, the debugger finds the program running in the process first by looking in the current working directory, then (if the program is not found) by using the source file search path (see Section 9.5 [Specifying Source Directories], page 105). You can also use the `file` command to load the program. See Section 18.1 [Commands to Specify Files], page 237.

The first thing GDB does after arranging to debug the specified process is to stop it. You can examine and modify an attached process with all the GDB commands that are ordinarily available when you start processes with `run`. You can insert breakpoints; you can step and continue; you can modify storage. If you would rather the process continue running, you may use the `continue` command after attaching GDB to the process.

`detach` When you have finished debugging the attached process, you can use the `detach` command to release it from GDB control. Detaching the process continues its execution. After the `detach` command, that process and GDB become completely independent once more, and you are ready to `attach` another process or start one with `run`. `detach` does not repeat if you press RET again after executing the command.

If you exit GDB while you have an attached process, you detach that process. If you use the `run` command, you kill that process. By default, GDB asks for confirmation if you try to do either of these things; you can control whether or not you need to confirm by using the `set confirm` command (see Section 22.8 [Optional Warnings and Messages], page 307).

### 4.8 Killing the Child Process

`kill` Kill the child process in which your program is running under GDB.

This command is useful if you wish to debug a core dump instead of a running process. GDB ignores any core dump file while your program is running.

On some operating systems, a program cannot be executed outside GDB while you have breakpoints set on it inside GDB. You can use the `kill` command in this situation to permit running your program outside the debugger.

The `kill` command is also useful if you wish to recompile and relink your program, since on many systems it is impossible to modify an executable file while it is running in a process. In this case, when you next type `run`, GDB notices that the file has changed, and reads the symbol table again (while trying to preserve your current breakpoint settings).

### 4.9 Debugging Multiple Inferiors and Programs

GDB lets you run and debug multiple programs in a single session. In addition, GDB on some systems may let you run several programs simultaneously (otherwise you have to exit from one before starting another). In the most general case, you can have multiple threads of execution in each of multiple processes, launched from multiple executables.

GDB represents the state of each program execution with an object called an `inferior`. An inferior typically corresponds to a process, but is more general and applies also to targets that do not have processes. Inferiors may be created before a process runs, and may be retained after a process exits. Inferiors have unique identifiers that are different from process ids. Usually each inferior will also have its own distinct address space, although
some embedded targets may have several inferiors running in different parts of a single address space. Each inferior may in turn have multiple threads running in it.

To find out what inferiors exist at any moment, use `info inferiors`:

**info inferiors**

Print a list of all inferiors currently being managed by GDB.

GDB displays for each inferior (in this order):

1. the inferior number assigned by GDB
2. the target system’s inferior identifier
3. the name of the executable the inferior is running.

An asterisk '*' preceding the GDB inferior number indicates the current inferior.

For example,

```
(gdb) info inferiors
  Num Description Executable
  2  process 2307  hello
*  1  process 3401  goodbye
```

To switch focus between inferiors, use the `inferior` command:

**inferior infno**

Make inferior number `infno` the current inferior. The argument `infno` is the inferior number assigned by GDB, as shown in the first field of the `info inferiors` display.

You can get multiple executables into a debugging session via the `add-inferior` and `clone-inferior` commands. On some systems GDB can add inferiors to the debug session automatically by following calls to `fork` and `exec`. To remove inferiors from the debugging session use the `remove-inferiors` command.

**add-inferior [ -copies n ] [ -exec executable ]**

Adds `n` inferiors to be run using `executable` as the executable; `n` defaults to 1. If no executable is specified, the inferiors begins empty, with no program. You can still assign or change the program assigned to the inferior at any time by using the `file` command with the executable name as its argument.

**clone-inferior [ -copies n ] [ infno ]**

Adds `n` inferiors ready to execute the same program as inferior `infno`; `n` defaults to 1, and `infno` defaults to the number of the current inferior. This is a convenient command when you want to run another instance of the inferior you are debugging.

```
(gdb) info inferiors
  Num Description Executable
  *  1  process 29964  helloworld
(gdb) clone-inferior
  Added inferior 2.
  1 inferiors added.
(gdb) info inferiors
  Num Description Executable
  2  <null>          helloworld
  *  1  process 29964  helloworld
```

You can now simply switch focus to inferior 2 and run it.
remove-inferiors infno...

   Removes the inferior or inferiors infno.... It is not possible to remove an
   inferior that is running with this command. For those, use the kill or detach
   command first.

   To quit debugging one of the running inferiors that is not the current inferior, you
   can either detach from it by using the detach inferior command (allowing it to run
   independently), or kill it using the kill inferiors command:

   detach inferior infno...
   Detach from the inferior or inferiors identified by GDB inferior number(s)
   infno.... Note that the inferior's entry still stays on the list of inferiors shown
   by info inferiors, but its Description will show ‘<null>’.

   kill inferiors infno...
   Kill the inferior or inferiors identified by GDB inferior number(s) infno....
   Note that the inferior’s entry still stays on the list of inferiors shown by info
   inferiors, but its Description will show ‘<null>’.

   After the successful completion of a command such as detach, detach inferiors, kill
   or kill inferiors, or after a normal process exit, the inferior is still valid and listed with
   info inferiors, ready to be restarted.

   To be notified when inferiors are started or exit under GDB’s control use
   set print inferior-events:

   set print inferior-events
   set print inferior-events on
   set print inferior-events off
   The set print inferior-events command allows you to enable or disable
   printing of messages when GDB notices that new inferiors have started or that
   inferiors have exited or have been detached. By default, these messages will
   not be printed.

   show print inferior-events
   Show whether messages will be printed when GDB detects that inferiors have
   started, exited or have been detached.

   Many commands will work the same with multiple programs as with a single program:
   e.g., print myglobal will simply display the value of myglobal in the current inferior.

   Occasionally, when debugging GDB itself, it may be useful to get more info about the
   relationship of inferiors, programs, address spaces in a debug session. You can do that with
   the maint info program-spaces command.

   maint info program-spaces
   Print a list of all program spaces currently being managed by GDB.
   GDB displays for each program space (in this order):
   1. the program space number assigned by GDB
   2. the name of the executable loaded into the program space, with e.g., the
      file command.
An asterisk ‘*’ preceding the GDB program space number indicates the current program space.

In addition, below each program space line, GDB prints extra information that isn’t suitable to display in tabular form. For example, the list of inferiors bound to the program space.

```
(gdb) maint info program-spaces
   Id  Executable
   2   goodbye
   * 1   hello

   Bound inferiors: ID 1 (process 21561)
```

Here we can see that no inferior is running the program hello, while process 21561 is running the program goodbye. On some targets, it is possible that multiple inferiors are bound to the same program space. The most common example is that of debugging both the parent and child processes of a vfork call. For example,

```
(gdb) maint info program-spaces
   Id  Executable
   * 1   vfork-test
   
   Bound inferiors: ID 2 (process 18050), ID 1 (process 18045)
```

Here, both inferior 2 and inferior 1 are running in the same program space as a result of inferior 1 having executed a vfork call.

### 4.10 Debugging Programs with Multiple Threads

In some operating systems, such as HP-UX and Solaris, a single program may have more than one thread of execution. The precise semantics of threads differ from one operating system to another, but in general the threads of a single program are akin to multiple processes—except that they share one address space (that is, they can all examine and modify the same variables). On the other hand, each thread has its own registers and execution stack, and perhaps private memory.

GDB provides these facilities for debugging multi-thread programs:

- automatic notification of new threads
- ‘thread threadno’, a command to switch among threads
- ‘info threads’, a command to inquire about existing threads
- ‘thread apply [threadno] [all] args’, a command to apply a command to a list of threads
- thread-specific breakpoints
- ‘set print thread-events’, which controls printing of messages on thread start and exit.
- ‘set libthread-db-search-path path’, which lets the user specify which libthread_db to use if the default choice isn’t compatible with the program.

**Warning:** These facilities are not yet available on every GDB configuration where the operating system supports threads. If your GDB does not support threads, these commands have no effect. For example, a system without thread support shows no output from ‘info threads’, and always rejects the thread command, like this:
(gdb) info threads
(gdb) thread 1
Thread ID 1 not known. Use the "info threads" command to see the IDs of currently known threads.

The GDB thread debugging facility allows you to observe all threads while your program runs—but whenever GDB takes control, one thread in particular is always the focus of debugging. This thread is called the current thread. Debugging commands show program information from the perspective of the current thread.

Whenever GDB detects a new thread in your program, it displays the target system’s identification for the thread with a message in the form ‘[New systag]’, where systag is a thread identifier whose form varies depending on the particular system. For example, on GNU/Linux, you might see

[New Thread 0x41e02940 (LWP 25582)]

when GDB notices a new thread. In contrast, on an SGI system, the systag is simply something like 'process 368', with no further qualifier.

For debugging purposes, GDB associates its own thread number—always a single integer—with each thread in your program.

```
info threads [id...]
```

Display a summary of all threads currently in your program. Optional argument id... is one or more thread ids separated by spaces, and means to print information only about the specified thread or threads. GDB displays for each thread (in this order):

1. the thread number assigned by GDB
2. the target system’s thread identifier (systag)
3. the thread’s name, if one is known. A thread can either be named by the user (see thread name, below), or, in some cases, by the program itself.
4. the current stack frame summary for that thread

An asterisk ‘*’ to the left of the GDB thread number indicates the current thread.

For example,

```
(gdb) info threads
Id  Target Id  Frame
 3  process 35 thread 27  0x34e5 in sigpause ()
 2  process 35 thread 23  0x34e5 in sigpause ()
* 1  process 35 thread 13  main (argc=1, argv=0x7fffffff8)
    at threadtest.c:68
```

On Solaris, you can display more information about user threads with a Solaris-specific command:

```
maint info sol-threads
```

Display info on Solaris user threads.

```
thread threadno
```

Make thread number threadno the current thread. The command argument threadno is the internal GDB thread number, as shown in the first field of the ‘info threads’ display. GDB responds by displaying the system identifier of the thread you selected, and its current stack frame summary:
Debugging with gdb

(gdb) thread 2
[Switching to thread 2 (Thread 0xb7fdab70 (LWP 12747))]#0 some_function (ignore=0x0) at example.c:8
8 printf ("hello\n");

As with the ‘[New ...]’ message, the form of the text after ‘Switching to’ depends on your system’s conventions for identifying threads.

The debugger convenience variable ‘$_thread’ contains the number of the current thread. You may find this useful in writing breakpoint conditional expressions, command scripts, and so forth. See Section 10.11 [Convenience Variables], page 137, for general information on convenience variables.

thread apply [threadno | all [-ascending]] command

The thread apply command allows you to apply the named command to one or more threads. Specify the numbers of the threads that you want affected with the command argument threadno. It can be a single thread number, one of the numbers shown in the first field of the ‘info threads’ display; or it could be a range of thread numbers, as in 2-4. To apply a command to all threads in descending order, type thread apply all command. To apply a command to all threads in ascending order, type thread apply all -ascending command.

thread name [name]

This command assigns a name to the current thread. If no argument is given, any existing user-specified name is removed. The thread name appears in the ‘info threads’ display.

On some systems, such as GNU/Linux, GDB is able to determine the name of the thread as given by the OS. On these systems, a name specified with ‘thread name’ will override the system-give name, and removing the user-specified name will cause GDB to once again display the system-specified name.

thread find [regexp]

Search for and display thread ids whose name or systag matches the supplied regular expression.

As well as being the complement to the ‘thread name’ command, this command also allows you to identify a thread by its target systag. For instance, on GNU/Linux, the target systag is the LWP id.

set print thread-events
set print thread-events on
set print thread-events off

The set print thread-events command allows you to enable or disable printing of messages when GDB notices that new threads have started or that threads have exited. By default, these messages will be printed if detection of these events is supported by the target. Note that these messages cannot be disabled on all targets.
show print thread-events
Show whether messages will be printed when GDB detects that threads have started and exited.

See Section 5.5 [Stopping and Starting Multi-thread Programs], page 75, for more information about how GDB behaves when you stop and start programs with multiple threads.

See Section 5.1.2 [Setting Watchpoints], page 52, for information about watchpoints in programs with multiple threads.

set libthread-db-search-path [path]
If this variable is set, path is a colon-separated list of directories GDB will use to search for libthread_db. If you omit path, ‘libthread-db-search-path’ will be reset to its default value ($sdir:$pdir on GNU/Linux and Solaris systems). Internally, the default value comes from the LIBTHREAD_DB_SEARCH_PATH macro.

On GNU/Linux and Solaris systems, GDB uses a “helper” libthread_db library to obtain information about threads in the inferior process. GDB will use ‘libthread-db-search-path’ to find libthread_db. GDB also consults first if inferior specific thread debugging library loading is enabled by ‘set auto-load libthread-db’ (see Section 22.7.2 [libthread_db.so.1 file], page 304).

A special entry ‘$sdir’ for ‘libthread-db-search-path’ refers to the default system directories that are normally searched for loading shared libraries. The ‘$sdir’ entry is the only kind not needing to be enabled by ‘set auto-load libthread-db’ (see Section 22.7.2 [libthread_db.so.1 file], page 304).

A special entry ‘$pdir’ for ‘libthread-db-search-path’ refers to the directory from which libpthread was loaded in the inferior process.

For any libthread_db library GDB finds in above directories, GDB attempts to initialize it with the current inferior process. If this initialization fails (which could happen because of a version mismatch between libthread_db and libpthread), GDB will unload libthread_db, and continue with the next directory. If none of libthread_db libraries initialize successfully, GDB will issue a warning and thread debugging will be disabled.

Setting libthread-db-search-path is currently implemented only on some platforms.

show libthread-db-search-path
Display current libthread_db search path.

set debug libthread-db
show debug libthread-db
Turns on or off display of libthread_db-related events. Use 1 to enable, 0 to disable.

4.11 Debugging Forks
On most systems, GDB has no special support for debugging programs which create additional processes using the fork function. When a program forks, GDB will continue to debug the parent process and the child process will run unimpeded. If you have set a breakpoint
in any code which the child then executes, the child will get a SIGTRAP signal which (unless it catches the signal) will cause it to terminate.

However, if you want to debug the child process there is a workaround which isn’t too painful. Put a call to sleep in the code which the child process executes after the fork. It may be useful to sleep only if a certain environment variable is set, or a certain file exists, so that the delay need not occur when you don’t want to run GDB on the child. While the child is sleeping, use the ps program to get its process ID. Then tell GDB (a new invocation of GDB if you are also debugging the parent process) to attach to the child process (see Section 4.7 [Attach], page 32). From that point on you can debug the child process just like any other process which you attached to.

On some systems, GDB provides support for debugging programs that create additional processes using the fork or vfork functions. Currently, the only platforms with this feature are HP-UX (11.x and later only?) and GNU/Linux (kernel version 2.5.60 and later).

The fork debugging commands are supported in both native mode and when connected to gdbserver using target extended-remote.

By default, when a program forks, GDB will continue to debug the parent process and the child process will run unimpeded.

If you want to follow the child process instead of the parent process, use the command set follow-fork-mode.

set follow-fork-mode mode
Set the debugger response to a program call of fork or vfork. A call to fork or vfork creates a new process. The mode argument can be:

parent The original process is debugged after a fork. The child process runs unimpeded. This is the default.

child The new process is debugged after a fork. The parent process runs unimpeded.

show follow-fork-mode
Display the current debugger response to a fork or vfork call.

On Linux, if you want to debug both the parent and child processes, use the command set detach-on-fork.

set detach-on-fork mode
Tell GDB whether to detach one of the processes after a fork, or retain debugger control over them both.

on The child process (or parent process, depending on the value of follow-fork-mode) will be detached and allowed to run independently. This is the default.

off Both processes will be held under the control of GDB. One process (child or parent, depending on the value of follow-fork-mode) is debugged as usual, while the other is held suspended.

show detach-on-fork
Show whether detach-on-fork mode is on/off.
If you choose to set ‘detach-on-fork’ mode off, then GDB will retain control of all forked processes (including nested forks). You can list the forked processes under the control of GDB by using the info inferiors command, and switch from one fork to another by using the inferior command (see Section 4.9 [Debugging Multiple Inferiors and Programs], page 33).

To quit debugging one of the forked processes, you can either detach from it by using the detach inferiors command (allowing it to run independently), or kill it using the kill inferiors command. See Section 4.9 [Debugging Multiple Inferiors and Programs], page 33.

If you ask to debug a child process and a vfork is followed by an exec, GDB executes the new target up to the first breakpoint in the new target. If you have a breakpoint set on main in your original program, the breakpoint will also be set on the child process’s main.

On some systems, when a child process is spawned by vfork, you cannot debug the child or parent until an exec call completes.

If you issue a run command to GDB after an exec call executes, the new target restarts. To restart the parent process, use the file command with the parent executable name as its argument. By default, after an exec call executes, GDB discards the symbols of the previous executable image. You can change this behaviour with the set follow-exec-mode command.

set follow-exec-mode mode
Set debugger response to a program call of exec. An exec call replaces the program image of a process.
follow-exec-mode can be:

new GDB creates a new inferior and rebinds the process to this new inferior. The program the process was running before the exec call can be restarted afterwards by restarting the original inferior.

For example:
```
(gdb) info inferiors
(gdb) info inferior
  Id  Description  Executable
* 1  <null>      prog1
(gdb) run
process 12020 is executing new program: prog2
Program exited normally.
(gdb) info inferiors
  Id  Description  Executable
* 2  <null>      prog2
1   <null>      prog1
```

same GDB keeps the process bound to the same inferior. The new executable image replaces the previous executable loaded in the inferior. Restarting the inferior after the exec call, with e.g., the run command, restarts the executable the process was running after the exec call. This is the default mode.

For example:
```
(gdb) info inferiors
  Id  Description  Executable
* 1  <null>      prog1
(gdb) run
```
process 12020 is executing new program: prog2
Program exited normally.
(gdb) info inferiors
    Id  Description   Executable
* 1     <null>     prog2

You can use the catch command to make gdb stop whenever a fork, vfork, or exec call is made. See Section 5.1.3 [Setting Catchpoints], page 55.

4.12 Setting a Bookmark to Return to Later

On certain operating systems\(^1\), gdb is able to save a snapshot of a program’s state, called a checkpoint, and come back to it later.

Returning to a checkpoint effectively undoes everything that has happened in the program since the checkpoint was saved. This includes changes in memory, registers, and even (within some limits) system state. Effectively, it is like going back in time to the moment when the checkpoint was saved.

Thus, if you’re stepping thru a program and you think you’re getting close to the point where things go wrong, you can save a checkpoint. Then, if you accidentally go too far and miss the critical statement, instead of having to restart your program from the beginning, you can just go back to the checkpoint and start again from there.

This can be especially useful if it takes a lot of time or steps to reach the point where you think the bug occurs.

To use the checkpoint/restart method of debugging:

`checkpoint`

Save a snapshot of the debugged program’s current execution state. The checkpoint command takes no arguments, but each checkpoint is assigned a small integer id, similar to a breakpoint id.

`info checkpoints`

List the checkpoints that have been saved in the current debugging session. For each checkpoint, the following information will be listed:

- Checkpoint ID
- Process ID
- Code Address
- Source line, or label

`restart checkpoint-id`

Restore the program state that was saved as checkpoint number checkpoint-id. All program variables, registers, stack frames etc. will be returned to the values that they had when the checkpoint was saved. In essence, gdb will “wind back the clock” to the point in time when the checkpoint was saved.

Note that breakpoints, gdb variables, command history etc. are not affected by restoring a checkpoint. In general, a checkpoint only restores things that reside in the program being debugged, not in the debugger.

\(^1\) Currently, only GNU/Linux.
delete checkpoint \textit{checkpoint-id}

Delete the previously-saved checkpoint identified by \textit{checkpoint-id}.

Returning to a previously saved checkpoint will restore the user state of the program
being debugged, plus a significant subset of the system (OS) state, including file pointers. It
won’t “un-write” data from a file, but it will rewind the file pointer to the previous location,
so that the previously written data can be overwritten. For files opened in read mode, the
pointer will also be restored so that the previously read data can be read again.

Of course, characters that have been sent to a printer (or other external device) cannot
be “snatched back”, and characters received from eg. a serial device can be removed from
internal program buffers, but they cannot be “pushed back” into the serial pipeline, ready
to be received again. Similarly, the actual contents of files that have been changed cannot
be restored (at this time).

However, within those constraints, you actually can “rewind” your program to a previ-
ously saved point in time, and begin debugging it again — and you can change the course
of events so as to debug a different execution path this time.

Finally, there is one bit of internal program state that will be different when you return
to a checkpoint — the program’s process id. Each checkpoint will have a unique process id
(or \textit{pid}), and each will be different from the program’s original \textit{pid}. If your program has
saved a local copy of its process id, this could potentially pose a problem.

\subsection{4.12.1 A Non-obvious Benefit of Using Checkpoints}

On some systems such as GNU/Linux, address space randomization is performed on new
processes for security reasons. This makes it difficult or impossible to set a breakpoint, or
watchpoint, on an absolute address if you have to restart the program, since the absolute
location of a symbol will change from one execution to the next.

A checkpoint, however, is an \textit{identical} copy of a process. Therefore if you create a
checkpoint at (eg.) the start of main, and simply return to that checkpoint instead of
restarting the process, you can avoid the effects of address randomization and your symbols
will all stay in the same place.
5 Stopping and Continuing

The principal purposes of using a debugger are so that you can stop your program before it terminates; or so that, if your program runs into trouble, you can investigate and find out why.

Inside GDB, your program may stop for any of several reasons, such as a signal, a breakpoint, or reaching a new line after a GDB command such as `step`. You may then examine and change variables, set new breakpoints or remove old ones, and then continue execution. Usually, the messages shown by GDB provide ample explanation of the status of your program—but you can also explicitly request this information at any time.

`info program`

Display information about the status of your program: whether it is running or not, what process it is, and why it stopped.

5.1 Breakpoints, Watchpoints, and Catchpoints

A breakpoint makes your program stop whenever a certain point in the program is reached. For each breakpoint, you can add conditions to control in finer detail whether your program stops. You can set breakpoints with the `break` command and its variants (see Section 5.1.1 [Setting Breakpoints], page 46), to specify the place where your program should stop by line number, function name or exact address in the program.

On some systems, you can set breakpoints in shared libraries before the executable is run. There is a minor limitation on HP-UX systems: you must wait until the executable is run in order to set breakpoints in shared library routines that are not called directly by the program (for example, routines that are arguments in a `pthread_create` call).

A watchpoint is a special breakpoint that stops your program when the value of an expression changes. The expression may be a value of a variable, or it could involve values of one or more variables combined by operators, such as `a + b`. This is sometimes called data breakpoints. You must use a different command to set watchpoints (see Section 5.1.2 [Setting Watchpoints], page 52), but aside from that, you can manage a watchpoint like any other breakpoint: you enable, disable, and delete both breakpoints and watchpoints using the same commands.

You can arrange to have values from your program displayed automatically whenever GDB stops at a breakpoint. See Section 10.7 [Automatic Display], page 124.

A catchpoint is another special breakpoint that stops your program when a certain kind of event occurs, such as the throwing of a C++ exception or the loading of a library. As with watchpoints, you use a different command to set a catchpoint (see Section 5.1.3 [Setting Catchpoints], page 55), but aside from that, you can manage a catchpoint like any other breakpoint: you enable, disable, and delete both breakpoints and watchpoints using the same commands.

GDB assigns a number to each breakpoint, watchpoint, or catchpoint when you create it; these numbers are successive integers starting with one. In many of the commands for controlling various features of breakpoints you use the breakpoint number to say which breakpoint you want to change. Each breakpoint may be `enabled` or `disabled`; if disabled, it has no effect on your program until you enable it again.
Some GDB commands accept a range of breakpoints on which to operate. A breakpoint range is either a single breakpoint number, like ‘5’, or two such numbers, in increasing order, separated by a hyphen, like ‘5-7’. When a breakpoint range is given to a command, all breakpoints in that range are operated on.

### 5.1.1 Setting Breakpoints

Breakpoints are set with the `break` command (abbreviated `b`). The debugger convenience variable ‘$bpnum’ records the number of the breakpoint you’ve set most recently; see Section 10.11 [Convenience Variables], page 137, for a discussion of what you can do with convenience variables.

**break location**

Set a breakpoint at the given `location`, which can specify a function name, a line number, or an address of an instruction. (See Section 9.2 [Specify Location], page 102, for a list of all the possible ways to specify a `location`.) The breakpoint will stop your program just before it executes any of the code in the specified `location`.

When using source languages that permit overloading of symbols, such as C++, a function name may refer to more than one possible place to break. See Section 10.2 [Ambiguous Expressions], page 116, for a discussion of that situation.

It is also possible to insert a breakpoint that will stop the program only if a specific thread (see Section 5.5.4 [Thread-Specific Breakpoints], page 79) or a specific task (see Section 15.4.9.6 [Ada Tasks], page 210) hits that breakpoint.

**break**

When called without any arguments, `break` sets a breakpoint at the next instruction to be executed in the selected stack frame (see Chapter 8 [Examining the Stack], page 93). In any selected frame but the innermost, this makes your program stop as soon as control returns to that frame. This is similar to the effect of a `finish` command in the frame inside the selected frame—except that `finish` does not leave an active breakpoint. If you use `break` without an argument in the innermost frame, GDB stops the next time it reaches the current location; this may be useful inside loops.

GDB normally ignores breakpoints when it resumes execution, until at least one instruction has been executed. If it did not do this, you would be unable to proceed past a breakpoint without first disabling the breakpoint. This rule applies whether or not the breakpoint already existed when your program stopped.

**break ... if cond**

Set a breakpoint with condition `cond`; evaluate the expression `cond` each time the breakpoint is reached, and stop only if the value is nonzero—that is, if `cond` evaluates as true. ‘...’ stands for one of the possible arguments described above (or no argument) specifying where to break. See Section 5.1.6 [Break Conditions], page 60, for more information on breakpoint conditions.

**tbreak args**

Set a breakpoint enabled only for one stop. The `args` are the same as for the `break` command, and the breakpoint is set in the same way, but the breakpoint
is automatically deleted after the first time your program stops there. See Section 5.1.5 [Disabling Breakpoints], page 59.

**hbreak** **args**

Set a hardware-assisted breakpoint. The **args** are the same as for the **break** command and the breakpoint is set in the same way, but the breakpoint requires hardware support and some target hardware may not have this support. The main purpose of this is EPROM/ROM code debugging, so you can set a breakpoint at an instruction without changing the instruction. This can be used with the new trap-generation provided by SPARClite DSU and most x86-based targets. These targets will generate traps when a program accesses some data or instruction address that is assigned to the debug registers. However the hardware breakpoint registers can take a limited number of breakpoints. For example, on the DSU, only two data breakpoints can be set at a time, and GDB will reject this command if more than two are used. Delete or disable unused hardware breakpoints before setting new ones (see Section 5.1.5 [Disabling Breakpoints], page 59). See also Section 5.1.6 [Break Conditions], page 60.

**thbreak** **args**

Set a hardware-assisted breakpoint enabled only for one stop. The **args** are the same as for the **hbreak** command and the breakpoint is set in the same way. However, like the **tbreak** command, the breakpoint is automatically deleted after the first time your program stops there. Also, like the **hbreak** command, the breakpoint requires hardware support and some target hardware may not have this support. See Section 5.1.5 [Disabling Breakpoints], page 59. See also Section 5.1.6 [Break Conditions], page 60.

**rbreak** **regex**

Set breakpoints on all functions matching the regular expression **regex**. This command sets an unconditional breakpoint on all matches, printing a list of all breakpoints it set. Once these breakpoints are set, they are treated just like the breakpoints set with the **break** command. You can delete them, disable them, or make them conditional the same way as any other breakpoint.

The syntax of the regular expression is the standard one used with tools like `grep`. Note that this is different from the syntax used by shells, so for instance `foo*` matches all functions that include an `fo` followed by zero or more `os`. There is an implicit `.*` leading and trailing the regular expression you supply, so to match only functions that begin with `foo`, use `^foo`.

When debugging C++ programs, **rbreak** is useful for setting breakpoints on overloaded functions that are not members of any special classes.

The **rbreak** command can be used to set breakpoints in **all** the functions in a program, like this:

```
(gdb) rbreak .
```
**rbreak file:regex**

If `rbreak` is called with a filename qualification, it limits the search for functions matching the given regular expression to the specified file. This can be used, for example, to set breakpoints on every function in a given file:

```plaintext
(gdb) rbreak file.c:.
```

The colon separating the filename qualifier from the regex may optionally be surrounded by spaces.

**info breakpoints [n...]**  
**info break [n...]**

Print a table of all breakpoints, watchpoints, and catchpoints set and not deleted. Optional argument `n` means print information only about the specified breakpoint(s) (or watchpoint(s) or catchpoint(s)). For each breakpoint, following columns are printed:

- **Breakpoint Numbers**
- **Type**   Breakpoint, watchpoint, or catchpoint.
- **Disposition** Whether the breakpoint is marked to be disabled or deleted when hit.
- **Enabled or Disabled** Enabled breakpoints are marked with ‘y’. ‘n’ marks breakpoints that are not enabled.
- **Address** Where the breakpoint is in your program, as a memory address. For a pending breakpoint whose address is not yet known, this field will contain ‘<PENDING>’.
- **What** Where the breakpoint is in the source for your program, as a file and line number. For a pending breakpoint, the original string passed to the breakpoint command will be listed as it cannot be resolved until the appropriate shared library is loaded in the future.

If a breakpoint is conditional, there are two evaluation modes: “host” and “target”. If mode is “host”, breakpoint condition evaluation is done by GDB on the host’s side. If it is “target”, then the condition is evaluated by the target. The `info break` command shows the condition on the line following the affected breakpoint, together with its condition evaluation mode in between parentheses.

Breakpoint commands, if any, are listed after that. A pending breakpoint is allowed to have a condition specified for it. The condition is not parsed for validity until a shared library is loaded that allows the pending breakpoint to resolve to a valid location.

`info break` with a breakpoint number `n` as argument lists only that breakpoint. The convenience variable `$_` and the default examining-address for the `x` command are set to the address of the last breakpoint listed (see Section 10.6 [Examining Memory], page 121).
**info break** displays a count of the number of times the breakpoint has been hit. This is especially useful in conjunction with the **ignore** command. You can ignore a large number of breakpoint hits, look at the breakpoint info to see how many times the breakpoint was hit, and then run again, ignoring one less than that number. This will get you quickly to the last hit of that breakpoint.

For a breakpoints with an enable count (xref) greater than 1, **info break** also displays that count.

**GDB** allows you to set any number of breakpoints at the same place in your program. There is nothing silly or meaningless about this. When the breakpoints are conditional, this is even useful (see Section 5.1.6 [Break Conditions], page 60).

It is possible that a breakpoint corresponds to several locations in your program. Examples of this situation are:

- Multiple functions in the program may have the same name.
- For a C++ constructor, the **gcc** compiler generates several instances of the function body, used in different cases.
- For a C++ template function, a given line in the function can correspond to any number of instantiations.
- For an inlined function, a given source line can correspond to several places where that function is inlined.

In all those cases, **GDB** will insert a breakpoint at all the relevant locations.

A breakpoint with multiple locations is displayed in the breakpoint table using several rows—one header row, followed by one row for each breakpoint location. The header row has ‘<MULTIPLE>’ in the address column. The rows for individual locations contain the actual addresses for locations, and show the functions to which those locations belong. The number column for a location is of the form `breakpoint-number.location-number`.

For example:

```
<table>
<thead>
<tr>
<th>Num</th>
<th>Type</th>
<th>Disp</th>
<th>Enb</th>
<th>Address</th>
<th>What</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>breakpoint</td>
<td>keep</td>
<td>y</td>
<td>&lt;MULTIPLE&gt;</td>
<td>stop only if i==1</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>breakpoint already hit 1 time</td>
</tr>
<tr>
<td>1.1</td>
<td>y</td>
<td></td>
<td></td>
<td>0x080486a2 in void foo&lt;int&gt;() at t.cc:8</td>
<td></td>
</tr>
<tr>
<td>1.2</td>
<td>y</td>
<td></td>
<td></td>
<td>0x080486ca in void foo&lt;double&gt;() at t.cc:8</td>
<td></td>
</tr>
</tbody>
</table>
```

Each location can be individually enabled or disabled by passing `breakpoint-number.location-number` as argument to the **enable** and **disable** commands. Note that you cannot delete the individual locations from the list, you can only delete the entire list of locations that belong to their parent breakpoint (with the **delete num** command, where `num` is the number of the parent breakpoint, 1 in the above example). Disabling or enabling the parent breakpoint (see Section 5.1.5 [Disabling], page 59) affects all of the locations that belong to that breakpoint.

It’s quite common to have a breakpoint inside a shared library. Shared libraries can be loaded and unloaded explicitly, and possibly repeatedly, as the program is executed. To support this use case, **GDB** updates breakpoint locations whenever any shared library is loaded or unloaded. Typically, you would set a breakpoint in a shared library at the beginning of your debugging session, when the library is not loaded, and when the symbols
from the library are not available. When you try to set breakpoint, GDB will ask you if you want to set a so called **pending breakpoint**—breakpoint whose address is not yet resolved.

After the program is run, whenever a new shared library is loaded, GDB reevaluates all the breakpoints. When a newly loaded shared library contains the symbol or line referred to by some pending breakpoint, that breakpoint is resolved and becomes an ordinary breakpoint. When a library is unloaded, all breakpoints that refer to its symbols or source lines become pending again.

This logic works for breakpoints with multiple locations, too. For example, if you have a breakpoint in a C++ template function, and a newly loaded shared library has an instantiation of that template, a new location is added to the list of locations for the breakpoint.

Except for having unresolved address, pending breakpoints do not differ from regular breakpoints. You can set conditions or commands, enable and disable them and perform other breakpoint operations.

GDB provides some additional commands for controlling what happens when the `break` command cannot resolve breakpoint address specification to an address:

**set breakpoint pending auto**

This is the default behavior. When GDB cannot find the breakpoint location, it queries you whether a pending breakpoint should be created.

**set breakpoint pending on**

This indicates that an unrecognized breakpoint location should automatically result in a pending breakpoint being created.

**set breakpoint pending off**

This indicates that pending breakpoints are not to be created. Any unrecognized breakpoint location results in an error. This setting does not affect any pending breakpoints previously created.

**show breakpoint pending**

Show the current behavior setting for creating pending breakpoints.

The settings above only affect the `break` command and its variants. Once breakpoint is set, it will be automatically updated as shared libraries are loaded and unloaded.

For some targets, GDB can automatically decide if hardware or software breakpoints should be used, depending on whether the breakpoint address is read-only or read-write. This applies to breakpoints set with the `break` command as well as to internal breakpoints set by commands like `next` and `finish`. For breakpoints set with `hbreak`, GDB will always use hardware breakpoints.

You can control this automatic behaviour with the following commands:

**set breakpoint auto-hw on**

This is the default behavior. When GDB sets a breakpoint, it will try to use the target memory map to decide if software or hardware breakpoint must be used.

**set breakpoint auto-hw off**

This indicates GDB should not automatically select breakpoint type. If the target provides a memory map, GDB will warn when trying to set software breakpoint at a read-only address.
GDB normally implements breakpoints by replacing the program code at the breakpoint address with a special instruction, which, when executed, given control to the debugger. By default, the program code is so modified only when the program is resumed. As soon as the program stops, GDB restores the original instructions. This behaviour guards against leaving breakpoints inserted in the target should gdb abruptly disconnect. However, with slow remote targets, inserting and removing breakpoint can reduce the performance. This behavior can be controlled with the following commands:

```
set breakpoint always-inserted off
```

All breakpoints, including newly added by the user, are inserted in the target only when the target is resumed. All breakpoints are removed from the target when it stops. This is the default mode.

```
set breakpoint always-inserted on
```

Causes all breakpoints to be inserted in the target at all times. If the user adds a new breakpoint, or changes an existing breakpoint, the breakpoints in the target are updated immediately. A breakpoint is removed from the target only when breakpoint itself is deleted.

GDB handles conditional breakpoints by evaluating these conditions when a breakpoint breaks. If the condition is true, then the process being debugged stops, otherwise the process is resumed.

If the target supports evaluating conditions on its end, GDB may download the breakpoint, together with its conditions, to it.

This feature can be controlled via the following commands:

```
set breakpoint condition-evaluation host
```

This option commands GDB to evaluate the breakpoint conditions on the host’s side. Unconditional breakpoints are sent to the target which in turn receives the triggers and reports them back to GDB for condition evaluation. This is the standard evaluation mode.

```
set breakpoint condition-evaluation target
```

This option commands GDB to download breakpoint conditions to the target at the moment of their insertion. The target is responsible for evaluating the conditional expression and reporting breakpoint stop events back to GDB whenever the condition is true. Due to limitations of target-side evaluation, some conditions cannot be evaluated there, e.g., conditions that depend on local data that is only known to the host. Examples include conditional expressions involving convenience variables, complex types that cannot be handled by the agent expression parser and expressions that are too long to be sent over to the target, specially when the target is a remote system. In these cases, the conditions will be evaluated by GDB.

```
set breakpoint condition-evaluation auto
```

This is the default mode. If the target supports evaluating breakpoint conditions on its end, GDB will download breakpoint conditions to the target (limitations mentioned previously apply). If the target does not support breakpoint condition evaluation, then GDB will fallback to evaluating all these conditions on the host’s side.
GDB itself sometimes sets breakpoints in your program for special purposes, such as proper handling of `longjmp` (in C programs). These internal breakpoints are assigned negative numbers, starting with -1; `info breakpoints` does not display them. You can see these breakpoints with the GDB maintenance command `maint info breakpoints` (see [maint info breakpoints], page 597).

### 5.1.2 Setting Watchpoints

You can use a watchpoint to stop execution whenever the value of an expression changes, without having to predict a particular place where this may happen. (This is sometimes called a data breakpoint.) The expression may be as simple as the value of a single variable, or as complex as many variables combined by operators. Examples include:

- A reference to the value of a single variable.
- An address cast to an appropriate data type. For example, `*(int *)0x12345678` will watch a 4-byte region at the specified address (assuming an `int` occupies 4 bytes).
- An arbitrarily complex expression, such as `a*b + c/d`. The expression can use any operators valid in the program’s native language (see Chapter 15 [Languages], page 187).

You can set a watchpoint on an expression even if the expression cannot be evaluated yet. For instance, you can set a watchpoint on `*global_ptr` before `global_ptr` is initialized. GDB will stop when your program sets `global_ptr` and the expression produces a valid value. If the expression becomes valid in some other way than changing a variable (e.g. if the memory pointed to by `*global_ptr` becomes readable as the result of a `malloc` call), GDB may not stop until the next time the expression changes.

Depending on your system, watchpoints may be implemented in software or hardware. GDB does software watchpointing by single-stepping your program and testing the variable’s value each time, which is hundreds of times slower than normal execution. (But this may still be worth it, to catch errors where you have no clue what part of your program is the culprit.)

On some systems, such as HP-UX, PowerPC, GNU/Linux and most other x86-based targets, GDB includes support for hardware watchpoints, which do not slow down the running of your program.

```
watch [-l|-location] expr [thread threadnum] [mask maskvalue]
```

Set a watchpoint for an expression. GDB will break when the expression `expr` is written into by the program and its value changes. The simplest (and the most popular) use of this command is to watch the value of a single variable:

```
(gdb) watch foo
```

If the command includes a `[thread threadnum]` argument, GDB breaks only when the thread identified by `threadnum` changes the value of `expr`. If any other threads change the value of `expr`, GDB will not break. Note that watchpoints restricted to a single thread in this way only work with Hardware Watchpoints. Ordinarily a watchpoint respects the scope of variables in `expr` (see below). The `-location` argument tells GDB to instead watch the memory referred to by `expr`. In this case, GDB will evaluate `expr`, take the address of the result, and watch the memory at that address. The type of the result is used to determine the size of the watched memory. If the expression’s result does not have an address, then GDB will print an error.
The \texttt{mask maskvalue} argument allows creation of masked watchpoints, if the current architecture supports this feature (e.g., PowerPC Embedded architecture, see Section 21.3.6 [PowerPC Embedded], page 290.) A \textit{masked watchpoint} specifies a mask in addition to an address to watch. The mask specifies that some bits of an address (the bits which are reset in the mask) should be ignored when matching the address accessed by the inferior against the watchpoint address. Thus, a masked watchpoint watches many addresses simultaneously—those addresses whose unmasked bits are identical to the unmasked bits in the watchpoint address. The \texttt{mask} argument implies \texttt{-location}. Examples:

\begin{verbatim}
(gdb) watch foo mask 0xffff00ff
(gdb) watch *0xdeadbeef mask 0xffffffff
\end{verbatim}

\texttt{rwatch [-l|-location] expr [thread threadnum] [mask maskvalue]}
Set a watchpoint that will break when the value of \textit{expr} is read by the program.

\texttt{awatch [-l|-location] expr [thread threadnum] [mask maskvalue]}
Set a watchpoint that will break when \textit{expr} is either read from or written into by the program.

\texttt{info watchpoints \{n...\}}
This command prints a list of watchpoints, using the same format as \texttt{info break} (see Section 5.1.1 [Set Breaks], page 46).

If you watch for a change in a numerically entered address you need to dereference it, as the address itself is just a constant number which will never change. GDB refuses to create a watchpoint that watches a never-changing value:

\begin{verbatim}
(gdb) watch 0x600850
Cannot watch constant value 0x600850.
(gdb) watch *(int *) 0x600850
Watchpoint 1: *(int *) 6293584
\end{verbatim}

GDB sets a \textit{hardware watchpoint} if possible. Hardware watchpoints execute very quickly, and the debugger reports a change in value at the exact instruction where the change occurs. If GDB cannot set a hardware watchpoint, it sets a software watchpoint, which executes more slowly and reports the change in value at the next \textit{statement}, not the instruction, after the change occurs.

You can force GDB to use only software watchpoints with the \texttt{set can-use-hw-watchpoints 0} command. With this variable set to zero, GDB will never try to use hardware watchpoints, even if the underlying system supports them. (Note that hardware-assisted watchpoints that were set \textit{before} setting \texttt{can-use-hw-watchpoints} to zero will still use the hardware mechanism of watching expression values.)

\texttt{set can-use-hw-watchpoints}
Set whether or not to use hardware watchpoints.

\texttt{show can-use-hw-watchpoints}
Show the current mode of using hardware watchpoints.

For remote targets, you can restrict the number of hardware watchpoints GDB will use, see \texttt{[set remote hardware-breakpoint-limit]}, page 266.

When you issue the \texttt{watch} command, GDB reports
Hardware watchpoint num: expr
if it was able to set a hardware watchpoint.

Currently, the `awatch` and `rwatch` commands can only set hardware watchpoints, because accesses to data that don’t change the value of the watched expression cannot be detected without examining every instruction as it is being executed, and GDB does not do that currently. If GDB finds that it is unable to set a hardware breakpoint with the `awatch` or `rwatch` command, it will print a message like this:

Expression cannot be implemented with read/access watchpoint.

Sometimes, GDB cannot set a hardware watchpoint because the data type of the watched expression is wider than what a hardware watchpoint on the target machine can handle. For example, some systems can only watch regions that are up to 4 bytes wide; on such systems you cannot set hardware watchpoints for an expression that yields a double-precision floating-point number (which is typically 8 bytes wide). As a work-around, it might be possible to break the large region into a series of smaller ones and watch them with separate watchpoints.

If you set too many hardware watchpoints, GDB might be unable to insert all of them when you resume the execution of your program. Since the precise number of active watchpoints is unknown until such time as the program is about to be resumed, GDB might not be able to warn you about this when you set the watchpoints, and the warning will be printed only when the program is resumed:

Hardware watchpoint num: Could not insert watchpoint
If this happens, delete or disable some of the watchpoints.

Watching complex expressions that reference many variables can also exhaust the resources available for hardware-assisted watchpoints. That’s because GDB needs to watch every variable in the expression with separately allocated resources.

If you call a function interactively using `print` or `call`, any watchpoints you have set will be inactive until GDB reaches another kind of breakpoint or the call completes.

GDB automatically deletes watchpoints that watch local (automatic) variables, or expressions that involve such variables, when they go out of scope, that is, when the execution leaves the block in which these variables were defined. In particular, when the program being debugged terminates, all local variables go out of scope, and so only watchpoints that watch global variables remain set. If you rerun the program, you will need to set all such watchpoints again. One way of doing that would be to set a code breakpoint at the entry to the `main` function and when it breaks, set all the watchpoints.

In multi-threaded programs, watchpoints will detect changes to the watched expression from every thread.

Warning: In multi-threaded programs, software watchpoints have only limited usefulness. If GDB creates a software watchpoint, it can only watch the value of an expression in a single thread. If you are confident that the expression can only change due to the current thread’s activity (and if you are also confident that no other thread can become current), then you can use software watchpoints as usual. However, GDB may not notice when a non-current thread’s activity changes the expression. (Hardware watchpoints, in contrast, watch an expression in all threads.)

See [set remote hardware-watchpoint-limit], page 266.
5.1.3 Setting Catchpoints

You can use catchpoints to cause the debugger to stop for certain kinds of program events, such as C++ exceptions or the loading of a shared library. Use the `catch` command to set a catchpoint.

```
catch event
```

Stop when `event` occurs. The `event` can be any of the following:

```
throw [regexp]
rethrow [regexp]
catch [regexp]
```

The throwing, re-throwing, or catching of a C++ exception.

If `regexp` is given, then only exceptions whose type matches the regular expression will be caught.

The convenience variable `$_exception` is available at an exception-related catchpoint, on some systems. This holds the exception being thrown.

There are currently some limitations to C++ exception handling in GDB:

- The support for these commands is system-dependent. Currently, only systems using the `gnu-v3` C++ ABI (see Section 22.6 [ABI], page 301) are supported.
- The regular expression feature and the `$_exception` convenience variable rely on the presence of some SDT probes in `libstdc++`. If these probes are not present, then these features cannot be used. These probes were first available in the GCC 4.8 release, but whether or not they are available in your GCC also depends on how it was built.
- The `$_exception` convenience variable is only valid at the instruction at which an exception-related catchpoint is set.
- When an exception-related catchpoint is hit, GDB stops at a location in the system library which implements runtime exception support for C++, usually `libstdc++`. You can use `up` (see Section 8.4 [Selection], page 99) to get to your code.
- If you call a function interactively, GDB normally returns control to you when the function has finished executing. If the call raises an exception, however, the call may bypass the mechanism that returns control to you and cause your program either to abort or to simply continue running until it hits a breakpoint, catches a signal that GDB is listening for, or exits. This is the case even if you set a catchpoint for the exception; catchpoints on exceptions are disabled within interactive calls. See Section 17.5 [Calling], page 229, for information on controlling this with `set unwind-on-terminating-exception`.
- You cannot raise an exception interactively.
- You cannot install an exception handler interactively.
**exception**
An Ada exception being raised. If an exception name is specified at the end of the command (e.g., `catch exception Program_Error`), the debugger will stop only when this specific exception is raised. Otherwise, the debugger stops execution when any Ada exception is raised.

When inserting an exception catchpoint on a user-defined exception whose name is identical to one of the exceptions defined by the language, the fully qualified name must be used as the exception name. Otherwise, GDB will assume that it should stop on the pre-defined exception rather than the user-defined one. For instance, assuming an exception called `Constraint_Error` is defined in package `Pck`, then the command to use to catch such exceptions is `catch exception Pck.Constraint_Error`.

**exception unhandled**
An exception that was raised but is not handled by the program.

**assert**
A failed Ada assertion.

**exec**
A call to `exec`. This is currently only available for HP-UX and GNU/Linux.

**syscall**
`syscall [name | number] ...`
A call to or return from a system call, a.k.a. `syscall`. A syscall is a mechanism for application programs to request a service from the operating system (OS) or one of the OS system services. GDB can catch some or all of the syscalls issued by the debuggee, and show the related information for each syscall. If no argument is specified, calls to and returns from all system calls will be caught.

`name` can be any system call name that is valid for the underlying OS. Just what syscalls are valid depends on the OS. On GNU and Unix systems, you can find the full list of valid syscall names on `/usr/include/asm/unistd.h`.

Normally, GDB knows in advance which syscalls are valid for each OS, so you can use the GDB command-line completion facilities (see Section 3.2 [command completion], page 19) to list the available choices.

You may also specify the system call numerically. A syscall’s number is the value passed to the OS’s syscall dispatcher to identify the requested service. When you specify the syscall by its name, GDB uses its database of syscalls to convert the name into the corresponding numeric code, but using the number directly may be useful if GDB’s database does not have the complete list of syscalls on your system (e.g., because GDB lags behind the OS upgrades).

The example below illustrates how this command works if you don’t provide arguments to it:
(gdb) catch syscall
Catchpoint 1 (syscall)
(gdb) r
Starting program: /tmp/catch-syscall
Catchpoint 1 (call to syscall 'close'), 0xffffe424 in __kernel_vsyscall ()
(gdb) c
Continuing.
Catchpoint 1 (returned from syscall 'close'), 0xffffe424 in __kernel_vsyscall ()
(gdb)

Here is an example of catching a system call by name:
(gdb) catch syscall chroot
Catchpoint 1 (syscall 'chroot' [61])
(gdb) r
Starting program: /tmp/catch-syscall
Catchpoint 1 (call to syscall 'chroot'), 0xffffe424 in __kernel_vsyscall ()
(gdb) c
Continuing.
Catchpoint 1 (returned from syscall 'chroot'), 0xffffe424 in __kernel_vsyscall ()
(gdb)

An example of specifying a system call numerically. In the case below, the syscall number has a corresponding entry in the XML file, so GDB finds its name and prints it:
(gdb) catch syscall 252
Catchpoint 1 (syscall(s) 'exit_group')
(gdb) r
Starting program: /tmp/catch-syscall
Catchpoint 1 (call to syscall 'exit_group'), 0xffffe424 in __kernel_vsyscall ()
(gdb) c
Continuing.
Program exited normally.
(gdb)

However, there can be situations when there is no corresponding name in XML file for that syscall number. In this case, GDB prints a warning message saying that it was not able to find the syscall name, but the catchpoint will be set anyway. See the example below:
(gdb) catch syscall 764
warning: The number '764' does not represent a known syscall.
Catchpoint 2 (syscall 764)
(gdb)

If you configure GDB using the 'without-expat' option, it will not be able to display syscall names. Also, if your architecture does not have an XML file describing its system calls, you will not be
able to see the syscall names. It is important to notice that these two features are used for accessing the syscall name database. In either case, you will see a warning like this:

```
(gdb) catch syscall
  warning: Could not open "syscalls/i386-linux.xml"
  warning: Could not load the syscall XML file 'syscalls/i386-linux.xml'.
  GDB will not be able to display syscall names.
  Catchpoint 1 (syscall)
(gdb)
```

Of course, the file name will change depending on your architecture and system.

Still using the example above, you can also try to catch a syscall by its number. In this case, you would see something like:

```
(gdb) catch syscall 252
  Catchpoint 1 (syscall(s) 252)
```

Again, in this case GDB would not be able to display syscall’s names.

**fork**

A call to `fork`. This is currently only available for HP-UX and GNU/Linux.

**vfork**

A call to `vfork`. This is currently only available for HP-UX and GNU/Linux.

**load [regexp]**

The loading or unloading of a shared library. If `regexp` is given, then the catchpoint will stop only if the regular expression matches one of the affected libraries.

**unload [regexp]**

The unloading of a shared library.

**signal [signal... | 'all']**

The delivery of a signal.

With no arguments, this catchpoint will catch any signal that is not used internally by GDB, specifically, all signals except ‘SIGTRAP’ and ‘SIGINT’.

With the argument ‘all’, all signals, including those used by GDB, will be caught. This argument cannot be used with other signal names.

Otherwise, the arguments are a list of signal names as given to `handle` (see Section 5.4 [Signals], page 73). Only signals specified in this list will be caught.

One reason that `catch signal` can be more useful than `handle` is that you can attach commands and conditions to the catchpoint.

When a signal is caught by a catchpoint, the signal’s `stop` and `print` settings, as specified by `handle`, are ignored. However, whether the signal is still delivered to the inferior depends on the `pass` setting; this can be changed in the catchpoint’s commands.

**tcatch event**

Set a catchpoint that is enabled only for one stop. The catchpoint is automatically deleted after the first time the event is caught.
Use the `info break` command to list the current catchpoints.

### 5.1.4 Deleting Breakpoints

It is often necessary to eliminate a breakpoint, watchpoint, or catchpoint once it has done its job and you no longer want your program to stop there. This is called deleting the breakpoint. A breakpoint that has been deleted no longer exists; it is forgotten.

With the `clear` command you can delete breakpoints according to where they are in your program. With the `delete` command you can delete individual breakpoints, watchpoints, or catchpoints by specifying their breakpoint numbers.

It is not necessary to delete a breakpoint to proceed past it. GDB automatically ignores breakpoints on the first instruction to be executed when you continue execution without changing the execution address.

**clear**

Delete any breakpoints at the next instruction to be executed in the selected stack frame (see Section 8.4 [Selecting a Frame], page 99). When the innermost frame is selected, this is a good way to delete a breakpoint where your program just stopped.

**clear location**

Delete any breakpoints set at the specified location. See Section 9.2 [Specify Location], page 102, for the various forms of location; the most useful ones are listed below:

- `clear function`  
  Delete any breakpoints set at entry to the named function.

- `clear linenum`  
  Delete any breakpoints set at or within the code of the specified linenum of the specified filename.

- `clear filename:linenum`  
  Delete any breakpoints set at or within the code of the specified linenum of the specified filename.

**delete [breakpoints] [range...]**

Delete the breakpoints, watchpoints, or catchpoints of the breakpoint ranges specified as arguments. If no argument is specified, delete all breakpoints (GDB asks confirmation, unless you have `set confirm off`). You can abbreviate this command as d.

### 5.1.5 Disabling Breakpoints

Rather than deleting a breakpoint, watchpoint, or catchpoint, you might prefer to disable it. This makes the breakpoint inoperative as if it had been deleted, but remembers the information on the breakpoint so that you can enable it again later.

You disable and enable breakpoints, watchpoints, and catchpoints with the `enable` and `disable` commands, optionally specifying one or more breakpoint numbers as arguments. Use `info break` to print a list of all breakpoints, watchpoints, and catchpoints if you do not know which numbers to use.

Disabling and enabling a breakpoint that has multiple locations affects all of its locations.

A breakpoint, watchpoint, or catchpoint can have any of several different states of enablement:
- Enabled. The breakpoint stops your program. A breakpoint set with the `break` command starts out in this state.
- Disabled. The breakpoint has no effect on your program.
- Enabled once. The breakpoint stops your program, but then becomes disabled.
- Enabled for a count. The breakpoint stops your program for the next N times, then becomes disabled.
- Enabled for deletion. The breakpoint stops your program, but immediately after it does so it is deleted permanently. A breakpoint set with the `tbreak` command starts out in this state.

You can use the following commands to enable or disable breakpoints, watchpoints, and catchpoints:

```plaintext
disable [breakpoints] [range...]  
Disable the specified breakpoints—or all breakpoints, if none are listed. A disabled breakpoint has no effect but is not forgotten. All options such as ignore-counts, conditions and commands are remembered in case the breakpoint is enabled again later. You may abbreviate disable as dis.
```

```plaintext
enable [breakpoints] [range...]  
Enable the specified breakpoints (or all defined breakpoints). They become effective once again in stopping your program.
```

```plaintext
enable [breakpoints] once range...  
Enable the specified breakpoints temporarily. GDB disables any of these breakpoints immediately after stopping your program.
```

```plaintext
enable [breakpoints] count count range...  
Enable the specified breakpoints temporarily. GDB records `count` with each of the specified breakpoints, and decrements a breakpoint’s count when it is hit. When any count reaches 0, GDB disables that breakpoint. If a breakpoint has an ignore count (see Section 5.1.6 [Break Conditions], page 60), that will be decremented to 0 before `count` is affected.
```

```plaintext
enable [breakpoints] delete range...  
Enable the specified breakpoints to work once, then die. GDB deletes any of these breakpoints as soon as your program stops there. Breakpoints set by the `tbreak` command start out in this state.
```

Except for a breakpoint set with `tbreak` (see Section 5.1.1 [Setting Breakpoints], page 46), breakpoints that you set are initially enabled; subsequently, they become disabled or enabled only when you use one of the commands above. (The command `until` can set and delete a breakpoint of its own, but it does not change the state of your other breakpoints; see Section 5.2 [Continuing and Stepping], page 68.)

### 5.1.6 Break Conditions

The simplest sort of breakpoint breaks every time your program reaches a specified place. You can also specify a `condition` for a breakpoint. A condition is just a Boolean expression in your programming language (see Section 10.1 [Expressions], page 115). A breakpoint with
a condition evaluates the expression each time your program reaches it, and your program stops only if the condition is true.

This is the converse of using assertions for program validation; in that situation, you want to stop when the assertion is violated—that is, when the condition is false. In C, if you want to test an assertion expressed by the condition assert, you should set the condition ‘! assert’ on the appropriate breakpoint.

Conditions are also accepted for watchpoints; you may not need them, since a watchpoint is inspecting the value of an expression anyhow—but it might be simpler, say, to just set a watchpoint on a variable name, and specify a condition that tests whether the new value is an interesting one.

Break conditions can have side effects, and may even call functions in your program. This can be useful, for example, to activate functions that log program progress, or to use your own print functions to format special data structures. The effects are completely predictable unless there is another enabled breakpoint at the same address. (In that case, GDB might see the other breakpoint first and stop your program without checking the condition of this one.) Note that breakpoint commands are usually more convenient and flexible than break conditions for the purpose of performing side effects when a breakpoint is reached (see Section 5.1.7 [Breakpoint Command Lists], page 62).

Breakpoint conditions can also be evaluated on the target’s side if the target supports it. Instead of evaluating the conditions locally, GDB encodes the expression into an agent expression (see Appendix F [Agent Expressions], page 675) suitable for execution on the target, independently of GDB. Global variables become raw memory locations, locals become stack accesses, and so forth.

In this case, GDB will only be notified of a breakpoint trigger when its condition evaluates to true. This mechanism may provide faster response times depending on the performance characteristics of the target since it does not need to keep GDB informed about every breakpoint trigger, even those with false conditions.

Break conditions can be specified when a breakpoint is set, by using ‘if’ in the arguments to the break command. See Section 5.1.1 [Setting Breakpoints], page 46. They can also be changed at any time with the condition command.

You can also use the if keyword with the watch command. The catch command does not recognize the if keyword; condition is the only way to impose a further condition on a catchpoint.

**condition bnum expression**

Specify expression as the break condition for breakpoint, watchpoint, or catchpoint number bnum. After you set a condition, breakpoint bnum stops your program only if the value of expression is true (nonzero, in C). When you use condition, GDB checks expression immediately for syntactic correctness, and to determine whether symbols in it have referents in the context of your breakpoint. If expression uses symbols not referenced in the context of the breakpoint, GDB prints an error message:

```
No symbol "foo" in current context.
```

GDB does not actually evaluate expression at the time the condition command (or a command that sets a breakpoint with a condition, like break if ...) is given, however. See Section 10.1 [Expressions], page 115.
condition bnum
   Remove the condition from breakpoint number bnum. It becomes an ordinary
   unconditional breakpoint.

   A special case of a breakpoint condition is to stop only when the breakpoint has been
   reached a certain number of times. This is so useful that there is a special way to do it,
   using the ignore count of the breakpoint. Every breakpoint has an ignore count, which is
   an integer. Most of the time, the ignore count is zero, and therefore has no effect. But if
   your program reaches a breakpoint whose ignore count is positive, then instead of stopping,
   it just decrements the ignore count by one and continues. As a result, if the ignore count
   value is n, the breakpoint does not stop the next n times your program reaches it.

ignore bnum count
   Set the ignore count of breakpoint number bnum to count. The next count
   times the breakpoint is reached, your program’s execution does not stop; other
   than to decrement the ignore count, GDB takes no action.
   To make the breakpoint stop the next time it is reached, specify a count of zero.
   When you use continue to resume execution of your program from a break-
   point, you can specify an ignore count directly as an argument to continue,
   rather than using ignore. See Section 5.2 [Continuing and Stepping], page 68.
   If a breakpoint has a positive ignore count and a condition, the condition is
   not checked. Once the ignore count reaches zero, GDB resumes checking the
   condition.
   You could achieve the effect of the ignore count with a condition such as
   ‘$foo-- <= 0’ using a debugger convenience variable that is decremented each
   time. See Section 10.11 [Convenience Variables], page 137.

Ignore counts apply to breakpoints, watchpoints, and catchpoints.

5.1.7 Breakpoint Command Lists
You can give any breakpoint (or watchpoint or catchpoint) a series of commands to execute
when your program stops due to that breakpoint. For example, you might want to print
the values of certain expressions, or enable other breakpoints.

 commands [range...]  ...
   Specify a list of commands for the given breakpoints. The commands themselves
   appear on the following lines. Type a line containing just end to terminate the
   commands.
   To remove all commands from a breakpoint, type commands and follow it im-
   mediately with end; that is, give no commands.
   With no argument, commands refers to the last breakpoint, watchpoint, or catch-
   point set (not to the breakpoint most recently encountered). If the most recent
   breakpoints were set with a single command, then the commands will apply
   to all the breakpoints set by that command. This applies to breakpoints set
   by rbreak, and also applies when a single break command creates multiple
   breakpoints (see Section 10.2 [Ambiguous Expressions], page 116).
Pressing RET as a means of repeating the last GDB command is disabled within a command-list.

You can use breakpoint commands to start your program up again. Simply use the continue command, or step, or any other command that resumes execution.

Any other commands in the command list, after a command that resumes execution, are ignored. This is because any time you resume execution (even with a simple next or step), you may encounter another breakpoint—which could have its own command list, leading to ambiguities about which list to execute.

If the first command you specify in a command list is silent, the usual message about stopping at a breakpoint is not printed. This may be desirable for breakpoints that are to print a specific message and then continue. If none of the remaining commands print anything, you see no sign that the breakpoint was reached. silent is meaningful only at the beginning of a breakpoint command list.

The commands echo, output, and printf allow you to print precisely controlled output, and are often useful in silent breakpoints. See Section 23.1.4 [Commands for Controlled Output], page 319.

For example, here is how you could use breakpoint commands to print the value of x at entry to foo whenever x is positive.

```
break foo if x>0
commands
silent
printf "x is %d\n",x
cont
end
```

One application for breakpoint commands is to compensate for one bug so you can test for another. Put a breakpoint just after the erroneous line of code, give it a condition to detect the case in which something erroneous has been done, and give it commands to assign correct values to any variables that need them. End with the continue command so that your program does not stop, and start with the silent command so that no output is produced. Here is an example:

```
break 403
commands
silent
set x = y + 4
cont
end
```

### 5.1.8 Dynamic Printf

The dynamic printf command dprintf combines a breakpoint with formatted printing of your program's data to give you the effect of inserting printf calls into your program on-the-fly, without having to recompile it.

In its most basic form, the output goes to the GDB console. However, you can set the variable dprintf-style for alternate handling. For instance, you can ask to format the output by calling your program's printf function. This has the advantage that the characters go to the program's output device, so they can recorded in redirects to files and so forth.
If you are doing remote debugging with a stub or agent, you can also ask to have the printf handled by the remote agent. In addition to ensuring that the output goes to the remote program’s device along with any other output the program might produce, you can also ask that the dprintf remain active even after disconnecting from the remote target. Using the stub/agent is also more efficient, as it can do everything without needing to communicate with GDB.

\texttt{dprintf location,template,expression[,expression...]}

Whenever execution reaches \textit{location}, print the values of one or more \textit{expressions} under the control of the string \textit{template}. To print several values, separate them with commas.

\texttt{set dprintf-style style}

Set the dprintf output to be handled in one of several different styles enumerated below. A change of style affects all existing dynamic printfs immediately. (If you need individual control over the print commands, simply define normal breakpoints with explicitly-supplied command lists.)

- \texttt{gdb} Handle the output using the GDB \texttt{printf} command.
- \texttt{call} Handle the output by calling a function in your program (normally \texttt{printf}).
- \texttt{agent} Have the remote debugging agent (such as \texttt{gdbserver}) handle the output itself. This style is only available for agents that support running commands on the target.

\texttt{set dprintf-function function}

Set the function to call if the dprintf style is \texttt{call}. By default its value is \texttt{printf}. You may set it to any expression that GDB can evaluate to a function, as per the \texttt{call} command.

\texttt{set dprintf-channel channel}

Set a “channel” for dprintf. If set to a non-empty value, GDB will evaluate it as an expression and pass the result as a first argument to the \texttt{dprintf-function}, in the manner of \texttt{fprintf} and similar functions. Otherwise, the dprintf format string will be the first argument, in the manner of \texttt{printf}.

As an example, if you wanted \texttt{dprintf} output to go to a logfile that is a standard I/O stream assigned to the variable \texttt{mylog}, you could do the following:

\begin{verbatim}
(gdb) set dprintf-style call
(gdb) set dprintf-function fprintf
(gdb) set dprintf-channel mylog
(gdb) dprintf 25,"at line 25, glob=%d\n",glob
Dprintf 1 at 0x123456: file main.c, line 25.
(gdb) info break
1  dprintf keep y 0x00123456 in main at main.c:25
    call (void) fprintf (mylog,"at line 25, glob=%d\n",glob)
(gdb) continue
\end{verbatim}

Note that the \texttt{info break} displays the dynamic printf commands as normal breakpoint commands; you can thus easily see the effect of the variable settings.
set disconnected-dprintf on
set disconnected-dprintf off
Choose whether dprintf commands should continue to run if GDB has discon-
nected from the target. This only applies if the dprintf-style is agent.

show disconnected-dprintf off
Show the current choice for disconnected dprintf.

GDB does not check the validity of function and channel, relying on you to supply values
that are meaningful for the contexts in which they are being used. For instance, the function
and channel may be the values of local variables, but if that is the case, then all enabled
dynamic prints must be at locations within the scope of those locals. If evaluation fails,
GDB will report an error.

5.1.9 How to save breakpoints to a file
To save breakpoint definitions to a file use the save breakpoints command.

save breakpoints [filename]
This command saves all current breakpoint definitions together with their com-
mands and ignore counts, into a file ‘filename’ suitable for use in a later debug-
ging session. This includes all types of breakpoints (breakpoints, watchpoints,
catchpoints, tracepoints). To read the saved breakpoint definitions, use the
source command (see Section 23.1.3 [Command Files], page 318). Note that
watchpoints with expressions involving local variables may fail to be recreated
because it may not be possible to access the context where the watchpoint is
valid anymore. Because the saved breakpoint definitions are simply a sequence
of GDB commands that recreate the breakpoints, you can edit the file in your
favorite editing program, and remove the breakpoint definitions you’re not in-
terested in, or that can no longer be recreated.

5.1.10 Static Probe Points
GDB supports SDT probes in the code. SDT stands for S statically Defined Tracing, and
the probes are designed to have a tiny runtime code and data footprint, and no dynamic
relocations.

Currently, the following types of probes are supported on ELF-compatible systems:

- **SystemTap** ([http://sourceware.org/systemtap/](http://sourceware.org/systemtap/)) SDT probes
  are usable from assembly, C and C++ languages\(^1\).

- **DTrace** ([http://oss.oracle.com/projects/DTrace](http://oss.oracle.com/projects/DTrace)) USDT
  probes. DTrace probes
  are usable from C and C++ languages.

Some SystemTap probes have an associated semaphore variable; for instance, this hap-
pens automatically if you defined your probe using a DTrace-style ‘.d’ file. If your probe
has a semaphore, GDB will automatically enable it when you specify a breakpoint using
the ‘-probe-stap’ notation. But, if you put a breakpoint at a probe’s location by some

\(^1\) See [http://sourceware.org/systemtap/wiki/AddingUserSpaceProbingToApps](http://sourceware.org/systemtap/wiki/AddingUserSpaceProbingToApps) for more information
on how to add SystemTap SDT probes in your applications.

\(^2\) See [http://sourceware.org/systemtap/wiki/UserSpaceProbeImplementation](http://sourceware.org/systemtap/wiki/UserSpaceProbeImplementation) for a good reference on
how the SDT probes are implemented.
other method (e.g., \texttt{break file:line}), then GDB will not automatically set the semaphore. DTrace probes do not support semaphores.

You can examine the available static static probes using \texttt{info probes}, with optional arguments:

\begin{verbatim}
info probes [type] [provider [name [objfile]]]
\end{verbatim}

If given, \texttt{type} is either \texttt{stap} for listing SystemTap probes or \texttt{dtrace} for listing DTrace probes. If omitted all probes are listed regardless of their types.

If given, \texttt{provider} is a regular expression used to match against provider names when selecting which probes to list. If omitted, probes by all probes from all providers are listed.

If given, \texttt{name} is a regular expression to match against probe names when selecting which probes to list. If omitted, probe names are not considered when deciding whether to display them.

If given, \texttt{objfile} is a regular expression used to select which object files (executable or shared libraries) to examine. If not given, all object files are considered.

\begin{verbatim}
info probes all
\end{verbatim}

List the available static probes, from all types.

Some probe points can be enabled and/or disabled. The effect of enabling or disabling a probe depends on the type of probe being handled. Some DTrace probes can be enabled or disabled, but SystemTap probes cannot be disabled.

You can enable (or disable) one or more probes using the following commands, with optional arguments:

\begin{verbatim}
enable probes [provider [name [objfile]]]
\end{verbatim}

If given, \texttt{provider} is a regular expression used to match against provider names when selecting which probes to enable. If omitted, all probes from all providers are enabled.

If given, \texttt{name} is a regular expression to match against probe names when selecting which probes to enable. If omitted, probe names are not considered when deciding whether to enable them.

If given, \texttt{objfile} is a regular expression used to select which object files (executable or shared libraries) to examine. If not given, all object files are considered.

\begin{verbatim}
disable probes [provider [name [objfile]]]
\end{verbatim}

See the \texttt{enable probes} command above for a description of the optional arguments accepted by this command.

A probe may specify up to twelve arguments. These are available at the point at which the probe is defined—that is, when the current PC is at the probe’s location. The arguments are available using the convenience variables (see Section 10.11 \[Convenience Vars\], page 137) \$_probe_arg0...$_probe_arg11. In SystemTap probes each probe argument is an integer of the appropriate size; types are not preserved. In DTrace probes types are preserved provided that they are recognized as such by GDB; otherwise the value of the
probe argument will be a long integer. The convenience variable `$_probe_argc` holds the number of arguments at the current probe point.

These variables are always available, but attempts to access them at any location other than a probe point will cause GDB to give an error message.

### 5.1.11 “Cannot insert breakpoints”

If you request too many active hardware-assisted breakpoints and watchpoints, you will see this error message:

```
Stopped; cannot insert breakpoints.
You may have requested too many hardware breakpoints and watchpoints.
```

This message is printed when you attempt to resume the program, since only then GDB knows exactly how many hardware breakpoints and watchpoints it needs to insert.

When this message is printed, you need to disable or remove some of the hardware-assisted breakpoints and watchpoints, and then continue.

### 5.1.12 “Breakpoint address adjusted...”

Some processor architectures place constraints on the addresses at which breakpoints may be placed. For architectures thus constrained, GDB will attempt to adjust the breakpoint’s address to comply with the constraints dictated by the architecture.

One example of such an architecture is the Fujitsu FR-V. The FR-V is a VLIW architecture in which a number of RISC-like instructions may be bundled together for parallel execution. The FR-V architecture constrains the location of a breakpoint instruction within such a bundle to the instruction with the lowest address. GDB honors this constraint by adjusting a breakpoint’s address to the first in the bundle.

It is not uncommon for optimized code to have bundles which contain instructions from different source statements, thus it may happen that a breakpoint’s address will be adjusted from one source statement to another. Since this adjustment may significantly alter GDB’s breakpoint related behavior from what the user expects, a warning is printed when the breakpoint is first set and also when the breakpoint is hit.

A warning like the one below is printed when setting a breakpoint that’s been subject to address adjustment:

```
warning: Breakpoint address adjusted from 0x00010414 to 0x00010410.
```

Such warnings are printed both for user settable and GDB’s internal breakpoints. If you see one of these warnings, you should verify that a breakpoint set at the adjusted address will have the desired affect. If not, the breakpoint in question may be removed and other breakpoints may be set which will have the desired behavior. E.g., it may be sufficient to place the breakpoint at a later instruction. A conditional breakpoint may also be useful in some cases to prevent the breakpoint from triggering too often.

GDB will also issue a warning when stopping at one of these adjusted breakpoints:

```
warning: Breakpoint 1 address previously adjusted from 0x00010414 to 0x00010410.
```

When this warning is encountered, it may be too late to take remedial action except in cases where the breakpoint is hit earlier or more frequently than expected.
5.2 Continuing and Stepping

Continuing means resuming program execution until your program completes normally. In contrast, stepping means executing just one more “step” of your program, where “step” may mean either one line of source code, or one machine instruction (depending on what particular command you use). Either when continuing or when stepping, your program may stop even sooner, due to a breakpoint or a signal. (If it stops due to a signal, you may want to use handle, or use ‘signal 0’ to resume execution (see Section 5.4 [Signals], page 73), or you may step into the signal’s handler (see [stepping and signal handlers], page 74.).)

```
continue [ignore-count]
c [ignore-count]
fg [ignore-count]
```

Resume program execution, at the address where your program last stopped; any breakpoints set at that address are bypassed. The optional argument `ignore-count` allows you to specify a further number of times to ignore a breakpoint at this location; its effect is like that of `ignore` (see Section 5.1.6 [Break Conditions], page 60).

The argument `ignore-count` is meaningful only when your program stopped due to a breakpoint. At other times, the argument to `continue` is ignored.

The synonyms `c` and `fg` (for foreground, as the debugged program is deemed to be the foreground program) are provided purely for convenience, and have exactly the same behavior as `continue`.

To resume execution at a different place, you can use `return` (see Section 17.4 [Returning from a Function], page 228) to go back to the calling function; or `jump` (see Section 17.2 [Continuing at a Different Address], page 226) to go to an arbitrary location in your program.

A typical technique for using stepping is to set a breakpoint (see Section 5.1 [Breakpoints; Watchpoints; and Catchpoints], page 45) at the beginning of the function or the section of your program where a problem is believed to lie, run your program until it stops at that breakpoint, and then step through the suspect area, examining the variables that are interesting, until you see the problem happen.

```
step
```

Continue running your program until control reaches a different source line, then stop it and return control to GDB. This command is abbreviated `s`.

Warning: If you use the `step` command while control is within a function that was compiled without debugging information, execution proceeds until control reaches a function that does have debugging information. Likewise, it will not step into a function which is compiled without debugging information. To step through functions without debugging information, use the `stepi` command, described below.

The `step` command only stops at the first instruction of a source line. This prevents the multiple stops that could otherwise occur in `switch` statements, `for` loops, etc. `step` continues to stop if a function that has debugging information is called within the line. In other words, `step steps inside` any functions called within the line.
Also, the `step` command only enters a function if there is line number information for the function. Otherwise it acts like the `next` command. This avoids problems when using `cc -gl` on MIPS machines. Previously, `step` entered subroutines if there was any debugging information about the routine.

`step count`
Continue running as in `step`, but do so `count` times. If a breakpoint is reached, or a signal not related to stepping occurs before `count` steps, stepping stops right away.

`next [count]`
Continue to the next source line in the current (innermost) stack frame. This is similar to `step`, but function calls that appear within the line of code are executed without stopping. Execution stops when control reaches a different line of code at the original stack level that was executing when you gave the `next` command. This command is abbreviated `n`.

An argument `count` is a repeat count, as for `step`.

The `next` command only stops at the first instruction of a source line. This prevents multiple stops that could otherwise occur in `switch` statements, `for` loops, etc.

`set step-mode`

`set step-mode on`
The `set step-mode on` command causes the `step` command to stop at the first instruction of a function which contains no debug line information rather than stepping over it.

This is useful in cases where you may be interested in inspecting the machine instructions of a function which has no symbolic info and do not want `gdb` to automatically skip over this function.

`set step-mode off`
Causes the `step` command to step over any functions which contains no debug information. This is the default.

`show step-mode`
Show whether `gdb` will stop in or step over functions without source line debug information.

`finish`
Continue running until just after function in the selected stack frame returns. Print the returned value (if any). This command can be abbreviated as `fin`.

Contrast this with the `return` command (see Section 17.4 [Returning from a Function], page 228).

`until`
Continue running until a source line past the current line, in the current stack frame, is reached. This command is used to avoid single stepping through a loop more than once. It is like the `next` command, except that when `until` encounters a jump, it automatically continues execution until the program counter is greater than the address of the jump.
This means that when you reach the end of a loop after single stepping through it, `until` makes your program continue execution until it exits the loop. In contrast, a `next` command at the end of a loop simply steps back to the beginning of the loop, which forces you to step through the next iteration.

`until` always stops your program if it attempts to exit the current stack frame. `until` may produce somewhat counterintuitive results if the order of machine code does not match the order of the source lines. For example, in the following excerpt from a debugging session, the `f(frame)` command shows that execution is stopped at line 206; yet when we use `until`, we get to line 195:

```
(gdb) f
#0 main (argc=4, argv=0xf7fffae8) at m4.c:206
206 expand_input();
(gdb) until
195 for ( ; argc > 0; NEXTARG) {
```

This happened because, for execution efficiency, the compiler had generated code for the loop closure test at the end, rather than the start, of the loop—even though the test in a C `for`-loop is written before the body of the loop. The `until` command appeared to step back to the beginning of the loop when it advanced to this expression; however, it has not really gone to an earlier statement—not in terms of the actual machine code.

`until` with no argument works by means of single instruction stepping, and hence is slower than `until` with an argument.

`until location`

Continue running your program until either the specified `location` is reached, or the current stack frame returns. The location is any of the forms described in Section 9.2 [Specify Location], page 102. This form of the command uses temporary breakpoints, and hence is quicker than `until` without an argument. The specified location is actually reached only if it is in the current frame. This implies that `until` can be used to skip over recursive function invocations. For instance in the code below, if the current location is line 96, issuing `until 99` will execute the program up to line 99 in the same invocation of factorial, i.e., after the inner invocations have returned.

```
94 int factorial (int value)
95 {
96   if (value > 1) {
97     value *= factorial (value - 1);
98   }
99   return (value);
100 }
```

`advance location`

Continue running the program up to the given `location`. An argument is required, which should be of one of the forms described in Section 9.2 [Specify Location], page 102. Execution will also stop upon exit from the current stack frame. This command is similar to `until`, but `advance` will not skip over recursive function calls, and the target location doesn’t have to be in the same frame as the current one.
Chapter 5: Stopping and Continuing

stepi
stepi arg
  Execute one machine instruction, then stop and return to the debugger.
  It is often useful to do `display/i $pc` when stepping by machine instructions.
  This makes GDB automatically display the next instruction to be executed, each
time your program stops. See Section 10.7 [Automatic Display], page 124.
  An argument is a repeat count, as in `step`.

nexti
nexti arg
  Execute one machine instruction, but if it is a function call, proceed until the
  function returns.
  An argument is a repeat count, as in `next`.

By default, and if available, GDB makes use of target-assisted range stepping. In other
words, whenever you use a stepping command (e.g., `step`, `next`), GDB tells the target to
step the corresponding range of instruction addresses instead of issuing multiple single-steps.
This speeds up line stepping, particularly for remote targets. Ideally, there should be no
reason you would want to turn range stepping off. However, it’s possible that a bug in the
debug info, a bug in the remote stub (for remote targets), or even a bug in GDB could make
line stepping behave incorrectly when target-assisted range stepping is enabled. You can
use the following command to turn off range stepping if necessary:

set range-stepping
show range-stepping
  Control whether range stepping is enabled.
  If `on`, and the target supports it, GDB tells the target to step a range of addresses
  itself, instead of issuing multiple single-steps. If `off`, GDB always issues single-
  steps, even if range stepping is supported by the target. The default is `on`.

5.3 Skipping Over Functions and Files

The program you are debugging may contain some functions which are uninteresting to
debug. The `skip` command lets you tell GDB to skip a function or all functions in a file when
stepping.

For example, consider the following C function:

```
int func()
{
  foo(boring());
  bar(boring());
}
```

Suppose you wish to step into the functions `foo` and `bar`, but you are not interested in
stepping through `boring`. If you run `step` at line 103, you’ll enter `boring()`, but if you run
`next`, you’ll step over both `foo` and `boring`!

One solution is to `step` into `boring` and use the `finish` command to immediately exit
it. But this can become tedious if `boring` is called from many places.

A more flexible solution is to execute `skip boring`. This instructs GDB never to step
into `boring`. Now when you execute `step` at line 103, you’ll step over `boring` and directly
into `foo`. 
You can also instruct GDB to skip all functions in a file, with, for example, `skip file boring.c`.

```
skip [linespec]
skip function [linespec]
```

After running this command, the function named by `linespec` or the function containing the line named by `linespec` will be skipped over when stepping. See Section 9.2 [Specify Location], page 102.

If you do not specify `linespec`, the function you’re currently debugging will be skipped.

(If you have a function called `file` that you want to skip, use `skip function file`.)

```
skip file [filename]
```

After running this command, any function whose source lives in `filename` will be skipped over when stepping.

If you do not specify `filename`, functions whose source lives in the file you’re currently debugging will be skipped.

Skips can be listed, deleted, disabled, and enabled, much like breakpoints. These are the commands for managing your list of skips:

```
info skip [range]
```

Print details about the specified skip(s). If `range` is not specified, print a table with details about all functions and files marked for skipping. `info skip` prints the following information about each skip:

- **Identifier**: A number identifying this skip.
- **Type**: The type of this skip, either `function` or `file`.
- **Enabled or Disabled**: Enabled skips are marked with ‘y’. Disabled skips are marked with ‘n’.
- **Address**: For function skips, this column indicates the address in memory of the function being skipped. If you’ve set a function skip on a function which has not yet been loaded, this field will contain ‘<PENDING>’. Once a shared library which has the function is loaded, `info skip` will show the function’s address here.
- **What**: For file skips, this field contains the filename being skipped. For functions skips, this field contains the function name and its line number in the file where it is defined.

```
skip delete [range]
```

Delete the specified skip(s). If `range` is not specified, delete all skips.

```
skip enable [range]
```

Enable the specified skip(s). If `range` is not specified, enable all skips.

```
skip disable [range]
```

Disable the specified skip(s). If `range` is not specified, disable all skips.
5.4 Signals

A signal is an asynchronous event that can happen in a program. The operating system defines the possible kinds of signals, and gives each kind a name and a number. For example, in Unix SIGINT is the signal a program gets when you type an interrupt character (often Ctrl-c); SIGSEGV is the signal a program gets from referencing a place in memory far away from all the areas in use; SIGALRM occurs when the alarm clock timer goes off (which happens only if your program has requested an alarm).

Some signals, including SIGALRM, are a normal part of the functioning of your program. Others, such as SIGSEGV, indicate errors; these signals are fatal (they kill your program immediately) if the program has not specified in advance some other way to handle the signal. SIGINT does not indicate an error in your program, but it is normally fatal so it can carry out the purpose of the interrupt: to kill the program.

GDB has the ability to detect any occurrence of a signal in your program. You can tell GDB in advance what to do for each kind of signal.

Normally, GDB is set up to let the non-erroneous signals like SIGALRM be silently passed to your program (so as not to interfere with their role in the program’s functioning) but to stop your program immediately whenever an error signal happens. You can change these settings with the handle command.

info signals
info handle
Print a table of all the kinds of signals and how GDB has been told to handle each one. You can use this to see the signal numbers of all the defined types of signals.

info signals sig
Similar, but print information only about the specified signal number.

info handle is an alias for info signals.

catch signal [signal... | ‘all’]
Set a catchpoint for the indicated signals. See Section 5.1.3 [Set Catchpoints], page 55, for details about this command.

handle signal [keywords...]
Change the way GDB handles signal signal. The signal can be the number of a signal or its name (with or without the ‘SIG’ at the beginning); a list of signal numbers of the form ‘low-high’; or the word ‘all’, meaning all the known signals. Optional arguments keywords, described below, say what change to make.

The keywords allowed by the handle command can be abbreviated. Their full names are:

nostop GDB should not stop your program when this signal happens. It may still print a message telling you that the signal has come in.

stop GDB should stop your program when this signal happens. This implies the print keyword as well.

print GDB should print a message when this signal happens.
GDB should not mention the occurrence of the signal at all. This implies the `nostop` keyword as well.

GDB should allow your program to see this signal; your program can handle the signal, or else it may terminate if the signal is fatal and not handled. `pass` and `noignore` are synonyms.

GDB should not allow your program to see this signal. `nopass` and `ignore` are synonyms.

When a signal stops your program, the signal is not visible to the program until you continue. Your program sees the signal then, if `pass` is in effect for the signal in question at that time. In other words, after GDB reports a signal, you can use the `handle` command with `pass` or `nopass` to control whether your program sees that signal when you continue.

The default is set to `nostop`, `noprint`, `pass` for non-erroneous signals such as `SIGALRM`, `SIGWINCH` and `SIGCHLD`, and to `stop`, `print`, `pass` for the erroneous signals.

You can also use the `signal` command to prevent your program from seeing a signal, or cause it to see a signal it normally would not see, or to give it any signal at any time. For example, if your program stopped due to some sort of memory reference error, you might store correct values into the erroneous variables and continue, hoping to see more execution; but your program would probably terminate immediately as a result of the fatal signal once it saw the signal. To prevent this, you can continue with `signal 0`. See Section 17.3 [Giving your Program a Signal], page 227.

GDB optimizes for stepping the mainline code. If a signal that has `handle nostop` and `handle pass` set arrives while a stepping command (e.g., `stepi`, `step`, `next`) is in progress, GDB lets the signal handler run and then resumes stepping the mainline code once the signal handler returns. In other words, GDB steps over the signal handler. This prevents signals that you’ve specified as not interesting (with `handle nostop`) from changing the focus of debugging unexpectedly. Note that the signal handler itself may still hit a breakpoint, stop for another signal that has `handle stop` in effect, or for any other event that normally results in stopping the stepping command sooner. Also note that GDB still informs you that the program received a signal if `handle print` is set.

If you set `handle pass` for a signal, and your program sets up a handler for it, then issuing a stepping command, such as `step` or `stepi`, when your program is stopped due to the signal will step into the signal handler (if the target supports that).

Likewise, if you use the `queue-signal` command to queue a signal to be delivered to the current thread when execution of the thread resumes (see Section 17.3 [Giving your Program a Signal], page 227), then a stepping command will step into the signal handler.

Here’s an example, using `stepi` to step to the first instruction of `SIGUSR1`’s handler:

```
(gdb) handle SIGUSR1
Signal  Stop  Print  Pass to program Description
SIGUSR1  Yes  Yes  Yes  User defined signal 1
(gdb) c
Continuing.

Program received signal SIGUSR1, User defined signal 1.
main () sigusr1.c:28
```
The same, but using `queue-signal` instead of waiting for the program to receive the signal first:

```
(gdb) n
28 p = 0;
(gdb) queue-signal SIGUSR1
(gdb) si
sigusr1_handler () at sigusr1.c:9
9 {
(gdb)
```

On some targets, GDB can inspect extra signal information associated with the intercepted signal, before it is actually delivered to the program being debugged. This information is exported by the convenience variable $._siginfo, and consists of data that is passed by the kernel to the signal handler at the time of the receipt of a signal. The data type of the information itself is target dependent. You can see the data type using the `ptype $._siginfo` command. On Unix systems, it typically corresponds to the standard `siginfo_t` type, as defined in the `signal.h` system header.

Here’s an example, on a GNU/Linux system, printing the stray referenced address that raised a segmentation fault.

```
(gdb) continue
Program received signal SIGSEGV, Segmentation fault.
0x000000000000400766 in main ()
69 *(int *)p = 0;
(gdb) ptype $._siginfo
type = struct {
    int si_signo;
    int si_errno;
    int si_code;
    union {
        int _pad[28];
        struct {...} _kill;
        struct {...} _timer;
        struct {...} _rt;
        struct {...} _sigchld;
        struct {...} _sigfault;
        struct {...} _sigpoll;
    } _sifields;
} $_siginfo;
(gdb) ptype $._siginfo._sifields._sigfault
(type = struct {
    void *si_addr;
} $_siginfo._sifields._sigfault
(gdb) p $._siginfo._sifields._sigfault.si_addr
$1 = (void *) 0x7fffffff7000
```

Depending on target support, $._siginfo may also be writable.

### 5.5 Stopping and Starting Multi-thread Programs

GDB supports debugging programs with multiple threads (see Section 4.10 [Debugging Programs with Multiple Threads], page 36). There are two modes of controlling execution of
your program within the debugger. In the default mode, referred to as all-stop mode, when any thread in your program stops (for example, at a breakpoint or while being stepped), all other threads in the program are also stopped by GDB. On some targets, GDB also supports non-stop mode, in which other threads can continue to run freely while you examine the stopped thread in the debugger.

5.5.1 All-Stop Mode

In all-stop mode, whenever your program stops under GDB for any reason, all threads of execution stop, not just the current thread. This allows you to examine the overall state of the program, including switching between threads, without worrying that things may change underfoot.

Conversely, whenever you restart the program, all threads start executing. This is true even when single-stepping with commands like step or next.

In particular, GDB cannot single-step all threads in lockstep. Since thread scheduling is up to your debugging target's operating system (not controlled by GDB), other threads may execute more than one statement while the current thread completes a single step. Moreover, in general other threads stop in the middle of a statement, rather than at a clean statement boundary, when the program stops.

You might even find your program stopped in another thread after continuing or even single-stepping. This happens whenever some other thread runs into a breakpoint, a signal, or an exception before the first thread completes whatever you requested.

Whenever GDB stops your program, due to a breakpoint or a signal, it automatically selects the thread where that breakpoint or signal happened. GDB alerts you to the context switch with a message such as ‘[Switching to Thread n]’ to identify the thread.

On some OSes, you can modify GDB’s default behavior by locking the OS scheduler to allow only a single thread to run.

```
set scheduler-locking mode
```

Set the scheduler locking mode. If it is off, then there is no locking and any thread may run at any time. If on, then only the current thread may run when the inferior is resumed. The step mode optimizes for single-stepping; it prevents other threads from preemption the current thread while you are stepping, so that the focus of debugging does not change unexpectedly. Other threads never get a chance to run when you step, and they are completely free to run when you use commands like ‘continue’, ‘until’, or ‘finish’. However, unless another thread hits a breakpoint during its timeslice, GDB does not change the current thread away from the thread that you are debugging.

```
show scheduler-locking
```

Display the current scheduler locking mode.

By default, when you issue one of the execution commands such as continue, next or step, GDB allows only threads of the current inferior to run. For example, if GDB is attached to two inferiors, each with two threads, the continue command resumes only the two threads of the current inferior. This is useful, for example, when you debug a program that forks and you want to hold the parent stopped (so that, for instance, it doesn’t run to exit), while you debug the child. In other situations, you may not be interested in inspecting
the current state of any of the processes GDB is attached to, and you may want to resume them all until some breakpoint is hit. In the latter case, you can instruct GDB to allow all threads of all the inferiors to run with the `set schedule-multiple` command.

**set schedule-multiple**

Set the mode for allowing threads of multiple processes to be resumed when an execution command is issued. When `on`, all threads of all processes are allowed to run. When `off`, only the threads of the current process are resumed. The default is `off`. The `scheduler-locking` mode takes precedence when set to `on`, or while you are stepping and set to `step`.

**show schedule-multiple**

Display the current mode for resuming the execution of threads of multiple processes.

### 5.5.2 Non-Stop Mode

For some multi-threaded targets, GDB supports an optional mode of operation in which you can examine stopped program threads in the debugger while other threads continue to execute freely. This minimizes intrusion when debugging live systems, such as programs where some threads have real-time constraints or must continue to respond to external events. This is referred to as *non-stop* mode.

In non-stop mode, when a thread stops to report a debugging event, *only* that thread is stopped; GDB does not stop other threads as well, in contrast to the all-stop mode behavior. Additionally, execution commands such as `continue` and `step` apply by default only to the current thread in non-stop mode, rather than all threads as in all-stop mode. This allows you to control threads explicitly in ways that are not possible in all-stop mode — for example, stepping one thread while allowing others to run freely, stepping one thread while holding all others stopped, or stepping several threads independently and simultaneously.

To enter non-stop mode, use this sequence of commands before you run or attach to your program:

```bash
# If using the CLI, pagination breaks non-stop.
set pagination off

# Finally, turn it on!
set non-stop on
```

You can use these commands to manipulate the non-stop mode setting:

**set non-stop on**

Enable selection of non-stop mode.

**set non-stop off**

Disable selection of non-stop mode.

**show non-stop**

Show the current non-stop enablement setting.

Note these commands only reflect whether non-stop mode is enabled, not whether the currently-executing program is being run in non-stop mode. In particular, the `set non-stop` preference is only consulted when GDB starts or connects to the target program, and it is generally not possible to switch modes once debugging has started. Furthermore, since
not all targets support non-stop mode, even when you have enabled non-stop mode, GDB may still fall back to all-stop operation by default.

In non-stop mode, all execution commands apply only to the current thread by default. That is, `continue` only continues one thread. To continue all threads, issue `continue -a` or `c -a`.

You can use GDB’s background execution commands (see Section 5.5.3 [Background Execution], page 78) to run some threads in the background while you continue to examine or step others from GDB. The MI execution commands (see Section 27.15 [GDB/MI Program Execution], page 490) are always executed asynchronously in non-stop mode.

Suspending execution is done with the `interrupt` command when running in the background, or `Ctrl-c` during foreground execution. In all-stop mode, this stops the whole process; but in non-stop mode the interrupt applies only to the current thread. To stop the whole program, use `interrupt -a`.

Other execution commands do not currently support the `-a` option.

In non-stop mode, when a thread stops, GDB doesn’t automatically make that thread current, as it does in all-stop mode. This is because the thread stop notifications are asynchronous with respect to GDB’s command interpreter, and it would be confusing if GDB unexpectedly changed to a different thread just as you entered a command to operate on the previously current thread.

### 5.5.3 Background Execution

GDB’s execution commands have two variants: the normal foreground (synchronous) behavior, and a background (asynchronous) behavior. In foreground execution, GDB waits for the program to report that some thread has stopped before prompting for another command. In background execution, GDB immediately gives a command prompt so that you can issue other commands while your program runs.

If the target doesn’t support async mode, GDB issues an error message if you attempt to use the background execution commands.

To specify background execution, add a `&` to the command. For example, the background form of the `continue` command is `continue&`, or just `c&`. The execution commands that accept background execution are:

- `run` [Starting your Program], page 26.
- `attach` [Debugging an Already-running Process], page 32.
- `step` [Continuing and Stepping], page 68.
- `stepi` [Continuing and Stepping], page 68.
- `next` [Continuing and Stepping], page 68.
- `nexti` [Continuing and Stepping], page 68.
- `continue` [Continuing and Stepping], page 68.
- `finish` [Continuing and Stepping], page 68.
- `until` [Continuing and Stepping], page 68.
Chapter 5: Stopping and Continuing

Background execution is especially useful in conjunction with non-stop mode for debugging programs with multiple threads; see Section 5.5.2 [Non-Stop Mode], page 77. However, you can also use these commands in the normal all-stop mode with the restriction that you cannot issue another execution command until the previous one finishes. Examples of commands that are valid in all-stop mode while the program is running include help and info break.

You can interrupt your program while it is running in the background by using the interrupt command.

```
interrupt
interrupt -a
```

Suspend execution of the running program. In all-stop mode, interrupt stops the whole process, but in non-stop mode, it stops only the current thread. To stop the whole program in non-stop mode, use interrupt -a.

### 5.5.4 Thread-Specific Breakpoints

When your program has multiple threads (see Section 4.10 [Debugging Programs with Multiple Threads], page 36), you can choose whether to set breakpoints on all threads, or on a particular thread.

```
break location thread threadno
break location thread threadno if ...
```

location specifies source lines; there are several ways of writing them (see Section 9.2 [Specify Location], page 102), but the effect is always to specify some source line.

Use the qualifier ‘thread threadno’ with a breakpoint command to specify that you only want GDB to stop the program when a particular thread reaches this breakpoint. The threadno specifier is one of the numeric thread identifiers assigned by GDB, shown in the first column of the ‘info threads’ display.

If you do not specify ‘thread threadno’ when you set a breakpoint, the breakpoint applies to all threads of your program.

You can use the thread qualifier on conditional breakpoints as well; in this case, place ‘thread threadno’ before or after the breakpoint condition, like this:

```
(gdb) break frik.c:13 thread 28 if bartab > lim
```

Thread-specific breakpoints are automatically deleted when GDB detects the corresponding thread is no longer in the thread list. For example:

```
(gdb) c
Thread-specific breakpoint 3 deleted - thread 28 no longer in the thread list.
```

There are several ways for a thread to disappear, such as a regular thread exit, but also when you detach from the process with the detach command (see Section 4.7 [Debugging an Already-running Process], page 32), or if GDB loses the remote connection (see Chapter 20 [Remote Debugging], page 257), etc. Note that with some targets, GDB is only able to detect a thread has exited when the user explicitly asks for the thread list with the info threads command.
5.5.5 Interrupted System Calls

There is an unfortunate side effect when using GDB to debug multi-threaded programs. If one thread stops for a breakpoint, or for some other reason, and another thread is blocked in a system call, then the system call may return prematurely. This is a consequence of the interaction between multiple threads and the signals that GDB uses to implement breakpoints and other events that stop execution.

To handle this problem, your program should check the return value of each system call and react appropriately. This is good programming style anyways.

For example, do not write code like this:

```c
sleep (10);
```

The call to `sleep` will return early if a different thread stops at a breakpoint or for some other reason.

Instead, write this:

```c
int unslept = 10;
while (unslept > 0)
    unslept = sleep (unslept);
```

A system call is allowed to return early, so the system is still conforming to its specification. But GDB does cause your multi-threaded program to behave differently than it would without GDB.

Also, GDB uses internal breakpoints in the thread library to monitor certain events such as thread creation and thread destruction. When such an event happens, a system call in another thread may return prematurely, even though your program does not appear to stop.

5.5.6 Observer Mode

If you want to build on non-stop mode and observe program behavior without any chance of disruption by GDB, you can set variables to disable all of the debugger’s attempts to modify state, whether by writing memory, inserting breakpoints, etc. These operate at a low level, intercepting operations from all commands.

When all of these are set to `off`, then GDB is said to be observer mode. As a convenience, the variable `observer` can be set to disable these, plus enable non-stop mode.

Note that GDB will not prevent you from making nonsensical combinations of these settings. For instance, if you have enabled `may-insert-breakpoints` but disabled `may-write-memory`, then breakpoints that work by writing trap instructions into the code stream will still not be able to be placed.

```
set observer on
set observer off
```

When set to `on`, this disables all the permission variables below (except for `insert-fast-tracepoints`), plus enables non-stop debugging. Setting this to `off` switches back to normal debugging, though remaining in non-stop mode.

```
show observer
```

Show whether observer mode is on or off.
set may-write-registers on
set may-write-registers off
This controls whether GDB will attempt to alter the values of registers, such as
with assignment expressions in print, or the jump command. It defaults to on.

show may-write-registers
Show the current permission to write registers.

set may-write-memory on
set may-write-memory off
This controls whether GDB will attempt to alter the contents of memory, such
as with assignment expressions in print. It defaults to on.

show may-write-memory
Show the current permission to write memory.

set may-insert-breakpoints on
set may-insert-breakpoints off
This controls whether GDB will attempt to insert breakpoints. This affects all
breakpoints, including internal breakpoints defined by GDB. It defaults to on.

show may-insert-breakpoints
Show the current permission to insert breakpoints.

set may-insert-tracepoints on
set may-insert-tracepoints off
This controls whether GDB will attempt to insert (regular) tracepoints at the
beginning of a tracing experiment. It affects only non-fast tracepoints, fast tra-
cepoints being under the control of may-insert-fast-tracepoints. It defaults
to on.

show may-insert-tracepoints
Show the current permission to insert tracepoints.

set may-insert-fast-tracepoints on
set may-insert-fast-tracepoints off
This controls whether GDB will attempt to insert fast tracepoints at the begin-
nning of a tracing experiment. It affects only fast tracepoints, regular (non-fast)
tracepoints being under the control of may-insert-tracepoints. It defaults
to on.

show may-insert-fast-tracepoints
Show the current permission to insert fast tracepoints.

set may-interrupt on
set may-interrupt off
This controls whether GDB will attempt to interrupt or stop program execution.
When this variable is off, the interrupt command will have no effect, nor will
Ctrl-c. It defaults to on.

show may-interrupt
Show the current permission to interrupt or stop the program.
6 Running programs backward

When you are debugging a program, it is not unusual to realize that you have gone too far, and some event of interest has already happened. If the target environment supports it, GDB can allow you to “rewind” the program by running it backward.

A target environment that supports reverse execution should be able to “undo” the changes in machine state that have taken place as the program was executing normally. Variables, registers etc. should revert to their previous values. Obviously this requires a great deal of sophistication on the part of the target environment; not all target environments can support reverse execution.

When a program is executed in reverse, the instructions that have most recently been executed are “un-executed”, in reverse order. The program counter runs backward, following the previous thread of execution in reverse. As each instruction is “un-executed”, the values of memory and/or registers that were changed by that instruction are reverted to their previous states. After executing a piece of source code in reverse, all side effects of that code should be “undone”, and all variables should be returned to their prior values.

If you are debugging in a target environment that supports reverse execution, GDB provides the following commands.

```
reverse-continue [ignore-count]
rc [ignore-count]
```

Beginning at the point where your program last stopped, start executing in reverse. Reverse execution will stop for breakpoints and synchronous exceptions (signals), just like normal execution. Behavior of asynchronous signals depends on the target environment.

```
reverse-step [count]
```

Run the program backward until control reaches the start of a different source line; then stop it, and return control to GDB.

Like the `step` command, `reverse-step` will only stop at the beginning of a source line. It “un-executes” the previously executed source line. If the previous source line included calls to debuggable functions, `reverse-step` will step (backward) into the called function, stopping at the beginning of the last statement in the called function (typically a return statement).

Also, as with the `step` command, if non-debuggable functions are called, `reverse-step` will run thru them backward without stopping.

```
reverse-stepi [count]
```

Reverse-execute one machine instruction. Note that the instruction to be reverse-executed is *not* the one pointed to by the program counter, but the

---

1 Note that some side effects are easier to undo than others. For instance, memory and registers are relatively easy, but device I/O is hard. Some targets may be able undo things like device I/O, and some may not.

The contract between GDB and the reverse executing target requires only that the target do something reasonable when GDB tells it to execute backwards, and then report the results back to GDB. Whatever the target reports back to GDB, GDB will report back to the user. GDB assumes that the memory and registers that the target reports are in a consistant state, but GDB accepts whatever it is given.
instruction executed prior to that one. For instance, if the last instruction was a jump, reverse-stepi will take you back from the destination of the jump to the jump instruction itself.

reverse-next [count]
Run backward to the beginning of the previous line executed in the current (innermost) stack frame. If the line contains function calls, they will be “un-executed” without stopping. Starting from the first line of a function, reverse-next will take you back to the caller of that function, before the function was called, just as the normal next command would take you from the last line of a function back to its return to its caller2.

reverse-nexti [count]
Like nexti, reverse-nexti executes a single instruction in reverse, except that called functions are “un-executed” atomically. That is, if the previously executed instruction was a return from another function, reverse-nexti will continue to execute in reverse until the call to that function (from the current stack frame) is reached.

reverse-finish
Just as the finish command takes you to the point where the current function returns, reverse-finish takes you to the point where it was called. Instead of ending up at the end of the current function invocation, you end up at the beginning.

set exec-direction
Set the direction of target execution.

set exec-direction reverse
GDB will perform all execution commands in reverse, until the exec-direction mode is changed to “forward”. Affected commands include step, stepi, next, nexti, continue, and finish. The return command cannot be used in reverse mode.

set exec-direction forward
GDB will perform all execution commands in the normal fashion. This is the default.

2 Unless the code is too heavily optimized.
7 Recording Inferior’s Execution and Replaying It

On some platforms, GDB provides a special process record and replay target that can record a log of the process execution, and replay it later with both forward and reverse execution commands.

When this target is in use, if the execution log includes the record for the next instruction, GDB will debug in replay mode. In the replay mode, the inferior does not really execute code instructions. Instead, all the events that normally happen during code execution are taken from the execution log. While code is not really executed in replay mode, the values of registers (including the program counter register) and the memory of the inferior are still changed as they normally would. Their contents are taken from the execution log.

If the record for the next instruction is not in the execution log, GDB will debug in record mode. In this mode, the inferior executes normally, and GDB records the execution log for future replay.

The process record and replay target supports reverse execution (see Chapter 6 [Reverse Execution], page 83), even if the platform on which the inferior runs does not. However, the reverse execution is limited in this case by the range of the instructions recorded in the execution log. In other words, reverse execution on platforms that don’t support it directly can only be done in the replay mode.

When debugging in the reverse direction, GDB will work in replay mode as long as the execution log includes the record for the previous instruction; otherwise, it will work in record mode, if the platform supports reverse execution, or stop if not.

For architecture environments that support process record and replay, GDB provides the following commands:

**record method**

This command starts the process record and replay target. The recording method can be specified as parameter. Without a parameter the command uses the full recording method. The following recording methods are available:

- **full** Full record/replay recording using GDB’s software record and replay implementation. This method allows replaying and reverse execution.

**btrace format**

Hardware-supported instruction recording. This method does not record data. Further, the data is collected in a ring buffer so old data will be overwritten when the buffer is full. It allows limited reverse execution. Variables and registers are not available during reverse execution.

The recording format can be specified as parameter. Without a parameter the command chooses the recording format. The following recording formats are available:

- **bts** Use the Branch Trace Store (BTS) recording format. In this format, the processor stores a from/to record for each executed branch in the btrace ring buffer.
Use the Intel(R) Processor Trace recording format. In this format, the processor stores the execution trace in a compressed form that is afterwards decoded by GDB. The trace can be recorded with very low overhead. The compressed trace format also allows small trace buffers to already contain a big number of instructions compared to BTS.

Decoding the recorded execution trace, on the other hand, is more expensive than decoding BTS trace. This is mostly due to the increased number of instructions to process. You should increase the buffer-size with care.

Not all recording formats may be available on all processors.

The process record and replay target can only debug a process that is already running. Therefore, you need first to start the process with the run or start commands, and then start the recording with the record method command.

Displaced stepping (see Appendix D [displaced stepping], page 597) will be automatically disabled when process record and replay target is started. That’s because the process record and replay target doesn’t support displaced stepping.

If the inferior is in the non-stop mode (see Section 5.5.2 [Non-Stop Mode], page 77) or in the asynchronous execution mode (see Section 5.5.3 [Background Execution], page 78), not all recording methods are available. The full recording method does not support these two modes.

Stop the process record and replay target. When process record and replay target stops, the entire execution log will be deleted and the inferior will either be terminated, or will remain in its final state.

When you stop the process record and replay target in record mode (at the end of the execution log), the inferior will be stopped at the next instruction that would have been recorded. In other words, if you record for a while and then stop recording, the inferior process will be left in the same state as if the recording never happened.

On the other hand, if the process record and replay target is stopped while in replay mode (that is, not at the end of the execution log, but at some earlier point), the inferior process will become “live” at that earlier state, and it will then be possible to continue the usual “live” debugging of the process from that state.

When the inferior process exits, or GDB detaches from it, process record and replay target will automatically stop itself.

Go to a specific location in the execution log. There are several ways to specify the location to go to:

record goto begin
record goto start

Go to the beginning of the execution log.
record goto end
   Go to the end of the execution log.

record goto n
   Go to instruction number n in the execution log.

record save filename
   Save the execution log to a file ‘filename’. Default filename is ‘gdb_record.process_id’, where process_id is the process ID of the inferior. This command may not be available for all recording methods.

record restore filename
   Restore the execution log from a file ‘filename’. File must have been created with record save.

set record full insn-number-max limit
set record full insn-number-max unlimited
   Set the limit of instructions to be recorded for the full recording method. Default value is 200000.
   If limit is a positive number, then GDB will start deleting instructions from the log once the number of the record instructions becomes greater than limit. For every new recorded instruction, GDB will delete the earliest recorded instruction to keep the number of recorded instructions at the limit. (Since deleting recorded instructions loses information, GDB lets you control what happens when the limit is reached, by means of the stop-at-limit option, described below.)
   If limit is unlimited or zero, GDB will never delete recorded instructions from the execution log. The number of recorded instructions is limited only by the available memory.

show record full insn-number-max
   Show the limit of instructions to be recorded with the full recording method.

set record full stop-at-limit
   Control the behavior of the full recording method when the number of recorded instructions reaches the limit. If ON (the default), GDB will stop when the limit is reached for the first time and ask you whether you want to stop the inferior or continue running it and recording the execution log. If you decide to continue recording, each new recorded instruction will cause the oldest one to be deleted.
   If this option is OFF, GDB will automatically delete the oldest record to make room for each new one, without asking.

show record full stop-at-limit
   Show the current setting of stop-at-limit.

set record full memory-query
   Control the behavior when GDB is unable to record memory changes caused by an instruction for the full recording method. If ON, GDB will query whether to stop the inferior in that case.
   If this option is OFF (the default), GDB will automatically ignore the effect of such instructions on memory. Later, when GDB replays this execution log, it
will mark the log of this instruction as not accessible, and it will not affect the replay results.

```
show record full memory-query
```

Show the current setting of `memory-query`.

The `btrace` record target does not trace data. As a convenience, when replaying, GDB reads read-only memory off the live program directly, assuming that the addresses of the read-only areas don’t change. This for example makes it possible to disassemble code while replaying, but not to print variables. In some cases, being able to inspect variables might be useful. You can use the following command for that:

```
set record btrace replay-memory-access
```

Control the behavior of the `btrace` recording method when accessing memory during replay. If `read-only` (the default), GDB will only allow accesses to read-only memory. If `read-write`, GDB will allow accesses to read-only and to read-write memory. Beware that the accessed memory corresponds to the live target and not necessarily to the current replay position.

```
show record btrace replay-memory-access
```

Show the current setting of `replay-memory-access`.

```
set record btrace bts buffer-size size
set record btrace bts buffer-size unlimited
```

Set the requested ring buffer size for branch tracing in BTS format. Default is 64KB.

If `size` is a positive number, then GDB will try to allocate a buffer of at least `size` bytes for each new thread that uses the btrace recording method and the BTS format. The actually obtained buffer size may differ from the requested size. Use the `info record` command to see the actual buffer size for each thread that uses the btrace recording method and the BTS format.

If `limit` is `unlimited` or zero, GDB will try to allocate a buffer of 4MB.

Bigger buffers mean longer traces. On the other hand, GDB will also need longer to process the branch trace data before it can be used.

```
show record btrace bts buffer-size size
```

Show the current setting of the requested ring buffer size for branch tracing in BTS format.

```
set record btrace pt buffer-size size
set record btrace pt buffer-size unlimited
```

Set the requested ring buffer size for branch tracing in Intel(R) Processor Trace format. Default is 16KB.

If `size` is a positive number, then GDB will try to allocate a buffer of at least `size` bytes for each new thread that uses the btrace recording method and the Intel(R) Processor Trace format. The actually obtained buffer size may differ from the requested `size`. Use the `info record` command to see the actual buffer size for each thread.

If `limit` is `unlimited` or zero, GDB will try to allocate a buffer of 4MB.
Bigger buffers mean longer traces. On the other hand, GDB will also need longer to process the branch trace data before it can be used.

**show record btrace pt buffer-size size**
Show the current setting of the requested ring buffer size for branch tracing in Intel(R) Processor Trace format.

**info record**
Show various statistics about the recording depending on the recording method:

- **full** For the full recording method, it shows the state of process record and its in-memory execution log buffer, including:
  - Whether in record mode or replay mode.
  - Lowest recorded instruction number (counting from when the current execution log started recording instructions).
  - Highest recorded instruction number.
  - Current instruction about to be replayed (if in replay mode).
  - Number of instructions contained in the execution log.
  - Maximum number of instructions that may be contained in the execution log.

- **btrace** For the btrace recording method, it shows:
  - Recording format.
  - Number of instructions that have been recorded.
  - Number of blocks of sequential control-flow formed by the recorded instructions.
  - Whether in record mode or replay mode.

For the bts recording format, it also shows:
  - Size of the perf ring buffer.

For the pt recording format, it also shows:
  - Size of the perf ring buffer.

**record delete**
When record target runs in replay mode ("in the past"), delete the subsequent execution log and begin to record a new execution log starting from the current address. This means you will abandon the previously recorded "future" and begin recording a new "future".

**record instruction-history**
Disassembles instructions from the recorded execution log. By default, ten instructions are disassembled. This can be changed using the `set record instruction-history-size` command. Instructions are printed in execution order.

Speculatively executed instructions are prefixed with ‘?’ This feature is not available for all recording formats.

There are several ways to specify what part of the execution log to disassemble:
record instruction-history insn
    Disassembles ten instructions starting from instruction number insn.

record instruction-history insn, +/−n
    Disassembles n instructions around instruction number insn. If n is preceded with +, disassembles n instructions after instruction number insn. If n is preceded with -, disassembles n instructions before instruction number insn.

record instruction-history
    Disassembles ten more instructions after the last disassembly.

record instruction-history -
    Disassembles ten more instructions before the last disassembly.

record instruction-history begin end
    Disassembles instructions beginning with instruction number begin until instruction number end. The instruction number end is included.

This command may not be available for all recording methods.

set record instruction-history-size size
set record instruction-history-size unlimited
    Define how many instructions to disassemble in the record instruction-history command. The default value is 10. A size of unlimited means unlimited instructions.

show record instruction-history-size
    Show how many instructions to disassemble in the record instruction-history command.

record function-call-history
    Prints the execution history at function granularity. It prints one line for each sequence of instructions that belong to the same function giving the name of that function, the source lines for this instruction sequence (if the /l modifier is specified), and the instructions numbers that form the sequence (if the /i modifier is specified). The function names are indented to reflect the call stack depth if the /c modifier is specified. The /l, /i, and /c modifiers can be given together.

    (gdb) list 1, 10
    1   void foo (void)
    2   {
    3   }
    4
    5   void bar (void)
    6   {
    7   ...
    8   foo ();
    9   ...
    10 }
    (gdb) record function-call-history /ilc
    1   bar   inst 1,4   at foo.c:6,8
2 foo inst 5,10 at foo.c:2,3
3 bar inst 11,13 at foo.c:9,10

By default, ten lines are printed. This can be changed using the `set record function-call-history-size` command. Functions are printed in execution order. There are several ways to specify what to print:

**record function-call-history func**
Prints ten functions starting from function number `func`.

**record function-call-history func, +/-n**
Prints `n` functions around function number `func`. If `n` is preceded with `+`, prints `n` functions after function number `func`. If `n` is preceded with `−`, prints `n` functions before function number `func`.

**record function-call-history**
Prints ten more functions after the last ten-line print.

**record function-call-history −**
Prints ten more functions before the last ten-line print.

**record function-call-history begin end**
Prints functions beginning with function number `begin` until function number `end`. The function number `end` is included.

This command may not be available for all recording methods.

**set record function-call-history-size size**
**set record function-call-history-size unlimited**
Define how many lines to print in the `record function-call-history` command. The default value is 10. A size of `unlimited` means unlimited lines.

**show record function-call-history-size**
Show how many lines to print in the `record function-call-history` command.
Chapter 8: Examining the Stack

8 Examining the Stack

When your program has stopped, the first thing you need to know is where it stopped and how it got there.

Each time your program performs a function call, information about the call is generated. That information includes the location of the call in your program, the arguments of the call, and the local variables of the function being called. The information is saved in a block of data called a stack frame. The stack frames are allocated in a region of memory called the call stack.

When your program stops, the GDB commands for examining the stack allow you to see all of this information.

One of the stack frames is selected by GDB and many GDB commands refer implicitly to the selected frame. In particular, whenever you ask GDB for the value of a variable in your program, the value is found in the selected frame. There are special GDB commands to select whichever frame you are interested in. See Section 8.4 [Selecting a Frame], page 99.

When your program stops, GDB automatically selects the currently executing frame and describes it briefly, similar to the frame command (see Section 8.5 [Information about a Frame], page 100).

8.1 Stack Frames

The call stack is divided up into contiguous pieces called stack frames, or frames for short; each frame is the data associated with one call to one function. The frame contains the arguments given to the function, the function’s local variables, and the address at which the function is executing.

When your program is started, the stack has only one frame, that of the function main. This is called the initial frame or the outermost frame. Each time a function is called, a new frame is made. Each time a function returns, the frame for that function invocation is eliminated. If a function is recursive, there can be many frames for the same function. The frame for the function in which execution is actually occurring is called the innermost frame. This is the most recently created of all the stack frames that still exist.

Inside your program, stack frames are identified by their addresses. A stack frame consists of many bytes, each of which has its own address; each kind of computer has a convention for choosing one byte whose address serves as the address of the frame. Usually this address is kept in a register called the frame pointer register (see Section 10.13 [Registers], page 141) while execution is going on in that frame.

GDB assigns numbers to all existing stack frames, starting with zero for the innermost frame, one for the frame that called it, and so on upward. These numbers do not really exist in your program; they are assigned by GDB to give you a way of designating stack frames in GDB commands.

Some compilers provide a way to compile functions so that they operate without stack frames. (For example, the GCC option

`-fomit-frame-pointer`

generates functions without a frame.) This is occasionally done with heavily used library functions to save the frame setup time. GDB has limited facilities for dealing with
these function invocations. If the innermost function invocation has no stack frame, GDB
nevertheless regards it as though it had a separate frame, which is numbered zero as usual,
allowing correct tracing of the function call chain. However, GDB has no provision for
frameless functions elsewhere in the stack.

(frame [framespec])
The frame command allows you to move from one stack frame to another, and
to print the stack frame you select. The framespec may be either the address
of the frame or the stack frame number. Without an argument, frame prints
the current stack frame.

select-frame
The select-frame command allows you to move from one stack frame to an-
other without printing the frame. This is the silent version of frame.

8.2 Backtraces
A backtrace is a summary of how your program got where it is. It shows one line per frame,
for many frames, starting with the currently executing frame (frame zero), followed by its
caller (frame one), and on up the stack.

backtrace
bt Print a backtrace of the entire stack: one line per frame for all frames in the
stack.
You can stop the backtrace at any time by typing the system interrupt charac-
ter, normally Ctrl-c.

backtrace n
bt n Similar, but print only the innermost n frames.

backtrace -n
bt -n Similar, but print only the outermost n frames.

backtrace full
bt full
bt full n
bt full -n
Print the values of the local variables also. As described above, n specifies the
number of frames to print.

backtrace no-filters
bt no-filters
bt no-filters n
bt no-filters -n
bt no-filters full
bt no-filters full n
bt no-filters full -n
Do not run Python frame filters on this backtrace. See Section 23.2.2.9 [Frame
Filter API], page 341, for more information. Additionally use [disable frame-
filter all], page 97 to turn off all frame filters. This is only relevant when GDB
has been configured with Python support.
Chapter 8: Examining the Stack

The names `where` and `info stack` (abbreviated `info s`) are additional aliases for `backtrace`.

In a multi-threaded program, GDB by default shows the backtrace only for the current thread. To display the backtrace for several or all of the threads, use the command `thread apply` (see Section 4.10 [Threads], page 36). For example, if you type `thread apply all backtrace`, GDB will display the backtrace for all the threads; this is handy when you debug a core dump of a multi-threaded program.

Each line in the backtrace shows the frame number and the function name. The program counter value is also shown—unless you use `set print address off`. The backtrace also shows the source file name and line number, as well as the arguments to the function. The program counter value is omitted if it is at the beginning of the code for that line number.

Here is an example of a backtrace. It was made with the command ‘`bt 3`’, so it shows the innermost three frames.

```
#0 m4_traceon (obs=0x24eb0, argc=1, argv=0x2b8c8)
   at builtin.c:993
#1 0x6e38 in expand_macro (sym=0x2b600, data=...) at macro.c:242
#2 0x6840 in expand_token (obs=0x0, t=177664, td=0xf7fffb08)
   at macro.c:71
(More stack frames follow...)
```

The display for frame zero does not begin with a program counter value, indicating that your program has stopped at the beginning of the code for line 993 of `builtin.c`.

The value of parameter `data` in frame 1 has been replaced by `. . .`. By default, GDB prints the value of a parameter only if it is a scalar (integer, pointer, enumeration, etc). See command `set print frame-arguments` in Section 10.8 [Print Settings], page 125 for more details on how to configure the way function parameter values are printed.

If your program was compiled with optimizations, some compilers will optimize away arguments passed to functions if those arguments are never used after the call. Such optimizations generate code that passes arguments through registers, but doesn’t store those arguments in the stack frame. GDB has no way of displaying such arguments in stack frames other than the innermost one. Here’s what such a backtrace might look like:

```
#0 m4_traceon (obs=0x24eb0, argc=1, argv=0x2b8c8)
   at builtin.c:993
#1 0x6e38 in expand_macro (sym=<optimized out>) at macro.c:242
#2 0x6840 in expand_token (obs=0x0, t=<optimized out>, td=0xf7fffb08)
   at macro.c:71
(More stack frames follow...)
```

The values of arguments that were not saved in their stack frames are shown as `<optimized out>`.

If you need to display the values of such optimized-out arguments, either deduce that from other variables whose values depend on the one you are interested in, or recompile without optimizations.

Most programs have a standard user entry point—a place where system libraries and startup code transition into user code. For C this is `main`

1. When GDB finds the entry function in a backtrace it will terminate the backtrace, to avoid tracing into highly system-specific (and generally uninteresting) code.

1 Note that embedded programs (the so-called “free-standing” environment) are not required to have a `main` function as the entry point. They could even have multiple entry points.
If you need to examine the startup code, or limit the number of levels in a backtrace, you can change this behavior:

```
set backtrace past-main
set backtrace past-main on
   Backtraces will continue past the user entry point.
set backtrace past-main off
   Backtraces will stop when they encounter the user entry point. This is the default.
show backtrace past-main
   Display the current user entry point backtrace policy.
set backtrace past-entry
set backtrace past-entry on
   Backtraces will continue past the internal entry point of an application. This entry point is encoded by the linker when the application is built, and is likely before the user entry point `main` (or equivalent) is called.
set backtrace past-entry off
   Backtraces will stop when they encounter the internal entry point of an application. This is the default.
show backtrace past-entry
   Display the current internal entry point backtrace policy.
set backtrace limit n
set backtrace limit 0
set backtrace limit unlimited
   Limit the backtrace to $n$ levels. A value of `unlimited` or zero means unlimited levels.
show backtrace limit
   Display the current limit on backtrace levels.
```

You can control how file names are displayed.

```
set filename-display
set filename-display relative
   Display file names relative to the compilation directory. This is the default.
set filename-display basename
   Display only basename of a filename.
set filename-display absolute
   Display an absolute filename.
show filename-display
   Show the current way to display filenames.
8.3 Management of Frame Filters.

Frame filters are Python based utilities to manage and decorate the output of frames. See Section 23.2.2.9 [Frame Filter API], page 341, for further information.

Managing frame filters is performed by several commands available within GDB, detailed here.

**info frame-filter**
Print a list of installed frame filters from all dictionaries, showing their name, priority and enabled status.

**disable frame-filter**
Disable a frame filter in the dictionary matching `filter-dictionary` and `filter-name`. The `filter-dictionary` may be all, global, progspace, or the name of the object file where the frame filter dictionary resides. When all is specified, all frame filters across all dictionaries are disabled. The `filter-name` is the name of the frame filter and is used when all is not the option for `filter-dictionary`. A disabled frame-filter is not deleted, it may be enabled again later.

**enable frame-filter**
Enable a frame filter in the dictionary matching `filter-dictionary` and `filter-name`. The `filter-dictionary` may be all, global, progspace or the name of the object file where the frame filter dictionary resides. When all is specified, all frame filters across all dictionaries are enabled. The `filter-name` is the name of the frame filter and is used when all is not the option for `filter-dictionary`.

Example:

```
(gdb) info frame-filter

    global frame-filters:
     Priority Enabled Name
      1000 No PrimaryFunctionFilter
       100 Yes Reverse

    progspace /build/test frame-filters:
     Priority Enabled Name
      100 Yes ProgspaceFilter

    objfile /build/test frame-filters:
     Priority Enabled Name
       999 Yes BuildProgra Filter

(gdb) disable frame-filter /build/test BuildProgramFilter
(gdb) info frame-filter

    global frame-filters:
     Priority Enabled Name
      1000 No PrimaryFunctionFilter
       100 Yes Reverse

    progspace /build/test frame-filters:
     Priority Enabled Name
       100 Yes ProgspaceFilter

    objfile /build/test frame-filters:
```
Debugging with GDB

```
Priority  Enabled  Name
999       No       BuildProgramFilter

(gdb) enable frame-filter global PrimaryFunctionFilter
(gdb) info frame-filter

global frame-filters:
  Priority  Enabled  Name
  1000      Yes       PrimaryFunctionFilter
  100       Yes       Reverse

progspace /build/test frame-filters:
  Priority  Enabled  Name
  100       Yes       ProgspaceFilter

objfile /build/test frame-filters:
  Priority  Enabled  Name
  999       No       BuildProgramFilter

set frame-filter priority filter-dictionary filter-name priority
  Set the priority of a frame filter in the dictionary matching filter-dictionary,
  and the frame filter name matching filter-name. The filter-dictionary may be
  global, progspace or the name of the object file where the frame filter dictionary
  resides. The priority is an integer.

show frame-filter priority filter-dictionary filter-name
  Show the priority of a frame filter in the dictionary matching filter-dictionary,
  and the frame filter name matching filter-name. The filter-dictionary may be
  global, progspace or the name of the object file where the frame filter dictionary
  resides.

Example:

  (gdb) info frame-filter

  global frame-filters:
    Priority  Enabled  Name
    1000      Yes       PrimaryFunctionFilter
    100       Yes       Reverse

  progspace /build/test frame-filters:
    Priority  Enabled  Name
    100       Yes       ProgspaceFilter

  objfile /build/test frame-filters:
    Priority  Enabled  Name
    999       No       BuildProgramFilter

  (gdb) set frame-filter priority global Reverse 50
  (gdb) info frame-filter

  global frame-filters:
    Priority  Enabled  Name
    1000      Yes       PrimaryFunctionFilter
    50        Yes       Reverse

  progspace /build/test frame-filters:
    Priority  Enabled  Name
```
8.4 Selecting a Frame

Most commands for examining the stack and other data in your program work on whichever stack frame is selected at the moment. Here are the commands for selecting a stack frame; all of them finish by printing a brief description of the stack frame just selected.

frame \( n \)
\( f \ n \) Select frame number \( n \). Recall that frame zero is the innermost (currently executing) frame, frame one is the frame that called the innermost one, and so on. The highest-numbered frame is the one for `main`.

frame \( \text{stack-addr} \ [ \text{pc-addr} ] \)
\( f \ \text{stack-addr} \ [ \text{pc-addr} ] \)
Select the frame at address `stack-addr`. This is useful mainly if the chaining of stack frames has been damaged by a bug, making it impossible for `gdb` to assign numbers properly to all frames. In addition, this can be useful when your program has multiple stacks and switches between them. The optional `pc-addr` can also be given to specify the value of PC for the stack frame.

up \( n \)
Move \( n \) frames up the stack; \( n \) defaults to 1. For positive numbers \( n \), this advances toward the outermost frame, to higher frame numbers, to frames that have existed longer.

down \( n \)
Move \( n \) frames down the stack; \( n \) defaults to 1. For positive numbers \( n \), this advances toward the innermost frame, to lower frame numbers, to frames that were created more recently. You may abbreviate `down` as `do`.

All of these commands end by printing two lines of output describing the frame. The first line shows the frame number, the function name, the arguments, and the source file and line number of execution in that frame. The second line shows the text of that source line.

For example:

(gdb) up
    #1 0x22f0 in main (argc=1, argv=0xf7fffbf4, env=0xf7fffbfc)
        at env.c:10
            read_input_file (argv[i]);

After such a printout, the `list` command with no arguments prints ten lines centered on the point of execution in the frame. You can also edit the program at the point of execution with your favorite editing program by typing `edit`. See Section 9.1 [Printing Source Lines], page 101, for details.

up-silently \( n \)
down-silently \( n \)
These two commands are variants of `up` and `down`, respectively; they differ in that they do their work silently, without causing display of the new frame. They
are intended primarily for use in GDB command scripts, where the output might be unnecessary and distracting.

8.5 Information About a Frame

There are several other commands to print information about the selected stack frame.

frame
    When used without any argument, this command does not change which frame is selected, but prints a brief description of the currently selected stack frame. It can be abbreviated f. With an argument, this command is used to select a stack frame. See Section 8.4 [Selecting a Frame], page 99.

info frame
    This command prints a verbose description of the selected stack frame, including:
    • the address of the frame
    • the address of the next frame down (called by this frame)
    • the address of the next frame up (caller of this frame)
    • the language in which the source code corresponding to this frame is written
    • the address of the frame’s arguments
    • the address of the frame’s local variables
    • the program counter saved in it (the address of execution in the caller frame)
    • which registers were saved in the frame

The verbose description is useful when something has gone wrong that has made the stack format fail to fit the usual conventions.

info frame addr
info f addr
    Print a verbose description of the frame at address addr, without selecting that frame. The selected frame remains unchanged by this command. This requires the same kind of address (more than one for some architectures) that you specify in the frame command. See Section 8.4 [Selecting a Frame], page 99.

info args
    Print the arguments of the selected frame, each on a separate line.

info locals
    Print the local variables of the selected frame, each on a separate line. These are all variables (declared either static or automatic) accessible at the point of execution of the selected frame.
9 Examining Source Files

GDB can print parts of your program’s source, since the debugging information recorded in the program tells GDB what source files were used to build it. When your program stops, GDB spontaneously prints the line where it stopped. Likewise, when you select a stack frame (see Section 8.4 [Selecting a Frame], page 99), GDB prints the line where execution in that frame has stopped. You can print other portions of source files by explicit command.

If you use GDB through its GNU Emacs interface, you may prefer to use Emacs facilities to view source; see Chapter 26 [Using GDB under GNU Emacs], page 455.

9.1 Printing Source Lines

To print lines from a source file, use the list command (abbreviated l). By default, ten lines are printed. There are several ways to specify what part of the file you want to print; see Section 9.2 [Specify Location], page 102, for the full list.

Here are the forms of the list command most commonly used:

list linenumber
   Print lines centered around line number linenumber in the current source file.

list function
   Print lines centered around the beginning of function function.

list
   Print more lines. If the last lines printed were printed with a list command, this prints lines following the last lines printed; however, if the last line printed was a solitary line printed as part of displaying a stack frame (see Chapter 8 [Examining the Stack], page 93), this prints lines centered around that line.

list -
   Print lines just before the lines last printed.

By default, GDB prints ten source lines with any of these forms of the list command. You can change this using set listsize:

set listsize count
   Make the list command display count source lines (unless the list argument explicitly specifies some other number). Setting count to unlimited or 0 means there’s no limit.

set listsize unlimited
   Make the list command display unlimited source lines (unless the list argument explicitly specifies some other number). Setting count to unlimited or 0 means there’s no limit.

show listsize
   Display the number of lines that list prints.

Repeating a list command with RET discards the argument, so it is equivalent to typing just list. This is more useful than listing the same lines again. An exception is made for an argument of ‘-’; that argument is preserved in repetition so that each repetition moves up in the source file.

In general, the list command expects you to supply zero, one or two locations. Locations specify source lines; there are several ways of writing them (see Section 9.2 [Specify Location], page 102), but the effect is always to specify some source line.

Here is a complete description of the possible arguments for list:
list location
  Print lines centered around the line specified by location.

list first, last
  Print lines from first to last. Both arguments are locations. When a list command has two locations, and the source file of the second location is omitted, this refers to the same source file as the first location.

list ,last
  Print lines ending with last.

list first,
  Print lines starting with first.

list +
  Print lines just after the lines last printed.

list -
  Print lines just before the lines last printed.

list
  As described in the preceding table.

9.2 Specifying a Location

Several GDB commands accept arguments that specify a location of your program’s code. Since GDB is a source-level debugger, a location usually specifies some line in the source code. Locations may be specified using three different formats: linespec locations, explicit locations, or address locations.

9.2.1 Linespec Locations

A linespec is a colon-separated list of source location parameters such as file name, function name, etc. Here are all the different ways of specifying a linespec:

linenum
  Specifies the line number linenum of the current source file.

–offset
  +offset
  Specifies the line offset lines before or after the current line. For the list command, the current line is the last one printed; for the breakpoint commands, this is the line at which execution stopped in the currently selected stack frame (see Section 8.1 [Frames], page 93, for a description of stack frames.) When used as the second of the two linespecs in a list command, this specifies the line offset lines up or down from the first linespec.

filename:linenum
  Specifies the line linenum in the source file filename. If filename is a relative file name, then it will match any source file name with the same trailing components. For example, if filename is ‘gcc/expr.c’, then it will match source file name of ‘/build/trunk/gcc/expr.c’, but not ‘/build/trunk/libcpp/expr.c’ or ‘/build/trunk/gcc/x-expr.c’.

function
  Specifies the line that begins the body of the function function. For example, in C, this is the line with the open brace.

function:label
  Specifies the line where label appears in function.
filename: function

Specifies the line that begins the body of the function function in the file filename. You only need the file name with a function name to avoid ambiguity when there are identically named functions in different source files.

label

Specifies the line at which the label named label appears in the function corresponding to the currently selected stack frame. If there is no current selected stack frame (for instance, if the inferior is not running), then GDB will not search for a label.

-pstap|-probe-stap [objfile:[provider:]]name

The GNU/Linux tool SystemTap provides a way for applications to embed static probes. See Section 5.1.10 [Static Probe Points], page 65, for more information on finding and using static probes. This form of linespec specifies the location of such a static probe.

If objfile is given, only probes coming from that shared library or executable matching objfile as a regular expression are considered. If provider is given, then only probes from that provider are considered. If several probes match the spec, GDB will insert a breakpoint at each one of those probes.

9.2.2 Explicit Locations

Explicit locations allow the user to directly specify the source location’s parameters using option-value pairs.

Explicit locations are useful when several functions, labels, or file names have the same name (base name for files) in the program’s sources. In these cases, explicit locations point to the source line you meant more accurately and unambiguously. Also, using explicit locations might be faster in large programs.

For example, the linespec ‘foo:bar’ may refer to a function bar defined in the file named ‘foo’ or the label bar in a function named foo. GDB must search either the file system or the symbol table to know.

The list of valid explicit location options is summarized in the following table:

-source filename

The value specifies the source file name. To differentiate between files with the same base name, prepend as many directories as is necessary to uniquely identify the desired file, e.g., ‘foo/bar/baz.c’. Otherwise GDB will use the first file it finds with the given base name. This option requires the use of either -function or -line.

-function function

The value specifies the name of a function. Operations on function locations unmodified by other options (such as -label or -line) refer to the line that begins the body of the function. In C, for example, this is the line with the open brace.

-label label

The value specifies the name of a label. When the function name is not specified, the label is searched in the function of the currently selected stack frame.
-line number
The value specifies a line offset for the location. The offset may either be absolute (-line 3) or relative (-line +3), depending on the command. When specified without any other options, the line offset is relative to the current line.

Explicit location options may be abbreviated by omitting any non-unique trailing characters from the option name, e.g., break -s main.c -li 3.

9.2.3 Address Locations
Address locations indicate a specific program address. They have the generalized form *address.

For line-oriented commands, such as list and edit, this specifies a source line that contains address. For break and other breakpoint-oriented commands, this can be used to set breakpoints in parts of your program which do not have debugging information or source files.

Here address may be any expression valid in the current working language (see Chapter 15 [Languages], page 187) that specifies a code address. In addition, as a convenience, GDB extends the semantics of expressions used in locations to cover several situations that frequently occur during debugging. Here are the various forms of address:

expression
Any expression valid in the current working language.

funcaddr
An address of a function or procedure derived from its name. In C, C++, Java, Objective-C, Fortran, minimal, and assembly, this is simply the function’s name function (and actually a special case of a valid expression). In Pascal and Modula-2, this is &function. In Ada, this is function’Address (although the Pascal form also works).

This form specifies the address of the function’s first instruction, before the stack frame and arguments have been set up.

'filename':funcaddr
Like funcaddr above, but also specifies the name of the source file explicitly. This is useful if the name of the function does not specify the function unambiguously, e.g., if there are several functions with identical names in different source files.

9.3 Editing Source Files
To edit the lines in a source file, use the edit command. The editing program of your choice is invoked with the current line set to the active line in the program. Alternatively, there are several ways to specify what part of the file you want to print if you want to see other parts of the program:

edit location
Edit the source file specified by location. Editing starts at that location, e.g., at the specified source line of the specified file. See Section 9.2 [Specify Location], page 102, for all the possible forms of the location argument; here are the forms of the edit command most commonly used:
Chapter 9: Examining Source Files

9.3.1 Choosing your Editor

You can customize GDB to use any editor you want\(^1\). By default, it is ‘/bin/ex’, but you can change this by setting the environment variable EDITOR before using GDB. For example, to configure GDB to use the vi editor, you could use these commands with the sh shell:

```
EDITOR=/usr/bin/vi
export EDITOR
gdb ...
```

or in the csh shell,

```
setenv EDITOR /usr/bin/vi
gdb ...
```

9.4 Searching Source Files

There are two commands for searching through the current source file for a regular expression.

```
forward-search regexp
search regexp
```

The command ‘forward-search regexp’ checks each line, starting with the one following the last line listed, for a match for regexp. It lists the line that is found. You can use the synonym ‘search regexp’ or abbreviate the command name as fo.

```
reverse-search regexp
```

The command ‘reverse-search regexp’ checks each line, starting with the one before the last line listed and going backward, for a match for regexp. It lists the line that is found. You can abbreviate this command as rev.

9.5 Specifying Source Directories

Executable programs sometimes do not record the directories of the source files from which they were compiled, just the names. Even when they do, the directories could be moved between the compilation and your debugging session. GDB has a list of directories to search for source files; this is called the source path. Each time GDB wants a source file, it tries all the directories in the list, in the order they are present in the list, until it finds a file with the desired name.

For example, suppose an executable references the file ‘/usr/src/foo-1.0/lib/foo.c’, and our source path is ‘/mnt/cross’. The file is first looked up literally; if this fails, ‘/mnt/cross/usr/src/foo-1.0/lib/foo.c’ is tried; if this fails, ‘/mnt/cross/foo.c’ is tried.

---

\(^1\) The only restriction is that your editor (say ex), recognizes the following command-line syntax:

```
ex +number file
```

The optional numeric value +number specifies the number of the line in the file where to start editing.
opened; if this fails, an error message is printed. GDB does not look up the parts of the source file name, such as ‘/mnt/cross/src/foo-1.0/lib/foo.c’. Likewise, the subdirectories of the source path are not searched: if the source path is ‘/mnt/cross’, and the binary refers to ‘foo.c’, GDB would not find it under ‘/mnt/cross/usr/src/foo-1.0/lib’.

Plain file names, relative file names with leading directories, file names containing dots, etc. are all treated as described above; for instance, if the source path is ‘/mnt/cross’, and the source file is recorded as ‘..lib/foo.c’, GDB would first try ‘..lib/foo.c’, then ‘/mnt/cross/..lib/foo.c’, and after that—‘/mnt/cross/foo.c’.

Note that the executable search path is not used to locate the source files.

Whenever you reset or rearrange the source path, GDB clears out any information it has cached about where source files are found and where each line is in the file.

When you start GDB, its source path includes only ‘cdir’ and ‘cwd’, in that order. To add other directories, use the directory command.

The search path is used to find both program source files and GDB script files (read using the ‘-command’ option and ‘source’ command).

In addition to the source path, GDB provides a set of commands that manage a list of source path substitution rules. A substitution rule specifies how to rewrite source directories stored in the program’s debug information in case the sources were moved to a different directory between compilation and debugging. A rule is made of two strings, the first specifying what needs to be rewritten in the path, and the second specifying how it should be rewritten. In [set substitute-path], page 107, we name these two parts from and to respectively. GDB does a simple string replacement of from with to at the start of the directory part of the source file name, and uses that result instead of the original file name to look up the sources.

Using the previous example, suppose the ‘foo-1.0’ tree has been moved from ‘/usr/src’ to ‘/mnt/cross’, then you can tell GDB to replace ‘/usr/src’ in all source path names with ‘/mnt/cross’. The first lookup will then be ‘/mnt/cross/foo-1.0/lib/foo.c’ in place of the original location of ‘/usr/src/foo-1.0/lib/foo.c’. To define a source path substitution rule, use the set substitute-path command (see [set substitute-path], page 107).

To avoid unexpected substitution results, a rule is applied only if the from part of the directory name ends at a directory separator. For instance, a rule substituting ‘/usr/source’ into ‘/mnt/cross’ will be applied to ‘/usr/source/foo-1.0’ but not to ‘/usr/sourceware/foo-2.0’. And because the substitution is applied only at the beginning of the directory name, this rule will not be applied to ‘/root/usr/source/baz.c’ either.

In many cases, you can achieve the same result using the directory command. However, set substitute-path can be more efficient in the case where the sources are organized in a complex tree with multiple subdirectories. With the directory command, you need to add each subdirectory of your project. If you moved the entire tree while preserving its internal organization, then set substitute-path allows you to direct the debugger to all the sources with one single command.

set substitute-path is also more than just a shortcut command. The source path is only used if the file at the original location no longer exists. On the other hand, set substitute-path modifies the debugger behavior to look at the rewritten location instead. So, if for any reason a source file that is not relevant to your executable is located at the
original location, a substitution rule is the only method available to point GDB at the new location.

You can configure a default source path substitution rule by configuring GDB with the ‘--with-relocated-sources=dir’ option. The dir should be the name of a directory under GDB’s configured prefix (set with ‘--prefix’ or ‘--exec-prefix’), and directory names in debug information under dir will be adjusted automatically if the installed GDB is moved to a new location. This is useful if GDB, libraries or executables with debug information and corresponding source code are being moved together.

directory dirname ...
dir dirname ...

Add directory dirname to the front of the source path. Several directory names may be given to this command, separated by ‘:’ (‘;’ on MS-DOS and MS-Windows, where ‘:’ usually appears as part of absolute file names) or whitespace. You may specify a directory that is already in the source path; this moves it forward, so GDB searches it sooner.

You can use the string ‘$cdir’ to refer to the compilation directory (if one is recorded), and ‘$cwd’ to refer to the current working directory. ‘$cwd’ is not the same as ‘.’—the former tracks the current working directory as it changes during your GDB session, while the latter is immediately expanded to the current directory at the time you add an entry to the source path.

directory

Reset the source path to its default value (‘$cdir:$cwd’ on Unix systems). This requires confirmation.

set directories path-list

Set the source path to path-list. ‘$cdir:$cwd’ are added if missing.

show directories

Print the source path: show which directories it contains.

set substitute-path from to

Define a source path substitution rule, and add it at the end of the current list of existing substitution rules. If a rule with the same from was already defined, then the old rule is also deleted.

For example, if the file ‘/foo/bar/baz.c’ was moved to ‘/mnt/cross/baz.c’, then the command

    (gdb) set substitute-path /usr/src /mnt/cross

will tell GDB to replace ‘/usr/src’ with ‘/mnt/cross’, which will allow GDB to find the file ‘baz.c’ even though it was moved.

In the case when more than one substitution rule have been defined, the rules are evaluated one by one in the order where they have been defined. The first one matching, if any, is selected to perform the substitution.

For instance, if we had entered the following commands:

    (gdb) set substitute-path /usr/src/include /mnt/include
    (gdb) set substitute-path /usr/src /mnt/src
GDB would then rewrite '/usr/src/include/defs.h' into '/mnt/include/defs.h' by using the first rule. However, it would use the second rule to rewrite '/usr/src/lib/foo.c' into '/mnt/src/lib/foo.c'.

unset substitute-path [path]
If a path is specified, search the current list of substitution rules for a rule that would rewrite that path. Delete that rule if found. A warning is emitted by the debugger if no rule could be found.

If no path is specified, then all substitution rules are deleted.

show substitute-path [path]
If a path is specified, then print the source path substitution rule which would rewrite that path, if any.

If no path is specified, then print all existing source path substitution rules.

If your source path is cluttered with directories that are no longer of interest, GDB may sometimes cause confusion by finding the wrong versions of source. You can correct the situation as follows:

1. Use directory with no argument to reset the source path to its default value.
2. Use directory with suitable arguments to reinstall the directories you want in the source path. You can add all the directories in one command.

9.6 Source and Machine Code
You can use the command info line to map source lines to program addresses (and vice versa), and the command disassemble to display a range of addresses as machine instructions. You can use the command set disassemble-next-line to set whether to disassemble next source line when execution stops. When run under GNU Emacs mode, the info line command causes the arrow to point to the line specified. Also, info line prints addresses in symbolic form as well as hex.

info line location
Print the starting and ending addresses of the compiled code for source line location. You can specify source lines in any of the ways documented in Section 9.2 [Specify Location], page 102.

For example, we can use info line to discover the location of the object code for the first line of function m4_changequote:

(gdb) info line m4_changequote
Line 895 of "builtin.c" starts at pc 0x634c and ends at 0x6350.

We can also inquire (using *addr as the form for location) what source line covers a particular address:

(gdb) info line *0x63ff
Line 926 of "builtin.c" starts at pc 0x63e4 and ends at 0x6404.

After info line, the default address for the x command is changed to the starting address of the line, so that ‘x/i’ is sufficient to begin examining the machine code (see Section 10.6 [Examining Memory], page 121). Also, this address is saved as the value of the convenience variable $_ (see Section 10.11 [Convenience Variables], page 137).
This specialized command dumps a range of memory as machine instructions. It can also print mixed source+disassembly by specifying the /m or /s modifier and print the raw instructions in hex as well as in symbolic form by specifying the /r modifier. The default memory range is the function surrounding the program counter of the selected frame. A single argument to this command is a program counter value; GDB dumps the function surrounding this value. When two arguments are given, they should be separated by a comma, possibly surrounded by whitespace. The arguments specify a range of addresses to dump, in one of two forms:

\texttt{start,end}

the addresses from \texttt{start} (inclusive) to \texttt{end} (exclusive)

\texttt{start,+length}

the addresses from \texttt{start} (inclusive) to \texttt{start+length} (exclusive).

When 2 arguments are specified, the name of the function is also printed (since there could be several functions in the given range).

The argument(s) can be any expression yielding a numeric value, such as `\texttt{0x32c4}`, `\texttt{&main+10}` or `\texttt{$pc - 8'}`. If the range of memory being disassembled contains current program counter, the instruction at that location is shown with a `\texttt{=\textgreater}` marker.

The following example shows the disassembly of a range of addresses of HP PA-RISC 2.0 code:

```plaintext
(gdb) disas 0x32c4, 0x32e4
Dump of assembler code from 0x32c4 to 0x32e4:
0x32c4 <main+204>: addil 0,dp
0x32c8 <main+208>: ldw 0x22c(sr0,r1),r26
0x32cc <main+212>: ldil 0x3000,r31
0x32d0 <main+216>: ble 0x3f8(sr4,r31)
0x32d4 <main+220>: ldo 0(r31),rp
0x32d8 <main+224>: addl -0x800,dp
0x32dc <main+228>: ldo 0x0000(r1),r26
0x32e0 <main+232>: ldil 0x3000,r31
End of assembler dump.
```

Here is an example showing mixed source+assembly for Intel x86 with /m or /s, when the program is stopped just after function prologue in a non-optimized function with no inline code.

```plaintext
(gdb) disas /m main
Dump of assembler code for function main:
  5 {
0x08048330 <+0>: push %ebp
0x08048331 <+1>: mov %esp,%ebp
0x08048333 <+3>: sub $0x8,%esp
0x08048336 <+6>: and $0xfffffffff0,%esp
0x08048339 <+9>: sub $0x10,%esp
```
printf ("Hello.
");

return 0;
}

End of assembler dump.

The /m option is deprecated as its output is not useful when there is either inlined code or re-ordered code. The /s option is the preferred choice. Here is an example for AMD x86-64 showing the difference between /m output and /s output. This example has one inline function defined in a header file, and the code is compiled with ‘-O2’ optimization. Note how the /m output is missing the disassembly of several instructions that are present in the /s output.

'foo.h':

int
foo (int a)
{
    if (a < 0)
        return a * 2;
    if (a == 0)
        return 1;
    return a + 10;
}

'foo.c':

#include "foo.h"
volatile int x, y;

main ()
{
    x = foo (y);
    return 0;
}

(gdb) disas /m main
Dump of assembler code for function main:
5 {
6     x = foo (y);
   0x0000000000040040 <+0>:   mov  0x200c2e(%rip),%eax # 0x601034 <y>
   0x00000000000400417 <+23>:   mov  %eax,0x200c13(%rip) # 0x601030 <x>
7     return 0;
8 }

(gdb) disas /s main
Dump of assembler code for function main:
foo.c:
Chapter 9: Examining Source Files

5 {
6   x = foo (y);
   0x0000000000400400 <+0>: mov 0x200c2e(%rip),%eax # 0x601034 <y>

foo.h:
4 if (a < 0)
   0x0000000000400406 <+6>: test %eax,%eax
   0x0000000000400408 <+8>: js 0x400420 <main+32>
6 if (a == 0)
7   return 1;
8 return a + 10;
   0x000000000040041a <+10>: lea 0xa(%rax),%edx
   0x000000000040041d <+13>: test %eax,%eax
   0x0000000000400420 <+15>: mov $0x1,%eax
   0x0000000000400424 <+19>: cmovne %edx,%eax

foo.c:
6   x = foo (y);
   0x0000000000400417 <+23>: mov %eax,0x200c13(%rip) # 0x601030 <x>
7   return 0;
8 }
   0x000000000040041d <+29>: xor %eax,%eax
   0x0000000000400421 <+31>: retq

foo.h:
5   return a * 2;
   0x0000000000400420 <+32>: add %eax,%eax
   0x0000000000400422 <+34>: jmp 0x400417 <main+23>

End of assembler dump.

Here is another example showing raw instructions in hex for AMD x86-64,

(gdb) disas /r 0x400281,+10
Dump of assembler code from 0x400281 to 0x40028b:
0x0000000000400281: 38 36 cmp %dh,(%rsi)
0x0000000000400283: 73 2d 36 34 2e 73 3b sub $0x732e3436,%eax
0x0000000000400288: 6f outsl %ds:(%rsi),(%edx)
0x0000000000400289: 2e 32 00 xor %cs:(%rax),%al

End of assembler dump.

Addresses cannot be specified as a location (see Section 9.2 [Specify Location], page 102). So, for example, if you want to disassemble function bar in file ‘foo.c’, you must type ‘disassemble ’foo.c’:::bar’ and not ‘disassemble foo.c::bar’.

Some architectures have more than one commonly-used set of instruction mnemonics or other syntax.

For programs that were dynamically linked and use shared libraries, instructions that call functions or branch to locations in the shared libraries might show a seemingly bogus location—it’s actually a location of the relocation table. On some architectures, GDB might be able to resolve these to actual function names.

set disassembly-flavor instruction-set
Select the instruction set to use when disassembling the program via the disassemble or x/i commands.
Currently this command is only defined for the Intel x86 family. You can set `instruction-set` to either `intel` or `att`. The default is `att`, the AT&T flavor used by default by Unix assemblers for x86-based targets.

`show disassembly-flavor`

Show the current setting of the disassembly flavor.

`set disassemble-next-line`

Control whether or not GDB will disassemble the next source line or instruction when execution stops. If ON, GDB will display disassembly of the next source line when execution of the program being debugged stops. This is in addition to displaying the source line itself, which GDB always does if possible. If the next source line cannot be displayed for some reason (e.g., if GDB cannot find the source file, or there’s no line info in the debug info), GDB will display disassembly of the next instruction instead of showing the next source line. If AUTO, GDB will display disassembly of next instruction only if the source line cannot be displayed. This setting causes GDB to display some feedback when you step through a function with no line info or whose source file is unavailable. The default is OFF, which means never display the disassembly of the next line or instruction.
10 Examining Data

The usual way to examine data in your program is with the \texttt{print} command (abbreviated \texttt{p}), or its synonym \texttt{inspect}. It evaluates and prints the value of an expression of the language your program is written in (see Chapter 15 [Using GDB with Different Languages], page 187). It may also print the expression using a Python-based pretty-printer (see Section 10.9 [Pretty Printing], page 133).

\texttt{print expr}
\texttt{print /f expr}

\texttt{expr} is an expression (in the source language). By default the value of \texttt{expr} is printed in a format appropriate to its data type; you can choose a different format by specifying '/\texttt{f}', where \texttt{f} is a letter specifying the format; see Section 10.5 [Output Formats], page 120.

\texttt{print}
\texttt{print /f}

If you omit \texttt{expr}, GDB displays the last value again (from the value history; see Section 10.10 [Value History], page 136). This allows you to conveniently inspect the same value in an alternative format.

A more low-level way of examining data is with the \texttt{x} command. It examines data in memory at a specified address and prints it in a specified format. See Section 10.6 [Examining Memory], page 121.

If you are interested in information about types, or about how the fields of a struct or a class are declared, use the \texttt{ptype exp} command rather than \texttt{print}. See Chapter 16 [Examining the Symbol Table], page 217.

Another way of examining values of expressions and type information is through the Python extension command \texttt{explore} (available only if the \texttt{gdb} build is configured with \texttt{--with-python}). It offers an interactive way to start at the highest level (or, the most abstract level) of the data type of an expression (or, the data type itself) and explore all the way down to leaf scalar values/fields embedded in the higher level data types.

\texttt{explore arg}

\texttt{arg} is either an expression (in the source language), or a type visible in the current context of the program being debugged.

The working of the \texttt{explore} command can be illustrated with an example. If a data type \texttt{struct ComplexStruct} is defined in your C program as

\begin{verbatim}
struct SimpleStruct {
    int i;
    double d;
};

struct ComplexStruct {
    struct SimpleStruct *ss_p;
    int arr[10];
};
\end{verbatim}

followed by variable declarations as
struct SimpleStruct ss = { 10, 1.11 };  
struct ComplexStruct cs = { &ss, { 0, 1, 2, 3, 4, 5, 6, 7, 8, 9 } };  

then, the value of the variable cs can be explored using the `explore` command as follows.

```plaintext
(gdb) explore cs  
The value of 'cs' is a struct/class of type 'struct ComplexStruct' with  
the following fields:

    ss_p = <Enter 0 to explore this field of type 'struct SimpleStruct *'>  
    arr = <Enter 1 to explore this field of type 'int [10]'>

Enter the field number of choice:
```

Since the fields of cs are not scalar values, you are being prompted to chose the field you want to explore. Let’s say you choose the field `ss_p` by entering 0. Then, since this field is a pointer, you will be asked if it is pointing to a single value. From the declaration of cs above, it is indeed pointing to a single value, hence you enter y. If you enter n, then you will be asked if it were pointing to an array of values, in which case this field will be explored as if it were an array.

    'cs.ss_p' is a pointer to a value of type 'struct SimpleStruct'  
    Continue exploring it as a pointer to a single value [y/n]: y

The value of ‘*(cs.ss_p)’ is a struct/class of type 'struct SimpleStruct' with the following fields:

    i = 10 .. (Value of type 'int')
    d = 1.1100000000000001 .. (Value of type 'double')

Press enter to return to parent value:

If the field `arr` of cs was chosen for exploration by entering 1 earlier, then since it is as array, you will be prompted to enter the index of the element in the array that you want to explore.

    'cs.arr' is an array of 'int'.  
    Enter the index of the element you want to explore in 'cs.arr': 5

    '(cs.arr)[5]' is a scalar value of type 'int'.

    (cs.arr)[5] = 4

Press enter to return to parent value:

In general, at any stage of exploration, you can go deeper towards the leaf values by responding to the prompts appropriately, or hit the return key to return to the enclosing data structure (the higher level data structure).

Similar to exploring values, you can use the `explore` command to explore types. Instead of specifying a value (which is typically a variable name or an expression valid in the current context of the program being debugged), you specify a type name. If you consider the same example as above, you can explore the type `struct ComplexStruct` by passing the argument `struct ComplexStruct` to the `explore` command.

```plaintext
(gdb) explore struct ComplexStruct
```

By responding to the prompts appropriately in the subsequent interactive session, you can explore the type `struct ComplexStruct` in a manner similar to how the value `cs` was explored in the above example.
The `explore` command also has two sub-commands, `explore value` and `explore type`. The former sub-command is a way to explicitly specify that value exploration of the argument is being invoked, while the latter is a way to explicitly specify that type exploration of the argument is being invoked.

**explore value expr**

This sub-command of `explore` explores the value of the expression `expr` (if `expr` is an expression valid in the current context of the program being debugged). The behavior of this command is identical to that of the behavior of the `explore` command being passed the argument `expr`.

**explore type arg**

This sub-command of `explore` explores the type of `arg` (if `arg` is a type visible in the current context of program being debugged), or the type of the value/expression `arg` (if `arg` is an expression valid in the current context of the program being debugged). If `arg` is a type, then the behavior of this command is identical to that of the `explore` command being passed the argument `arg`. If `arg` is an expression, then the behavior of this command will be identical to that of the `explore` command being passed the type of `arg` as the argument.

### 10.1 Expressions

`print` and many other GDB commands accept an expression and compute its value. Any kind of constant, variable or operator defined by the programming language you are using is valid in an expression in GDB. This includes conditional expressions, function calls, casts, and string constants. It also includes preprocessor macros, if you compiled your program to include this information; see Section 4.1 [Compilation], page 25.

GDB supports array constants in expressions input by the user. The syntax is `{element, element...}`. For example, you can use the command `print {1, 2, 3}` to create an array of three integers. If you pass an array to a function or assign it to a program variable, GDB copies the array to memory that is `malloc`ed in the target program.

Because C is so widespread, most of the expressions shown in examples in this manual are in C. See Chapter 15 [Using GDB with Different Languages], page 187, for information on how to use expressions in other languages.

In this section, we discuss operators that you can use in GDB expressions regardless of your programming language.

Casts are supported in all languages, not just in C, because it is so useful to cast a number into a pointer in order to examine a structure at that address in memory.

GDB supports these operators, in addition to those common to programming languages:

- `@` ‘@’ is a binary operator for treating parts of memory as arrays. See Section 10.4 [Artificial Arrays], page 119, for more information.

- `::` ‘::’ allows you to specify a variable in terms of the file or function where it is defined. See Section 10.3 [Program Variables], page 117.

- `{type} addr` Refers to an object of type `type` stored at address `addr` in memory. The address `addr` may be any expression whose value is an integer or pointer (but parenthe-
ses are required around binary operators, just as in a cast). This construct is allowed regardless of what kind of data is normally supposed to reside at $addr$.

### 10.2 Ambiguous Expressions

Expressions can sometimes contain some ambiguous elements. For instance, some programming languages (notably Ada, C++ and Objective-C) permit a single function name to be defined several times, for application in different contexts. This is called overloading. Another example involving Ada is generics. A *generic package* is similar to C++ templates and is typically instantiated several times, resulting in the same function name being defined in different contexts.

In some cases and depending on the language, it is possible to adjust the expression to remove the ambiguity. For instance in C++, you can specify the signature of the function you want to break on, as in `break function(types)`. In Ada, using the fully qualified name of your function often makes the expression unambiguous as well.

When an ambiguity that needs to be resolved is detected, the debugger has the capability to display a menu of numbered choices for each possibility, and then waits for the selection with the prompt ‘>’. The first option is always ‘[0] cancel’, and typing 0 RET aborts the current command. If the command in which the expression was used allows more than one choice to be selected, the next option in the menu is ‘[1] all’, and typing 1 RET selects all possible choices.

For example, the following session excerpt shows an attempt to set a breakpoint at the overloaded symbol `String::after`. We choose three particular definitions of that function name:

```
(gdb) b String::after
[0] cancel
[1] all
[2] file:String.cc; line number:867
[3] file:String.cc; line number:860
[4] file:String.cc; line number:875
[5] file:String.cc; line number:853
[7] file:String.cc; line number:735
> 2 4 6
Breakpoint 1 at 0xb26c: file String.cc, line 867.
Breakpoint 2 at 0xb344: file String.cc, line 875.
Breakpoint 3 at 0xafcc: file String.cc, line 846.
Multiple breakpoints were set.
Use the "delete" command to delete unwanted breakpoints.
```

**set multiple-symbols mode**

This option allows you to adjust the debugger behavior when an expression is ambiguous.

By default, `mode` is set to `all`. If the command with which the expression is used allows more than one choice, then GDB automatically selects all possible choices. For instance, inserting a breakpoint on a function using an ambiguous name results in a breakpoint inserted on each possible match. However, if a unique choice must be made, then GDB uses the menu to help you disambiguate
the expression. For instance, printing the address of an overloaded function will result in the use of the menu.

When mode is set to ask, the debugger always uses the menu when an ambiguity is detected.

Finally, when mode is set to cancel, the debugger reports an error due to the ambiguity and the command is aborted.

**show multiple-symbols**

Show the current value of the multiple-symbols setting.

### 10.3 Program Variables

The most common kind of expression to use is the name of a variable in your program.

Variables in expressions are understood in the selected stack frame (see Section 8.4 [Selecting a Frame], page 99); they must be either:

- global (or file-static)
- visible according to the scope rules of the programming language from the point of execution in that frame

This means that in the function

```c
foo (a)
{
  int a;

  bar (a);
  {
    int b = test ();
    bar (b);
  }
}
```

you can examine and use the variable `a` whenever your program is executing within the function `foo`, but you can only use or examine the variable `b` while your program is executing inside the block where `b` is declared.

There is an exception: you can refer to a variable or function whose scope is a single source file even if the current execution point is not in this file. But it is possible to have more than one such variable or function with the same name (in different source files). If that happens, referring to that name has unpredictable effects. If you wish, you can specify a static variable in a particular function or file by using the colon-colon (::) notation:

```c
file::variable
function::variable
```

Here file or function is the name of the context for the static variable. In the case of file names, you can use quotes to make sure GDB parses the file name as a single word—for example, to print a global value of `x` defined in `f2.c`:

```bash
(gdb) p 'f2.c':x
```

The :: notation is normally used for referring to static variables, since you typically disambiguate uses of local variables in functions by selecting the appropriate frame and using the simple name of the variable. However, you may also use this notation to refer to local variables in frames enclosing the selected frame:
void foo (int a)
{
    if (a < 10)
        bar (a);
    else
        process (a); /* Stop here */
}

int bar (int a)
{
    foo (a + 5);
}

For example, if there is a breakpoint at the commented line, here is what you might see when the program stops after executing the call bar(0):

(gdb) p a
$1 = 10
(gdb) p bar::a
$2 = 5
(gdb) up 2
#2 0x080483d0 in foo (a=5) at foobar.c:12
(gdb) p a
$3 = 5
(gdb) p bar::a
$4 = 0

These uses of `::` are very rarely in conflict with the very similar use of the same notation in C++. When they are in conflict, the C++ meaning takes precedence; however, this can be overridden by quoting the file or function name with single quotes.

For example, suppose the program is stopped in a method of a class that has a field named `includefile`, and there is also an include file named `includefile` that defines a variable, `some_global`.

(gdb) p includefile
$1 = 23
(gdb) p includefile::some_global
A syntax error in expression, near `'`
(gdb) p 'includefile'::some_global
$2 = 27

**Warning:** Occasionally, a local variable may appear to have the wrong value at certain points in a function—just after entry to a new scope, and just before exit.

You may see this problem when you are stepping by machine instructions. This is because, on most machines, it takes more than one instruction to set up a stack frame (including local variable definitions); if you are stepping by machine instructions, variables may appear to have the wrong values until the stack frame is completely built. On exit, it usually also takes more than one machine instruction to destroy a stack frame; after you begin stepping through that group of instructions, local variable definitions may be gone.

This may also happen when the compiler does significant optimizations. To be sure of always seeing accurate values, turn off all optimization when compiling.

Another possible effect of compiler optimizations is to optimize unused variables out of existence, or assign variables to registers (as opposed to memory addresses). Depending
Chapter 10: Examining Data

on the support for such cases offered by the debug info format used by the compiler, GDB might not be able to display values for such local variables. If that happens, GDB will print a message like this:

No symbol "foo" in current context.

To solve such problems, either recompile without optimizations, or use a different debug info format, if the compiler supports several such formats. See Section 4.1 [Compilation], page 25, for more information on choosing compiler options. See Section 15.4.1 [C and C++], page 191, for more information about debug info formats that are best suited to C++ programs.

If you ask to print an object whose contents are unknown to GDB, e.g., because its data type is not completely specified by the debug information, GDB will say ‘<incomplete type>’. See Chapter 16 [Symbols], page 217, for more about this.

If you append @entry string to a function parameter name you get its value at the time the function got called. If the value is not available an error message is printed. Entry values are available only with some compilers. Entry values are normally also printed at the function parameter list according to [set print entry-values], page 128.

Breakpoint 1, d (i=30) at gdb.base/entry-value.c:29
29 i++;
(gdb) next
30 e (i);
(gdb) print i
$1 = 31
(gdb) print i@entry
$2 = 30

Strings are identified as arrays of char values without specified signedness. Arrays of either signed char or unsigned char get printed as arrays of 1 byte sized integers. -fsigned-char or -funsigned-char GCC options have no effect as GDB defines literal string type "char" as char without a sign. For program code

```c
char var0[] = "A";
signed char var1[] = "A";
```

You get during debugging

```c
(gdb) print var0
$1 = "A"
(gdb) print var1
$2 = {65 'A', 0 '\0'}
```

10.4 Artificial Arrays

It is often useful to print out several successive objects of the same type in memory; a section of an array, or an array of dynamically determined size for which only a pointer exists in the program.

You can do this by referring to a contiguous span of memory as an artificial array, using the binary operator ‘@’. The left operand of ‘@’ should be the first element of the desired array and be an individual object. The right operand should be the desired length of the array. The result is an array value whose elements are all of the type of the left argument. The first element is actually the left argument; the second element comes from bytes of memory immediately following those that hold the first element, and so on. Here is an example. If a program says
int *array = (int *) malloc (len * sizeof (int));
you can print the contents of array with
p *array@len

The left operand of '@' must reside in memory. Array values made with '@' in this way
behave just like other arrays in terms of subscripting, and are coerced to pointers when
used in expressions. Artificial arrays most often appear in expressions via the value history
(see Section 10.10 [Value History], page 136), after printing one out.

Another way to create an artificial array is to use a cast. This re-interprets a value as if
it were an array. The value need not be in memory:
(gdb) p/x (short[2])0x12345678
$1 = {0x1234, 0x5678}

As a convenience, if you leave the array length out (as in '(type[])value') GDB calculates
the size to fill the value (as 'sizeof(value)/sizeof(type)'):
(gdb) p/x (short[])0x12345678
$2 = {0x1234, 0x5678}

Sometimes the artificial array mechanism is not quite enough; in moderately complex
data structures, the elements of interest may not actually be adjacent—for example, if you
are interested in the values of pointers in an array. One useful work-around in this situation
is to use a convenience variable (see Section 10.11 [Convenience Variables], page 137)
as a counter in an expression that prints the first interesting value, and then repeat that
expression via RET. For instance, suppose you have an array dtab of pointers to structures,
and you are interested in the values of a field fv in each structure. Here is an example of
what you might type:
set $i = 0
p dtab[$i++]->fv
RET
RET
...

10.5 Output Formats

By default, GDB prints a value according to its data type. Sometimes this is not what you
want. For example, you might want to print a number in hex, or a pointer in decimal. Or
you might want to view data in memory at a certain address as a character string or as an
instruction. To do these things, specify an output format when you print a value.

The simplest use of output formats is to say how to print a value already computed.
This is done by starting the arguments of the print command with a slash and a format
letter. The format letters supported are:
x  Regard the bits of the value as an integer, and print the integer in hexadecimal.
d  Print as integer in signed decimal.
u  Print as integer in unsigned decimal.
o  Print as integer in octal.
t  Print as integer in binary. The letter ‘t’ stands for “two”.¹

¹ ‘b’ cannot be used because these format letters are also used with the x command, where ‘b’ stands for
“byte”; see Section 10.6 [Examining Memory], page 121.
Print as an address, both absolute in hexadecimal and as an offset from the nearest preceding symbol. You can use this format used to discover where (in what function) an unknown address is located:

```
(gdb) p/a 0x54320
$3 = 0x54320 <_initialize_vx+396>
```

The command `info symbol 0x54320` yields similar results. See Chapter 16 [Symbols], page 217.

Regard as an integer and print it as a character constant. This prints both the numerical value and its character representation. The character representation is replaced with the octal escape ‘\nnn’ for characters outside the 7-bit ASCII range.

Without this format, GDB displays `char`, `unsigned char`, and `signed char` data as character constants. Single-byte members of vectors are displayed as integer data.

Regard the bits of the value as a floating point number and print using typical floating point syntax.

Regard as a string, if possible. With this format, pointers to single-byte data are displayed as null-terminated strings and arrays of single-byte data are displayed as fixed-length strings. Other values are displayed in their natural types.

Without this format, GDB displays pointers to and arrays of `char`, `unsigned char`, and `signed char` as strings. Single-byte members of a vector are displayed as an integer array.

Like ‘x’ formatting, the value is treated as an integer and printed as hexadecimal, but leading zeros are printed to pad the value to the size of the integer type.

Print using the ‘raw’ formatting. By default, GDB will use a Python-based pretty-printer, if one is available (see Section 10.9 [Pretty Printing], page 133). This typically results in a higher-level display of the value’s contents. The ‘r’ format bypasses any Python pretty-printer which might exist.

For example, to print the program counter in hex (see Section 10.13 [Registers], page 141), type

```
p/x $pc
```

Note that no space is required before the slash; this is because command names in GDB cannot contain a slash.

To reprint the last value in the value history with a different format, you can use the `print` command with just a format and no expression. For example, ‘p/x’ reprints the last value in hex.

### 10.6 Examining Memory

You can use the command `x` (for “examine”) to examine memory in any of several formats, independently of your program’s data types.
Debugging with gdb

x/nfu addr
x addr
x

Use the x command to examine memory.

n, f, and u are all optional parameters that specify how much memory to display and how to format it; addr is an expression giving the address where you want to start displaying memory. If you use defaults for nfu, you need not type the slash `/'. Several commands set convenient defaults for addr.

n, the repeat count
The repeat count is a decimal integer; the default is 1. It specifies how much memory (counting by units u) to display.

f, the display format
The display format is one of the formats used by print (‘x’, ‘d’, ‘u’, ‘o’, ‘t’, ‘a’, ‘c’, ‘f’, ‘s’), and in addition ‘i’ (for machine instructions). The default is ‘x’ (hexadecimal) initially. The default changes each time you use either x or print.

u, the unit size
The unit size is any of

b  Bytes.
h  Halfwords (two bytes).
w  Words (four bytes). This is the initial default.
g  Giant words (eight bytes).

Each time you specify a unit size with x, that size becomes the default unit the next time you use x. For the ‘i’ format, the unit size is ignored and is normally not written. For the ‘s’ format, the unit size defaults to ‘b’, unless it is explicitly given. Use x/hs to display 16-bit char strings and x/ws to display 32-bit strings. The next use of x/s will again display 8-bit strings. Note that the results depend on the programming language of the current compilation unit. If the language is C, the ‘s’ modifier will use the UTF-16 encoding while ‘w’ will use UTF-32. The encoding is set by the programming language and cannot be altered.

addr, starting display address
addr is the address where you want GDB to begin displaying memory. The expression need not have a pointer value (though it may); it is always interpreted as an integer address of a byte of memory. See Section 10.1 [Expressions], page 115, for more information on expressions. The default for addr is usually just after the last address examined—but several other commands also set the default address: info breakpoints (to the address of the last breakpoint listed), info line (to the starting address of a line), and print (if you use it to display a value from memory).

For example, ‘x/3uh 0x54320’ is a request to display three halfwords (h) of memory, formatted as unsigned decimal integers (‘u’), starting at address 0x54320. ‘x/4xw $sp’
prints the four words (‘w’) of memory above the stack pointer (here, ‘$sp’; see Section 10.13 [Registers], page 141) in hexadecimal (‘x’).

Since the letters indicating unit sizes are all distinct from the letters specifying output formats, you do not have to remember whether unit size or format comes first; either order works. The output specifications ‘4xw’ and ‘4wx’ mean exactly the same thing. (However, the count n must come first; ‘wx4’ does not work.)

Even though the unit size u is ignored for the formats ‘s’ and ‘i’, you might still want to use a count n; for example, ‘3i’ specifies that you want to see three machine instructions, including any operands. For convenience, especially when used with the display command, the ‘i’ format also prints branch delay slot instructions, if any, beyond the count specified, which immediately follow the last instruction that is within the count. The command disassemble gives an alternative way of inspecting machine instructions; see Section 9.6 [Source and Machine Code], page 108.

All the defaults for the arguments to x are designed to make it easy to continue scanning memory with minimal specifications each time you use x. For example, after you have inspected three machine instructions with ‘x/3i addr’, you can inspect the next seven with just ‘x/7’. If you use RET to repeat the x command, the repeat count n is used again; the other arguments default as for successive uses of x.

When examining machine instructions, the instruction at current program counter is shown with a => marker. For example:

```
(gdb) x/5i $pc-6
0x804837f <main+11>: mov %esp,%ebp
0x8048381 <main+13>: push %ecx
0x8048382 <main+14>: sub $0x4,%esp
=> 0x8048385 <main+17>: movl $0x8048460,(%esp)
0x804838c <main+24>: call 0x80482d4 <puts@plt>
```

The addresses and contents printed by the x command are not saved in the value history because there is often too much of them and they would get in the way. Instead, GDB makes these values available for subsequent use in expressions as values of the convenience variables $$_$$ and $$$_$$. After an x command, the last address examined is available for use in expressions in the convenience variable $$_$$. The contents of that address, as examined, are available in the convenience variable $$$_$$. If the x command has a repeat count, the address and contents saved are from the last memory unit printed; this is not the same as the last address printed if several units were printed on the last line of output.

Most targets have an addressable memory unit size of 8 bits. This means that to each memory address are associated 8 bits of data. Some targets, however, have other addressable memory unit sizes. Within GDB and this document, the term addressable memory unit (or memory unit for short) is used when explicitly referring to a chunk of data of that size. The word byte is used to refer to a chunk of data of 8 bits, regardless of the addressable memory unit size of the target. For most systems, addressable memory unit is a synonym of byte.

When you are debugging a program running on a remote target machine (see Chapter 20 [Remote Debugging], page 257), you may wish to verify the program’s image in the remote machine’s memory against the executable file you downloaded to the target. Or, on any
target, you may want to check whether the program has corrupted its own read-only sections. The \texttt{compare-sections} command is provided for such situations.

\texttt{compare-sections [section-name]|-r}\n
Compare the data of a loadable section \texttt{section-name} in the executable file of the program being debugged with the same section in the target machine’s memory, and report any mismatches. With no arguments, compares all loadable sections. With an argument of \texttt{-r}, compares all loadable read-only sections.

Note: for remote targets, this command can be accelerated if the target supports computing the CRC checksum of a block of memory (see \texttt{[qCRC packet]}, page 622).

10.7 Automatic Display

If you find that you want to print the value of an expression frequently (to see how it changes), you might want to add it to the automatic display list so that \texttt{gdb} prints its value each time your program stops. Each expression added to the list is given a number to identify it; to remove an expression from the list, you specify that number. The automatic display looks like this:

2: foo = 38
3: bar[5] = (struct hack *) 0x3804

This display shows item numbers, expressions and their current values. As with displays you request manually using \texttt{x} or \texttt{print}, you can specify the output format you prefer; in fact, \texttt{display} decides whether to use \texttt{print} or \texttt{x} depending your format specification—it uses \texttt{x} if you specify either the ‘i’ or ‘s’ format, or a unit size; otherwise it uses \texttt{print}.

\texttt{display expr}  
Add the expression \texttt{expr} to the list of expressions to display each time your program stops. See Section 10.1 [Expressions], page 115.

\texttt{display} does not repeat if you press \texttt{RET} again after using it.

\texttt{display/fmt expr}  
For \texttt{fmt} specifying only a display format and not a size or count, add the expression \texttt{expr} to the auto-display list but arrange to display it each time in the specified format \texttt{fmt}. See Section 10.5 [Output Formats], page 120.

\texttt{display/fmt addr}  
For \texttt{fmt} ‘i’ or ‘s’, or including a unit-size or a number of units, add the expression \texttt{addr} as a memory address to be examined each time your program stops. Examining means in effect doing \texttt{‘x/fmt addr’}. See Section 10.6 [Examining Memory], page 121.

For example, ‘\texttt{display/i $pc}’ can be helpful, to see the machine instruction about to be executed each time execution stops (‘$pc’ is a common name for the program counter; see Section 10.13 [Registers], page 141).

\texttt{undisplay dnuns...}  
\texttt{delete display dnuns...}  
Remove items from the list of expressions to display. Specify the numbers of the displays that you want affected with the command argument \texttt{dnuns}. It can
be a single display number, one of the numbers shown in the first field of the ‘info display’ display; or it could be a range of display numbers, as in 2–4.

undisplay does not repeat if you press RET after using it. (Otherwise you would just get the error ‘No display number ...’.)

disable display dnus...
Disable the display of item numbers dnus. A disabled display item is not printed automatically, but is not forgotten. It may be enabled again later. Specify the numbers of the displays that you want affected with the command argument dnus. It can be a single display number, one of the numbers shown in the first field of the ‘info display’ display; or it could be a range of display numbers, as in 2–4.

enable display dnus...
Enable display of item numbers dnus. It becomes effective once again in auto display of its expression, until you specify otherwise. Specify the numbers of the displays that you want affected with the command argument dnus. It can be a single display number, one of the numbers shown in the first field of the ‘info display’ display; or it could be a range of display numbers, as in 2–4.

display
Display the current values of the expressions on the list, just as is done when your program stops.

info display
Print the list of expressions previously set up to display automatically, each one with its item number, but without showing the values. This includes disabled expressions, which are marked as such. It also includes expressions which would not be displayed right now because they refer to automatic variables not currently available.

If a display expression refers to local variables, then it does not make sense outside the lexical context for which it was set up. Such an expression is disabled when execution enters a context where one of its variables is not defined. For example, if you give the command display last_char while inside a function with an argument last_char, GDB displays this argument while your program continues to stop inside that function. When it stops elsewhere—where there is no variable last_char—the display is disabled automatically. The next time your program stops where last_char is meaningful, you can enable the display expression once again.

10.8 Print Settings
GDB provides the following ways to control how arrays, structures, and symbols are printed. These settings are useful for debugging programs in any language:

set print address
set print address on
GDB prints memory addresses showing the location of stack traces, structure values, pointer values, breakpoints, and so forth, even when it also displays the contents of those addresses. The default is on. For example, this is what a stack frame display looks like with set print address on:
set print address off
Do not print addresses when displaying their contents. For example, this is the same stack frame displayed with set print address off:

```
(gdb) set print addr off
(gdb) f
#0 set_quotes (lq=0x34c78 "<<", rq=0x34c88 ") at input.c:530
530 if (lquote != def_lquote)
```

You can use `set print address off` to eliminate all machine dependent displays from the GDB interface. For example, with `print address off`, you should get the same text for backtraces on all machines—whether or not they involve pointer arguments.

show print address
Show whether or not addresses are to be printed.

When GDB prints a symbolic address, it normally prints the closest earlier symbol plus an offset. If that symbol does not uniquely identify the address (for example, it is a name whose scope is a single source file), you may need to clarify. One way to do this is with `info line`, for example `info line *0x4537'`. Alternately, you can set GDB to print the source file and line number when it prints a symbolic address:

```
(gdb) set print symbol-filename on
```

```
(gdb) f
#0 set_quotes (lq="<<", rq="">") at input.c:530
530 if (lquote != def_lquote)
```

Tell GDB to print the source file name and line number of a symbol in the symbolic form of an address.

```
(gdb) set print symbol-filename off
```

Do not print source file name and line number of a symbol. This is the default.

```
(gdb) print symbol-filename
```

Show whether or not GDB will print the source file name and line number of a symbol in the symbolic form of an address.

Another situation where it is helpful to show symbol filenames and line numbers is when disassembling code; GDB shows you the line number and source file that corresponds to each instruction.

Also, you may wish to see the symbolic form only if the address being printed is reasonably close to the closest earlier symbol:

```
(gdb) set print max-symbolic-offset max-offset
```

```
(gdb) set print max-symbolic-offset unlimited
```

Tell GDB to only display the symbolic form of an address if the offset between the closest earlier symbol and the address is less than `max-offset`. The default is `unlimited`, which tells GDB to always print the symbolic form of an address if any symbol precedes it. Zero is equivalent to `unlimited`.

```
(gdb) show print max-symbolic-offset
```

Ask how large the maximum offset is that GDB prints in a symbolic address.
If you have a pointer and you are not sure where it points, try ‘\texttt{set print symbol-filename on}’. Then you can determine the name and source file location of the variable where it points, using ‘\texttt{p/a pointer}’. This interprets the address in symbolic form. For example, here GDB shows that a variable \texttt{ptt} points at another variable \texttt{t}, defined in ‘\texttt{hi2.c}’:

\begin{verbatim}
(gdb) set print symbol-filename on
(gdb) p/a ptt
$4 = 0xe008 \textless \textit{t} in hi2.c>
\end{verbatim}

\textit{Warning:} For pointers that point to a local variable, ‘\texttt{p/a}’ does not show the symbol name and filename of the referent, even with the appropriate \texttt{set print} options turned on.

You can also enable ‘\texttt{/a}’-like formatting all the time using ‘\texttt{set print symbol on}’:

\begin{verbatim}
set print symbol on
\end{verbatim}

Tell GDB to print the symbol corresponding to an address, if one exists.

\begin{verbatim}
set print symbol off
\end{verbatim}

Tell GDB not to print the symbol corresponding to an address. In this mode, GDB will still print the symbol corresponding to pointers to functions. This is the default.

\begin{verbatim}
show print symbol
\end{verbatim}

Show whether GDB will display the symbol corresponding to an address.

Other settings control how different kinds of objects are printed:

\begin{verbatim}
set print array
set print array on
\end{verbatim}

Pretty print arrays. This format is more convenient to read, but uses more space. The default is off.

\begin{verbatim}
set print array off
\end{verbatim}

Return to compressed format for arrays.

\begin{verbatim}
show print array
\end{verbatim}

Show whether compressed or pretty format is selected for displaying arrays.

\begin{verbatim}
set print array-indexes
set print array-indexes on
\end{verbatim}

Print the index of each element when displaying arrays. May be more convenient to locate a given element in the array or quickly find the index of a given element in that printed array. The default is off.

\begin{verbatim}
set print array-indexes off
\end{verbatim}

Stop printing element indexes when displaying arrays.

\begin{verbatim}
show print array-indexes
\end{verbatim}

Show whether the index of each element is printed when displaying arrays.

\begin{verbatim}
set print elements number-of-elements
set print elements unlimited
\end{verbatim}

Set a limit on how many elements of an array GDB will print. If GDB is printing a large array, it stops printing after it has printed the number of elements set
by the \texttt{set print elements} command. This limit also applies to the display of strings. When GDB starts, this limit is set to 200. Setting \texttt{number-of-elements} to \texttt{unlimited} or zero means that the number of elements to print is unlimited.

\textbf{show print elements}
Display the number of elements of a large array that GDB will print. If the number is 0, then the printing is unlimited.

\textbf{set print frame-arguments value}
This command allows to control how the values of arguments are printed when the debugger prints a frame (see Section 8.1 [Frames], page 93). The possible values are:

- \texttt{all} The values of all arguments are printed.
- \texttt{scalars} Print the value of an argument only if it is a scalar. The value of more complex arguments such as arrays, structures, unions, etc, is replaced by \texttt{...}. This is the default. Here is an example where only scalar arguments are shown:
  
  \begin{verbatim}
  #1 0x08048361 in call_me (i=3, s=..., ss=0xbf8d508c, u=..., e=green)
  at frame-args.c:23
  \end{verbatim}

- \texttt{none} None of the argument values are printed. Instead, the value of each argument is replaced by \texttt{...}. In this case, the example above now becomes:
  
  \begin{verbatim}
  #1 0x08048361 in call_me (i=..., s=..., ss=..., u=..., e=...) 
  at frame-args.c:23
  \end{verbatim}

By default, only scalar arguments are printed. This command can be used to configure the debugger to print the value of all arguments, regardless of their type. However, it is often advantageous to not print the value of more complex parameters. For instance, it reduces the amount of information printed in each frame, making the backtrace more readable. Also, it improves performance when displaying Ada frames, because the computation of large arguments can sometimes be CPU-intensive, especially in large applications. Setting \texttt{print frame-arguments to scalars} (the default) or \texttt{none} avoids this computation, thus speeding up the display of each Ada frame.

\textbf{show print frame-arguments}
Show how the value of arguments should be displayed when printing a frame.

\textbf{set print raw frame-arguments on}
Print frame arguments in raw, non pretty-printed, form.

\textbf{set print raw frame-arguments off}
Print frame arguments in pretty-printed form, if there is a pretty-printer for the value (see Section 10.9 [Pretty Printing], page 133), otherwise print the value in raw form. This is the default.

\textbf{show print raw frame-arguments}
Show whether to print frame arguments in raw form.

\textbf{set print entry-values value}
Set printing of frame argument values at function entry. In some cases GDB can determine the value of function argument which was passed by the function...
caller, even if the value was modified inside the called function and therefore is different. With optimized code, the current value could be unavailable, but the entry value may still be known.

The default value is `default` (see below for its description). Older GDB behaved as with the setting `no`. Compilers not supporting this feature will behave in the `default` setting the same way as with the `no` setting.

This functionality is currently supported only by DWARF 2 debugging format and the compiler has to produce `DW_TAG_GNU_call_site` tags. With GCC, you need to specify `'-O -g'` during compilation, to get this information.

The `value` parameter can be one of the following:

- **no**
  - Print only actual parameter values, never print values from function entry point.
    - `#0 equal (val=5)`
    - `#0 different (val=6)`
    - `#0 lost (val=<optimized out>)`
    - `#0 born (val=10)`
    - `#0 invalid (val=<optimized out>)`

- **only**
  - Print only parameter values from function entry point. The actual parameter values are never printed.
    - `#0 equal (val@entry=5)`
    - `#0 different (val@entry=5)`
    - `#0 lost (val@entry=5)`
    - `#0 born (val@entry=<optimized out>)`
    - `#0 invalid (val@entry=<optimized out>)`

- **preferred**
  - Print only parameter values from function entry point. If value from function entry point is not known while the actual value is known, print the actual value for such parameter.
    - `#0 equal (val@entry=5)`
    - `#0 different (val@entry=5)`
    - `#0 lost (val@entry=5)`
    - `#0 born (val=10)`
    - `#0 invalid (val@entry=<optimized out>)`

- **if-needed**
  - Print actual parameter values. If actual parameter value is not known while value from function entry point is known, print the entry point value for such parameter.
    - `#0 equal (val=5)`
    - `#0 different (val=6)`
    - `#0 lost (val@entry=5)`
    - `#0 born (val=10)`
    - `#0 invalid (val=<optimized out>)`

- **both**
  - Always print both the actual parameter value and its value from function entry point, even if values of one or both are not available due to compiler optimizations.
    - `#0 equal (val=5, val@entry=5)`
    - `#0 different (val=6, val@entry=5)`
    - `#0 lost (val=<optimized out>, val@entry=5)`
compact  Print the actual parameter value if it is known and also its value from function entry point if it is known. If neither is known, print for the actual value <optimized out>. If not in MI mode (see Chapter 27 [GDB/MI], page 457) and if both values are known and identical, print the shortened param=param@entry=VALUE notation.

#0 born (val=10, val@entry=<optimized out>)
#0 invalid (val=<optimized out>, val@entry=<optimized out>)

default  Always print the actual parameter value. Print also its value from function entry point, but only if it is known. If not in MI mode (see Chapter 27 [GDB/MI], page 457) and if both values are known and identical, print the shortened param=param@entry=VALUE notation.

#0 equal (val=val@entry=5)
#0 different (val=6, val@entry=5)
#0 lost (val@entry=5)
#0 born (val=10)
#0 invalid (val=<optimized out>)

For analysis messages on possible failures of frame argument values at function entry resolution see \[set debug entry-values\], page 156.

show print entry-values  
Show the method being used for printing of frame argument values at function entry.

set print repeats number-of-repeats  
set print repeats unlimited  
Set the threshold for suppressing display of repeated array elements. When the number of consecutive identical elements of an array exceeds the threshold, GDB prints the string "<repeats n times>", where n is the number of identical repetitions, instead of displaying the identical elements themselves. Setting the threshold to unlimited or zero will cause all elements to be individually printed. The default threshold is 10.

show print repeats  
Display the current threshold for printing repeated identical elements.

set print null-stop  
Cause GDB to stop printing the characters of an array when the first NULL is encountered. This is useful when large arrays actually contain only short strings. The default is off.

show print null-stop  
Show whether GDB stops printing an array on the first NULL character.

set print pretty on  
Cause GDB to print structures in an indented format with one member per line, like this:
Chapter 10: Examining Data

```c
$1 = {
    next = 0x0,
    flags = {
        sweet = 1,
        sour = 1
    },
    meat = 0x54 "Pork"
}
```

**set print pretty off**
Cause GDB to print structures in a compact format, like this:
```c
$1 = {next = 0x0, flags = {sweet = 1, sour = 1}, 
    meat = 0x54 "Pork"}
```
This is the default format.

**show print pretty**
Show which format GDB is using to print structures.

**set print sevenbit-strings on**
Print using only seven-bit characters; if this option is set, GDB displays any eight-bit characters (in strings or character values) using the notation \nnn. This setting is best if you are working in English (ASCII) and you use the high-order bit of characters as a marker or “meta” bit.

**set print sevenbit-strings off**
Print full eight-bit characters. This allows the use of more international character sets, and is the default.

**show print sevenbit-strings**
Show whether or not GDB is printing only seven-bit characters.

**set print union on**
Tell GDB to print unions which are contained in structures and other unions. This is the default setting.

**set print union off**
Tell GDB not to print unions which are contained in structures and other unions. GDB will print "{...}" instead.

**show print union**
Ask GDB whether or not it will print unions which are contained in structures and other unions.

For example, given the declarations
```c
typedef enum {Tree, Bug} Species;
typedef enum {Big_tree, Acorn, Seedling} Tree_forms;
typedef enum {Caterpillar, Cocoon, Butterfly} Bug_forms;

struct thing {
    Species it;
    union {
        Tree_forms tree;
        Bug_forms bug;
    } form;
};
```
struct thing foo = {Tree, {Acorn}};

with set print union on in effect ‘p foo’ would print
$1 = \{it = Tree, form = \{tree = Acorn, bug = Cocoon\}\}

and with set print union off in effect it would print
$1 = \{it = Tree, form = \{..\}\}

set print union affects programs written in C-like languages and in Pascal.

These settings are of interest when debugging C++ programs:

set print demangle
set print demangle on
Print C++ names in their source form rather than in the encoded (“mangled”) form passed to the assembler and linker for type-safe linkage. The default is on.

show print demangle
  Show whether C++ names are printed in mangled or demangled form.

set print asm-demangle
set print asm-demangle on
Print C++ names in their source form rather than their mangled form, even in assembler code printouts such as instruction disassemblies. The default is off.

show print asm-demangle
  Show whether C++ names in assembly listings are printed in mangled or demangled form.

set demangle-style style
Choose among several encoding schemes used by different compilers to represent C++ names. The choices for style are currently:

  auto   Allow GDB to choose a decoding style by inspecting your program. This is the default.
  gnu    Decode based on the GNU C++ compiler (g++) encoding algorithm.
  hp      Decode based on the HP ANSI C++ (aCC) encoding algorithm.
  lucid   Decode based on the Lucid C++ compiler (lcc) encoding algorithm.
  arm     Decode using the algorithm in the C++ Annotated Reference Manual. **Warning:** this setting alone is not sufficient to allow debugging cfront-generated executables. GDB would require further enhancement to permit that.

If you omit style, you will see a list of possible formats.

show demangle-style
  Display the encoding style currently in use for decoding C++ symbols.

set print object
set print object on
When displaying a pointer to an object, identify the actual (derived) type of the object rather than the declared type, using the virtual function table. Note
that the virtual function table is required—this feature can only work for objects that have run-time type identification; a single virtual method in the object’s declared type is sufficient. Note that this setting is also taken into account when working with variable objects via MI (see Chapter 27 [GDB/MI], page 457).

```plaintext
set print object off
```
Display only the declared type of objects, without reference to the virtual function table. This is the default setting.

```plaintext
show print object
```
Show whether actual, or declared, object types are displayed.

```plaintext
set print static-members
set print static-members on
```
Print static members when displaying a C++ object. The default is on.

```plaintext
set print static-members off
```
Do not print static members when displaying a C++ object.

```plaintext
show print static-members
```
Show whether C++ static members are printed or not.

```plaintext
set print pascal_static-members
set print pascal_static-members on
```
Print static members when displaying a Pascal object. The default is on.

```plaintext
set print pascal_static-members off
```
Do not print static members when displaying a Pascal object.

```plaintext
show print pascal_static-members
```
Show whether Pascal static members are printed or not.

```plaintext
set print vtbl
set print vtbl on
```
Pretty print C++ virtual function tables. The default is off. (The `vtbl` commands do not work on programs compiled with the HP ANSI C++ compiler (aCC).)

```plaintext
set print vtbl off
```
Do not pretty print C++ virtual function tables.

```plaintext
show print vtbl
```
Show whether C++ virtual function tables are pretty printed, or not.

### 10.9 Pretty Printing

`gdb` provides a mechanism to allow pretty-printing of values using Python code. It greatly simplifies the display of complex objects. This mechanism works for both MI and the CLI.

#### 10.9.1 Pretty-Printer Introduction

When `gdb` prints a value, it first sees if there is a pretty-printer registered for the value. If there is then `gdb` invokes the pretty-printer to print the value. Otherwise the value is printed normally.
Pretty-printers are normally named. This makes them easy to manage. The `info pretty-printer` command will list all the installed pretty-printers with their names. If a pretty-printer can handle multiple data types, then its subprinters are the printers for the individual data types. Each such subprinter has its own name. The format of the name is `printer-name;subprinter-name`.

Pretty-printers are installed by registering them with GDB. Typically they are automatically loaded and registered when the corresponding debug information is loaded, thus making them available without having to do anything special.

There are three places where a pretty-printer can be registered.

- Pretty-printers registered globally are available when debugging all inferiors.
- Pretty-printers registered with a program space are available only when debugging that program. See Section 23.2.2.22 [Progspace In Python], page 369, for more details on program spaces in Python.
- Pretty-printers registered with an objfile are loaded and unloaded with the corresponding objfile (e.g., shared library). See Section 23.2.2.23 [Objfiles In Python], page 370, for more details on objfiles in Python.

See Section 23.2.2.6 [Selecting Pretty-Printers], page 337, for further information on how pretty-printers are selected.

See Section 23.2.2.7 [Writing a Pretty-Printer], page 338, for implementing pretty printers for new types.

### 10.9.2 Pretty-Printer Example

Here is how a C++ `std::string` looks without a pretty-printer:

```gdb
(gdb) print s
$1 = {
    static npos = 4294967295,
    _M_dataplus = {
        <std::allocator<char>> = {
            <__gnu_cxx::new_allocator<char>> = {
                <No data fields>}, <No data fields>
        },
        members of std::basic_string<char, std::char_traits<char>,
            std::allocator<char>> ::_Alloc_hider:
            _M_p = 0x804a014  "abcd"
    }
}
```

With a pretty-printer for `std::string` only the contents are printed:

```gdb
(gdb) print s
$2 =  "abcd"
```

### 10.9.3 Pretty-Printer Commands

`info pretty-printer [object-regexp [name-regexp]]`

Print the list of installed pretty-printers. This includes disabled pretty-printers, which are marked as such.

`object-regexp` is a regular expression matching the objects whose pretty-printers to list. Objects can be `global`, the program space’s file (see Section 23.2.2.22 [Progspace In Python], page 369), and the object files within that program.
space (see Section 23.2.2.23 [Objfiles In Python], page 370). See Section 23.2.2.6 [Selecting Pretty-Printers], page 337, for details on how GDB looks up a printer from these three objects.

`name-regexp` is a regular expression matching the name of the printers to list.

**disable pretty-printer [object-regexp [name-regexp]]**

Disable pretty-printers matching `object-regexp` and `name-regexp`. A disabled pretty-printer is not forgotten, it may be enabled again later.

**enable pretty-printer [object-regexp [name-regexp]]**

Enable pretty-printers matching `object-regexp` and `name-regexp`.

Example:

Suppose we have three pretty-printers installed: one from library1.so named `foo` that prints objects of type `foo`, and another from library2.so named `bar` that prints two types of objects, `bar1` and `bar2`.

```bash
(gdb) info pretty-printer
library1.so:
  foo
library2.so:
  bar
  bar1
  bar2
(gdb) info pretty-printer library2
library2.so:
  bar
  bar1
  bar2
(gdb) disable pretty-printer library1
1 printer disabled
2 of 3 printers enabled
(gdb) info pretty-printer
library1.so:
  foo [disabled]
library2.so:
  bar
  bar1
  bar2
(gdb) disable pretty-printer library2 bar:bar1
1 printer disabled
1 of 3 printers enabled
(gdb) info pretty-printer library2
library1.so:
  foo [disabled]
library2.so:
  bar
  bar1 [disabled]
  bar2
(gdb) disable pretty-printer library2 bar
1 printer disabled
0 of 3 printers enabled
(gdb) info pretty-printer library2
library1.so:
  foo [disabled]
library2.so:
  bar [disabled]
```
bar1 [disabled]
bar2

Note that for bar the entire printer can be disabled, as can each individual subprinter.

10.10 Value History

Values printed by the print command are saved in the GDB value history. This allows you to refer to them in other expressions. Values are kept until the symbol table is re-read or discarded (for example with the file or symbol-file commands). When the symbol table changes, the value history is discarded, since the values may contain pointers back to the types defined in the symbol table.

The values printed are given history numbers by which you can refer to them. These are successive integers starting with one. print shows you the history number assigned to a value by printing ‘$num = ’ before the value; here num is the history number.

To refer to any previous value, use ‘$’ followed by the value’s history number. The way print labels its output is designed to remind you of this. Just $ refers to the most recent value in the history, and $$ refers to the value before that. $$n refers to the nth value from the end; $$2 is the value just prior to $$, $$1 is equivalent to $$, and $$0 is equivalent to $.

For example, suppose you have just printed a pointer to a structure and want to see the contents of the structure. It suffices to type

```
   p *$
```

If you have a chain of structures where the component next points to the next one, you can print the contents of the next one with this:

```
   p *$.next
```

You can print successive links in the chain by repeating this command—which you can do by just typing RET.

Note that the history records values, not expressions. If the value of x is 4 and you type these commands:

```
   print x
   set x=5
```

then the value recorded in the value history by the print command remains 4 even though the value of x has changed.

show values

Print the last ten values in the value history, with their item numbers. This is like ‘p $$9’ repeated ten times, except that show values does not change the history.

show values n

Print ten history values centered on history item number n.

show values +

Print ten history values just after the values last printed. If no more values are available, show values + produces no display.

Pressing RET to repeat show values n has exactly the same effect as ‘show values +’. 
10.11 Convenience Variables

GDB provides convenience variables that you can use within GDB to hold on to a value and refer to it later. These variables exist entirely within GDB; they are not part of your program, and setting a convenience variable has no direct effect on further execution of your program. That is why you can use them freely.

Convenience variables are prefixed with ‘$’. Any name preceded by ‘$’ can be used for a convenience variable, unless it is one of the predefined machine-specific register names (see Section 10.13 [Registers], page 141). (Value history references, in contrast, are numbers preceded by ‘$’. See Section 10.10 [Value History], page 136.)

You can save a value in a convenience variable with an assignment expression, just as you would set a variable in your program. For example:

```
set $foo = *object_ptr
```

would save in $foo the value contained in the object pointed to by object_ptr.

Using a convenience variable for the first time creates it, but its value is void until you assign a new value. You can alter the value with another assignment at any time.

Convenience variables have no fixed types. You can assign a convenience variable any type of value, including structures and arrays, even if that variable already has a value of a different type. The convenience variable, when used as an expression, has the type of its current value.

```
show convenience
```

Print a list of convenience variables used so far, and their values, as well as a list of the convenience functions. Abbreviated show conv.

```
init-if-undefined $variable = expression
```

Set a convenience variable if it has not already been set. This is useful for user-defined commands that keep some state. It is similar, in concept, to using local static variables with initializers in C (except that convenience variables are global). It can also be used to allow users to override default values used in a command script.

If the variable is already defined then the expression is not evaluated so any side-effects do not occur.

One of the ways to use a convenience variable is as a counter to be incremented or a pointer to be advanced. For example, to print a field from successive elements of an array of structures:

```
set $i = 0
print bar[$i++]->contents
```

Repeat that command by typing RET.

Some convenience variables are created automatically by GDB and given values likely to be useful.

```
$_
```

The variable $_ is automatically set by the x command to the last address examined (see Section 10.6 [Examining Memory], page 121). Other commands which provide a default address for x to examine also set $_ to that address; these commands include info line and info breakpoint. The type of $_ is void * except when set by the x command, in which case it is a pointer to the type of $_.
$$_

The variable $$_ is automatically set by the $x command to the value found in the last address examined. Its type is chosen to match the format in which the data was printed.

$_exitcode

When the program being debugged terminates normally, GDB automatically sets this variable to the exit code of the program, and resets $_exitsignal to void.

$_exitsignal

When the program being debugged dies due to an uncaught signal, GDB automatically sets this variable to that signal’s number, and resets $_exitcode to void.

To distinguish between whether the program being debugged has exited (i.e., $_exitcode is not void) or signalled (i.e., $_exitsignal is not void), the convenience function $_isvoid can be used (see Section 10.12 [Convenience Functions], page 139). For example, considering the following source code:

```c
#include <signal.h>

int main (int argc, char *argv[])
{
    raise (SIGALRM);
    return 0;
}
```

A valid way of telling whether the program being debugged has exited or signalled would be:

```gdb
(gdb) define has_exited_or_signalled
Type commands for definition of 'has_exited_or_signalled'.
End with a line saying just 'end'.
>if $_isvoid ($_exitsignal)
>echo The program has exited
>else
>echo The program has signalled
>end
>end
(gdb) run
Starting program:

Program terminated with signal SIGALRM, Alarm clock.
The program no longer exists.
(gdb) has_exited_or_signalled
The program has signalled
```

As can be seen, GDB correctly informs that the program being debugged has signalled, since it calls `raise` and raises a `SIGALRM` signal. If the program being debugged had not called `raise`, then GDB would report a normal exit:

```gdb
(gdb) has_exited_or_signalled
The program has exited
```

$_exception

The variable $_exception is set to the exception object being thrown at an exception-related catchpoint. See Section 5.1.3 [Set Catchpoints], page 55.
$\_probe\_argc
$\_probe\_arg0...$\_probe\_arg11
Arguments to a static probe. See Section 5.1.10 [Static Probe Points], page 65.

$\_sdata
The variable $\_sdata contains extra collected static tracepoint data. See Section 13.1.6 [Tracepoint Action Lists], page 168. Note that $\_sdata could be empty, if not inspecting a trace buffer, or if extra static tracepoint data has not been collected.

$\_siginfo
The variable $\_siginfo contains extra signal information (see [extra signal information], page 75). Note that $\_siginfo could be empty, if the application has not yet received any signals. For example, it will be empty before you execute the run command.

$\_tlb
The variable $\_tlb is automatically set when debugging applications running on MS-Windows in native mode or connected to gdbserver that supports the qGetTIBAddr request. See Section E.4 [General Query Packets], page 621. This variable contains the address of the thread information block.

On HP-UX systems, if you refer to a function or variable name that begins with a dollar sign, GDB searches for a user or system name first, before it searches for a convenience variable.

10.12 Convenience Functions

GDB also supplies some convenience functions. These have a syntax similar to convenience variables. A convenience function can be used in an expression just like an ordinary function; however, a convenience function is implemented internally to GDB.

These functions do not require GDB to be configured with Python support, which means that they are always available.

$\_isvoid (expr)
Return one if the expression expr is void. Otherwise it returns zero.

A void expression is an expression where the type of the result is void. For example, you can examine a convenience variable (see Section 10.11 [Convenience Variables], page 137) to check whether it is void:

```gdb
(gdb) print $\_exitcode
$1 = void
(gdb) print $\_isvoid ($\_exitcode)
$2 = 1
(gdb) run
Starting program: ./a.out
[Inferior 1 (process 29572) exited normally]
(gdb) print $\_exitcode
$3 = 0
(gdb) print $\_isvoid ($\_exitcode)
$4 = 0
```

In the example above, we used $\_isvoid to check whether $\_exitcode is void before and after the execution of the program being debugged. Before the execution there is no exit code to be examined, therefore $\_exitcode is void.
After the execution the program being debugged returned zero, therefore $-_exitoce$ is zero, which means that it is not void anymore.

The void expression can also be a call of a function from the program being debugged. For example, given the following function:

```c
void
foo (void)
{
}
```

The result of calling it inside GDB is void:

```gdb
(gdb) print foo ()
$1 = void
(gdb) print $_isvoid (foo ()
$2 = 1
(gdb) set $v = foo ()
(gdb) print $v
$3 = void
(gdb) print $_isvoid ($v)
$4 = 1
```

These functions require GDB to be configured with Python support.

$-_memeq(buf1, buf2, length)$

Returns one if the length bytes at the addresses given by buf1 and buf2 are equal. Otherwise it returns zero.

$-_regex(str, regex)$

Returns one if the string str matches the regular expression regex. Otherwise it returns zero. The syntax of the regular expression is that specified by Python's regular expression support.

$-_streq(str1, str2)$

Returns one if the strings str1 and str2 are equal. Otherwise it returns zero.

$-_strlen(str)$

Returns the length of string str.

$-_caller_is(name[, number_of_frames])$

Returns one if the calling function’s name is equal to name. Otherwise it returns zero.

If the optional argument number_of_frames is provided, it is the number of frames up in the stack to look. The default is 1.

Example:

```gdb
(gdb) backtrace
#0  bottom_func ()
     at testsuite/gdb.python/py-caller-is.c:21
#1  0x00000000004005a0 in middle_func ()
     at testsuite/gdb.python/py-caller-is.c:27
#2  0x00000000004005ab in top_func ()
     at testsuite/gdb.python/py-caller-is.c:33
#3  0x00000000004005b6 in main ()
     at testsuite/gdb.python/py-caller-is.c:39
(gdb) print $_ caller_is ("middle_func")
$1 = 1
(gdb) print $_ caller_is ("top_func", 2)
$1 = 1
```
$_caller_matches(regexp[, number_of_frames])

Returns one if the calling function’s name matches the regular expression regexp. Otherwise it returns zero.

If the optional argument number_of_frames is provided, it is the number of frames up in the stack to look. The default is 1.

$_any_caller_is(name[, number_of_frames])

Returns one if any calling function’s name is equal to name. Otherwise it returns zero.

If the optional argument number_of_frames is provided, it is the number of frames up in the stack to look. The default is 1.

This function differs from $_caller_is in that this function checks all stack frames from the immediate caller to the frame specified by number_of_frames, whereas $_caller_is only checks the frame specified by number_of_frames.

$_any_caller_matches(regexp[, number_of_frames])

Returns one if any calling function’s name matches the regular expression regexp. Otherwise it returns zero.

If the optional argument number_of_frames is provided, it is the number of frames up in the stack to look. The default is 1.

This function differs from $_caller_matches in that this function checks all stack frames from the immediate caller to the frame specified by number_of_frames, whereas $_caller_matches only checks the frame specified by number_of_frames.

GDB provides the ability to list and get help on convenience functions.

help function

Print a list of all convenience functions.

10.13 Registers

You can refer to machine register contents, in expressions, as variables with names starting with ‘$’. The names of registers are different for each machine; use info registers to see the names used on your machine.

info registers

Print the names and values of all registers except floating-point and vector registers (in the selected stack frame).

info all-registers

Print the names and values of all registers, including floating-point and vector registers (in the selected stack frame).

info registers regname ...

Print the relativized value of each specified register regname. As discussed in detail below, register values are normally relative to the selected stack frame. The regname may be any register name valid on the machine you are using, with or without the initial ‘$’.
GDB has four “standard” register names that are available (in expressions) on most machines—whenever they do not conflict with an architecture’s canonical mnemonics for registers. The register names $pc$ and $sp$ are used for the program counter register and the stack pointer. $fp$ is used for a register that contains a pointer to the current stack frame, and $ps$ is used for a register that contains the processor status. For example, you could print the program counter in hex with

```
p/x $pc
```

or print the instruction to be executed next with

```
x/i $pc
```

or add four to the stack pointer\(^2\) with

```
set $sp += 4
```

Whenever possible, these four standard register names are available on your machine even though the machine has different canonical mnemonics, so long as there is no conflict. The `info registers` command shows the canonical names. For example, on the SPARC, `info registers` displays the processor status register as $psr$ but you can also refer to it as $ps$; and on x86-based machines $ps$ is an alias for the EFLAGS register.

GDB always considers the contents of an ordinary register as an integer when the register is examined in this way. Some machines have special registers which can hold nothing but floating point; these registers are considered to have floating point values. There is no way to refer to the contents of an ordinary register as floating point value (although you can `print` it as a floating point value with `’print/f $regname’`).

Some registers have distinct “raw” and “virtual” data formats. This means that the data format in which the register contents are saved by the operating system is not the same one that your program normally sees. For example, the registers of the 68881 floating point coprocessor are always saved in “extended” (raw) format, but all C programs expect to work with “double” (virtual) format. In such cases, GDB normally works with the virtual format only (the format that makes sense for your program), but the `info registers` command prints the data in both formats.

Some machines have special registers whose contents can be interpreted in several different ways. For example, modern x86-based machines have SSE and MMX registers that can hold several values packed together in several different formats. GDB refers to such registers in `struct` notation:

```
(gdb) print $xmm1
$1 = {
  v4_float = {0, 3.43859137e-038, 1.54142831e-044, 1.821668e-044},
  v2_double = {9.92129282474342e-303, 2.758945287983262e-313},
  v16_int8 = "\000\000\000\000\000\000\000\000\000\000\000\000\000\000\000\000",
  v8_int16 = {0, 0, 14072, 315, 11, 0, 13, 0},
  v4_int32 = {0, 20657912, 11, 13},
  v2_int64 = {88725056443645952, 55834574859},
  uint128 = 0x0000000000000000b013b36f800000000
}
```

\(^2\) This is a way of removing one word from the stack, on machines where stacks grow downward in memory (most machines, nowadays). This assumes that the innermost stack frame is selected; setting $sp$ is not allowed when other stack frames are selected. To pop entire frames off the stack, regardless of machine architecture, use `return`; see Section 17.4 [Returning from a Function], page 228.
To set values of such registers, you need to tell GDB which view of the register you wish to change, as if you were assigning value to a `struct` member:

```
(gdb) set $xmm1.uint128 = 0x000000000000000000000000FFFFFFFF
```

Normally, register values are relative to the selected stack frame (see Section 8.4 [Selecting a Frame], page 99). This means that you get the value that the register would contain if all stack frames farther in were exited and their saved registers restored. In order to see the true contents of hardware registers, you must select the innermost frame (with `frame 0`).

Usually ABIs reserve some registers as not needed to be saved by the callee (a.k.a.: “caller-saved”, “call-clobbered” or “volatile” registers). It may therefore not be possible for GDB to know the value a register had before the call (in other words, in the outer frame), if the register value has since been changed by the callee. GDB tries to deduce where the inner frame saved (“callee-saved”) registers, from the debug info, unwind info, or the machine code generated by your compiler. If some register is not saved, and GDB knows the register is “caller-saved” (via its own knowledge of the ABI, or because the debug/unwind info explicitly says the register’s value is undefined), GDB displays `<not saved>` as the register’s value. With targets that GDB has no knowledge of the register saving convention, if a register was not saved by the callee, then its value and location in the outer frame are assumed to be the same of the inner frame. This is usually harmless, because if the register is call-clobbered, the caller either does not care what is in the register after the call, or has code to restore the value that it does care about. Note, however, that if you change such a register in the outer frame, you may also be affecting the inner frame. Also, the more “outer” the frame is you’re looking at, the more likely a call-clobbered register’s value is to be wrong, in the sense that it doesn’t actually represent the value the register had just before the call.

### 10.14 Floating Point Hardware

Depending on the configuration, GDB may be able to give you more information about the status of the floating point hardware.

```
info float
```

Display hardware-dependent information about the floating point unit. The exact contents and layout vary depending on the floating point chip. Currently, `info float` is supported on the ARM and x86 machines.

### 10.15 Vector Unit

Depending on the configuration, GDB may be able to give you more information about the status of the vector unit.

```
info vector
```

Display information about the vector unit. The exact contents and layout vary depending on the hardware.

### 10.16 Operating System Auxiliary Information

GDB provides interfaces to useful OS facilities that can help you debug your program.
Some operating systems supply an *auxiliary vector* to programs at startup. This is akin to the arguments and environment that you specify for a program, but contains a system-dependent variety of binary values that tell system libraries important details about the hardware, operating system, and process. Each value’s purpose is identified by an integer tag; the meanings are well-known but system-specific. Depending on the configuration and operating system facilities, GDB may be able to show you this information. For remote targets, this functionality may further depend on the remote stub’s support of the ‘qXfer:auxv:read’ packet, see [qXfer auxiliary vector read], page 637.

**info auxv** Display the auxiliary vector of the inferior, which can be either a live process or a core dump file. GDB prints each tag value numerically, and also shows names and text descriptions for recognized tags. Some values in the vector are numbers, some bit masks, and some pointers to strings or other data. GDB displays each value in the most appropriate form for a recognized tag, and in hexadecimal for an unrecognized tag.

On some targets, GDB can access operating system-specific information and show it to you. The types of information available will differ depending on the type of operating system running on the target. The mechanism used to fetch the data is described in Appendix H [Operating System Information], page 697. For remote targets, this functionality depends on the remote stub’s support of the ‘qXfer:osdata:read’ packet, see [qXfer osdata read], page 641.

**info os infotype** Display OS information of the requested type.

On GNU/Linux, the following values of *infotype* are valid:

- **cpus** Display the list of all CPUs/cores. For each CPU/core, GDB prints the available fields from /proc/cpuinfo. For each supported architecture different fields are available. Two common entries are processor which gives CPU number and bogomips; a system constant that is calculated during kernel initialization.

- **files** Display the list of open file descriptors on the target. For each file descriptor, GDB prints the identifier of the process owning the descriptor, the command of the owning process, the value of the descriptor, and the target of the descriptor.

- **modules** Display the list of all loaded kernel modules on the target. For each module, GDB prints the module name, the size of the module in bytes, the number of times the module is used, the dependencies of the module, the status of the module, and the address of the loaded module in memory.

- **msg** Display the list of all System V message queues on the target. For each message queue, GDB prints the message queue key, the message queue identifier, the access permissions, the current number of bytes on the queue, the current number of messages on the queue, the processes that last sent and received a message on the queue, the user and group of the owner and creator of the message queue, the
times at which a message was last sent and received on the queue, and the time at which the message queue was last changed.

**processes**

Display the list of processes on the target. For each process, GDB prints the process identifier, the name of the user, the command corresponding to the process, and the list of processor cores that the process is currently running on. (To understand what these properties mean, for this and the following info types, please consult the general GNU/Linux documentation.)

**procgrouops**

Display the list of process groups on the target. For each process, GDB prints the identifier of the process group that it belongs to, the command corresponding to the process group leader, the process identifier, and the command line of the process. The list is sorted first by the process group identifier, then by the process identifier, so that processes belonging to the same process group are grouped together and the process group leader is listed first.

**semaphores**

Display the list of all System V semaphore sets on the target. For each semaphore set, GDB prints the semaphore set key, the semaphore set identifier, the access permissions, the number of semaphores in the set, the user and group of the owner and creator of the semaphore set, and the times at which the semaphore set was operated upon and changed.

**shm**

Display the list of all System V shared-memory regions on the target. For each shared-memory region, GDB prints the region key, the shared-memory identifier, the access permissions, the size of the region, the process that created the region, the process that last attached to or detached from the region, the current number of live attaches to the region, and the times at which the region was last attached to, detach from, and changed.

**sockets**

Display the list of Internet-domain sockets on the target. For each socket, GDB prints the address and port of the local and remote endpoints, the current state of the connection, the creator of the socket, the IP address family of the socket, and the type of the connection.

**threads**

Display the list of threads running on the target. For each thread, GDB prints the identifier of the process that the thread belongs to, the command of the process, the thread identifier, and the processor core that it is currently running on. The main thread of a process is not listed.

**info os**

If infotype is omitted, then list the possible values for infotype and the kind of OS information available for each infotype. If the target does not return a list of possible types, this command will report an error.
10.17 Memory Region Attributes

Memory region attributes allow you to describe special handling required by regions of your target’s memory. GDB uses attributes to determine whether to allow certain types of memory accesses; whether to use specific width accesses; and whether to cache target memory. By default the description of memory regions is fetched from the target (if the current target supports this), but the user can override the fetched regions.

Defined memory regions can be individually enabled and disabled. When a memory region is disabled, GDB uses the default attributes when accessing memory in that region. Similarly, if no memory regions have been defined, GDB uses the default attributes when accessing all memory.

When a memory region is defined, it is given a number to identify it; to enable, disable, or remove a memory region, you specify that number.

**mem lower upper attributes...**

Define a memory region bounded by *lower* and *upper* with attributes *attributes...*, and add it to the list of regions monitored by GDB. Note that *upper == 0* is a special case: it is treated as the target’s maximum memory address. (0xffff on 16 bit targets, 0xffffffff on 32 bit targets, etc.)

**mem auto**

Discard any user changes to the memory regions and use target-supplied regions, if available, or no regions if the target does not support.

**delete mem nums...**

Remove memory regions *nums...* from the list of regions monitored by GDB.

**disable mem nums...**

Disable monitoring of memory regions *nums...*. A disabled memory region is not forgotten. It may be enabled again later.

**enable mem nums...**

Enable monitoring of memory regions *nums...*.

**info mem**

Print a table of all defined memory regions, with the following columns for each region:

- **Memory Region Number**
- **Enabled or Disabled.**
  - Enabled memory regions are marked with ‘y’. Disabled memory regions are marked with ‘n’.
- **Lo Address**
  - The address defining the inclusive lower bound of the memory region.
- **Hi Address**
  - The address defining the exclusive upper bound of the memory region.
- **Attributes**
  - The list of attributes set for this memory region.

10.17.1 Attributes
10.17.1.1 Memory Access Mode

The access mode attributes set whether GDB may make read or write accesses to a memory region.

While these attributes prevent GDB from performing invalid memory accesses, they do nothing to prevent the target system, I/O DMA, etc. from accessing memory.

- `ro` Memory is read only.
- `wo` Memory is write only.
- `rw` Memory is read/write. This is the default.

10.17.1.2 Memory Access Size

The access size attribute tells GDB to use specific sized accesses in the memory region. Often memory mapped device registers require specific sized accesses. If no access size attribute is specified, GDB may use accesses of any size.

- `8` Use 8 bit memory accesses.
- `16` Use 16 bit memory accesses.
- `32` Use 32 bit memory accesses.
- `64` Use 64 bit memory accesses.

10.17.1.3 Data Cache

The data cache attributes set whether GDB will cache target memory. While this generally improves performance by reducing debug protocol overhead, it can lead to incorrect results because GDB does not know about volatile variables or memory mapped device registers.

- `cache` Enable GDB to cache target memory.
- `nocache` Disable GDB from caching target memory. This is the default.

10.17.2 Memory Access Checking

GDB can be instructed to refuse accesses to memory that is not explicitly described. This can be useful if accessing such regions has undesired effects for a specific target, or to provide better error checking. The following commands control this behaviour.

`set mem inaccessible-by-default [on|off]`

If `on` is specified, make GDB treat memory not explicitly described by the memory ranges as non-existent and refuse accesses to such memory. The checks are only performed if there’s at least one memory range defined. If `off` is specified, make GDB treat the memory not explicitly described by the memory ranges as RAM. The default value is `on`.

`show mem inaccessible-by-default`

Show the current handling of accesses to unknown memory.
10.18 Copy Between Memory and a File

You can use the commands `dump`, `append`, and `restore` to copy data between target memory and a file. The `dump` and `append` commands write data to a file, and the `restore` command reads data from a file back into the inferior’s memory. Files may be in binary, Motorola S-record, Intel hex, Tektronix Hex, or Verilog Hex format; however, GDB can only append to binary files, and cannot read from Verilog Hex files.

```
dump [format] memory filename start_addr end_addr
dump [format] value filename expr
```

Dump the contents of memory from `start_addr` to `end_addr`, or the value of `expr`, to `filename` in the given format.

The `format` parameter may be any one of:

- **binary**: Raw binary form.
- **ihex**: Intel hex format.
- **srec**: Motorola S-record format.
- **tekhex**: Tektronix Hex format.
- **verilog**: Verilog Hex format.

GDB uses the same definitions of these formats as the GNU binary utilities, like ‘objdump’ and ‘objc’.

If `format` is omitted, GDB dumps the data in raw binary form.

```
append [binary] memory filename start_addr end_addr
append [binary] value filename expr
```

Append the contents of memory from `start_addr` to `end_addr`, or the value of `expr`, to the file `filename`, in raw binary form. (GDB can only append data to files in raw binary form.)

```
restore filename [binary] bias start end
```

Restore the contents of file `filename` into memory. The `restore` command can automatically recognize any known bfd file format, except for raw binary. To restore a raw binary file you must specify the optional keyword `binary` after the filename.

If `bias` is non-zero, its value will be added to the addresses contained in the file. Binary files always start at address zero, so they will be restored at address `bias`. Other bfd files have a built-in location; they will be restored at offset `bias` from that location.

If `start` and/or `end` are non-zero, then only data between file offset `start` and file offset `end` will be restored. These offsets are relative to the addresses in the file, before the `bias` argument is applied.

10.19 How to Produce a Core File from Your Program

A core file or core dump is a file that records the memory image of a running process and its process status (register values etc.). Its primary use is post-mortem debugging of a program that crashed while it ran outside a debugger. A program that crashes automatically
produces a core file, unless this feature is disabled by the user. See Section 18.1 [Files], page 237, for information on invoking GDB in the post-mortem debugging mode.

Occasionally, you may wish to produce a core file of the program you are debugging in order to preserve a snapshot of its state. GDB has a special command for that.

`generate-core-file [file]`
`gcore [file]`

Produce a core dump of the inferior process. The optional argument file specifies the file name where to put the core dump. If not specified, the file name defaults to ‘core.pid’, where pid is the inferior process ID.

Note that this command is implemented only for some systems (as of this writing, GNU/Linux, FreeBSD, Solaris, and S390).

On GNU/Linux, this command can take into account the value of the file ‘/proc/pid/coredump_filter’ when generating the core dump (see [set use-coredump-filter], page 149).

`set use-coredump-filter on`
`set use-coredump-filter off`

Enable or disable the use of the file ‘/proc/pid/coredump_filter’ when generating core dump files. This file is used by the Linux kernel to decide what types of memory mappings will be dumped or ignored when generating a core dump file. pid is the process ID of a currently running process.

To make use of this feature, you have to write in the ‘/proc/pid/coredump_filter’ file a value, in hexadecimal, which is a bit mask representing the memory mapping types. If a bit is set in the bit mask, then the memory mappings of the corresponding types will be dumped; otherwise, they will be ignored. This configuration is inherited by child processes. For more information about the bits that can be set in the ‘/proc/pid/coredump_filter’ file, please refer to the manpage of core(5).

By default, this option is on. If this option is turned off, GDB does not read the ‘coredump_filter’ file and instead uses the same default value as the Linux kernel in order to decide which pages will be dumped in the core dump file. This value is currently 0x33, which means that bits 0 (anonymous private mappings), 1 (anonymous shared mappings), 4 (ELF headers) and 5 (private huge pages) are active. This will cause these memory mappings to be dumped automatically.

### 10.20 Character Sets

If the program you are debugging uses a different character set to represent characters and strings than the one GDB uses itself, GDB can automatically translate between the character sets for you. The character set GDB uses we call the host character set; the one the inferior program uses we call the target character set.

For example, if you are running GDB on a GNU/Linux system, which uses the ISO Latin 1 character set, but you are using GDB’s remote protocol (see Chapter 20 [Remote Debugging], page 257) to debug a program running on an IBM mainframe, which uses the EBCDIC character set, then the host character set is Latin-1, and the target character set is EBCDIC.
If you give GDB the command `set target-charset EBCDIC-US`, then GDB translates between EBCDIC and Latin 1 as you print character or string values, or use character and string literals in expressions.

GDB has no way to automatically recognize which character set the inferior program uses; you must tell it, using the `set target-charset` command, described below.

Here are the commands for controlling GDB’s character set support:

```
set target-charset charset
Set the current target character set to `charset`. To display the list of supported target character sets, type `set target-charset TABTAB`.

set host-charset charset
Set the current host character set to `charset`.

By default, GDB uses a host character set appropriate to the system it is running on; you can override that default using the `set host-charset` command. On some systems, GDB cannot automatically determine the appropriate host character set. In this case, GDB uses ‘UTF-8’.

GDB can only use certain character sets as its host character set. If you type `set host-charset TABTAB`, GDB will list the host character sets it supports.

set charset charset
Set the current host and target character sets to `charset`. As above, if you type `set charset TABTAB`, GDB will list the names of the character sets that can be used for both host and target.

show charset
Show the names of the current host and target character sets.

show host-charset
Show the name of the current host character set.

show target-charset
Show the name of the current target character set.

set target-wide-charset charset
Set the current target’s wide character set to `charset`. This is the character set used by the target’s `wchar_t` type. To display the list of supported wide character sets, type `set target-wide-charset TABTAB`.

show target-wide-charset
Show the name of the current target’s wide character set.
```

Here is an example of GDB’s character set support in action. Assume that the following source code has been placed in the file ‘charset-test.c’:

```
#include <stdio.h>

char ibm1047_hello[] = {200, 133, 147, 147, 150, 107, 64, 166, 150, 153, 147, 132, 90, 37, 0};
```
main ()
{
    printf ("Hello, world!\n");
}

In this program, ascii_hello and ibm1047_hello are arrays containing the string ‘Hello, world!’ followed by a newline, encoded in the ASCII and IBM1047 character sets.

We compile the program, and invoke the debugger on it:

$ gcc -g charset-test.c -o charset-test
$ gdb -nw charset-test
GNU gdb 2001-12-19-cvs
Copyright 2001 Free Software Foundation, Inc.
...
(gdb)

We can use the show charset command to see what character sets GDB is currently using to interpret and display characters and strings:

(gdb) show charset
The current host and target character set is ‘ISO-8859-1’.
(gdb)

For the sake of printing this manual, let’s use ASCII as our initial character set:

(gdb) set charset ASCII
(gdb) show charset
The current host and target character set is ‘ASCII’.
(gdb)

Let’s assume that ASCII is indeed the correct character set for our host system — in other words, let’s assume that if GDB prints characters using the ASCII character set, our terminal will display them properly. Since our current target character set is also ASCII, the contents of ascii_hello print legibly:

(gdb) print ascii_hello
$1 = 0x401698 "Hello, world!\n"
(gdb) print ascii_hello[0]
$2 = 72 'H'
(gdb)

GDB uses the target character set for character and string literals you use in expressions:

(gdb) print '+'
$3 = 43 '+'
(gdb)

The ASCII character set uses the number 43 to encode the ‘+’ character.

GDB relies on the user to tell it which character set the target program uses. If we print ibm1047_hello while our target character set is still ASCII, we get jibberish:

(gdb) print ibm1047_hello
$4 = 0x4016a8 "\310\205\223\223\226k@\246\226\231\223\204Z"
(gdb) print ibm1047_hello[0]
$5 = 200 '\310'
(gdb)

If we invoke the set target-charset followed by TABTAB, GDB tells us the character sets it supports:

(gdb) set target-charset
ASCII   EBCDIC-US  IBM1047   ISO-8859-1
(gdb) set target-charset
We can select IBM1047 as our target character set, and examine the program’s strings again. Now the ASCII string is wrong, but GDB translates the contents of `ibm1047_hello` from the target character set, IBM1047, to the host character set, ASCII, and they display correctly:

```
(gdb) set target-charset IBM1047
(gdb) show charset
The current host character set is ‘ASCII’.
The current target character set is ‘IBM1047’.
(gdb) print ascii_hello
$6 = 0x401698 "\110\145%%?\054\040\167?\162%\144\041\012"
(gdb) print ascii_hello[0]
$7 = 72 \110'
(gdb) print ibm1047_hello
$8 = 0x0416A8 "Hello, world!\n"
(gdb) print ibm1047_hello[0]
$9 = 200 \H'
(gdb)
```

As above, GDB uses the target character set for character and string literals you use in expressions:

```
(gdb) print '+'
$10 = 78 \+'
(gdb)
```

The IBM1047 character set uses the number 78 to encode the ‘+’ character.

**10.21 Caching Data of Targets**

GDB caches data exchanged between the debugger and a target. Each cache is associated with the address space of the inferior. See Section 4.9 [Inferiors and Programs], page 33, about inferior and address space. Such caching generally improves performance in remote debugging (see Chapter 20 [Remote Debugging], page 257), because it reduces the overhead of the remote protocol by bundling memory reads and writes into large chunks. Unfortunately, simply caching everything would lead to incorrect results, since GDB does not necessarily know anything about volatile values, memory-mapped I/O addresses, etc. Furthermore, in non-stop mode (see Section 5.5.2 [Non-Stop Mode], page 77) memory can be changed while a gdb command is executing. Therefore, by default, GDB only caches data known to be on the stack\(^3\) or in the code segment. Other regions of memory can be explicitly marked as cacheable; see Section 10.17 [Memory Region Attributes], page 146.

```
set remotecache on
set remotecache off

This option no longer does anything; it exists for compatibility with old scripts.
```

```
show remotecache

Show the current state of the obsolete remotecache flag.
```

```
set stack-cache on
set stack-cache off

Enable or disable caching of stack accesses. When on, use caching. By default, this option is on.
```

\(^3\) In non-stop mode, it is moderately rare for a running thread to modify the stack of a stopped thread in a way that would interfere with a backtrace, and caching of stack reads provides a significant speed up of remote backtraces.
show stack-cache
Show the current state of data caching for memory accesses.

set code-cache on
set code-cache off
Enable or disable caching of code segment accesses. When on, use caching. By
default, this option is on. This improves performance of disassembly in remote
debugging.

show code-cache
Show the current state of target memory cache for code segment accesses.

info dcache [line]
Print the information about the performance of data cache of the current infe-
rior’s address space. The information displayed includes the dcache width and
depth, and for each cache line, its number, address, and how many times it was
referenced. This command is useful for debugging the data cache operation.
If a line number is specified, the contents of that line will be printed in hex.

set dcache size size
Set maximum number of entries in dcache (dcache depth above).

set dcache line-size line-size
Set number of bytes each dcache entry caches (dcache width above). Must be
a power of 2.

show dcache size
Show maximum number of dcache entries. See Section 10.21 [Caching Target
Data], page 152.

show dcache line-size
Show default size of dcache lines.

10.22 Search Memory
Memory can be searched for a particular sequence of bytes with the find command.

find [/sn] start_addr, +len, val1 [, val2, ...]
find [/sn] start_addr, end_addr, val1 [, val2, ...]
Search memory for the sequence of bytes specified by val1, val2, etc. The search
begins at address start_addr and continues for either len bytes or through to
end_addr inclusive.

s and n are optional parameters. They may be specified in either order, apart or together.

s, search query size
The size of each search query value.
  b bytes
  h halfwords (two bytes)
  w words (four bytes)
  g giant words (eight bytes)
All values are interpreted in the current language. This means, for example, that if the current source language is C/C++ then searching for the string “hello” includes the trailing ‘\0’.

If the value size is not specified, it is taken from the value’s type in the current language. This is useful when one wants to specify the search pattern as a mixture of types. Note that this means, for example, that in the case of C-like languages a search for an untyped 0x42 will search for ‘(int) 0x42’ which is typically four bytes.

\[n\], maximum number of finds

The maximum number of matches to print. The default is to print all finds.

You can use strings as search values. Quote them with double-quotes ("). The string value is copied into the search pattern byte by byte, regardless of the endianness of the target and the size specification.

The address of each match found is printed as well as a count of the number of matches found.

The address of the last value found is stored in convenience variable ‘$_’. A count of the number of matches is stored in ‘$numfound’.

For example, if stopped at the `printf` in this function:

```c
void
hello ()
{
    static char hello[] = "hello-hello";
    static struct { char c; short s; int i; }
        __attribute__(\((\text{packed})\)) mixed
            = { 'c', 0x1234, 0x87654321 };
    printf ("%s\n", hello);
}
```

you get during debugging:

```plaintext
(gdb) find &hello[0], +sizeof(hello), "hello"
0x804956d <hello.1620+6>
1 pattern found
(gdb) find &hello[0], +sizeof(hello), 'h', 'e', 'l', 'l', 'o'
0x8049567 <hello.1620>
0x804956d <hello.1620+6>
2 patterns found
(gdb) find /b1 &hello[0], +sizeof(hello), 'h', 0x65, 'l'
0x8049567 <hello.1620>
1 pattern found
(gdb) find &mixed, +sizeof(mixed), (char) 'c', (short) 0x1234, (int) 0x87654321
0x8049560 <mixed.1625>
1 pattern found
(gdb) print $numfound
$1 = 1
(gdb) print $_
$2 = (void *) 0x8049560
```
11 Debugging Optimized Code

Almost all compilers support optimization. With optimization disabled, the compiler generates assembly code that corresponds directly to your source code, in a simplistic way. As the compiler applies more powerful optimizations, the generated assembly code diverges from your original source code. With help from debugging information generated by the compiler, GDB can map from the running program back to constructs from your original source.

GDB is more accurate with optimization disabled. If you can recompile without optimization, it is easier to follow the progress of your program during debugging. But, there are many cases where you may need to debug an optimized version.

When you debug a program compiled with ‘-g -O’, remember that the optimizer has rearranged your code; the debugger shows you what is really there. Do not be too surprised when the execution path does not exactly match your source file! An extreme example: if you define a variable, but never use it, GDB never sees that variable—because the compiler optimizes it out of existence.

Some things do not work as well with ‘-g -O’ as with just ‘-g’, particularly on machines with instruction scheduling. If in doubt, recompile with ‘-g’ alone, and if this fixes the problem, please report it to us as a bug (including a test case!). See Section 10.3 [Variables], page 117, for more information about debugging optimized code.

11.1 Inline Functions

Inlining is an optimization that inserts a copy of the function body directly at each call site, instead of jumping to a shared routine. GDB displays inlined functions just like non-inlined functions. They appear in backtraces. You can view their arguments and local variables, step into them with step, skip them with next, and escape from them with finish. You can check whether a function was inlined by using the info frame command.

For GDB to support inlined functions, the compiler must record information about inlining in the debug information — GCC using the DWARF 2 format does this, and several other compilers do also. GDB only supports inlined functions when using DWARF 2. Versions of GCC before 4.1 do not emit two required attributes (‘DW_AT_call_file’ and ‘DW_AT_call_line’); GDB does not display inlined function calls with earlier versions of GCC. It instead displays the arguments and local variables of inlined functions as local variables in the caller.

The body of an inlined function is directly included at its call site; unlike a non-inlined function, there are no instructions devoted to the call. GDB still pretends that the call site and the start of the inlined function are different instructions. Stepping to the call site shows the call site, and then stepping again shows the first line of the inlined function, even though no additional instructions are executed.

This makes source-level debugging much clearer; you can see both the context of the call and then the effect of the call. Only stepping by a single instruction using stepi or nexti does not do this; single instruction steps always show the inlined body.

There are some ways that GDB does not pretend that inlined function calls are the same as normal calls:
Setting breakpoints at the call site of an inlined function may not work, because the call site does not contain any code. GDB may incorrectly move the breakpoint to the next line of the enclosing function, after the call. This limitation will be removed in a future version of GDB; until then, set a breakpoint on an earlier line or inside the inlined function instead.

GDB cannot locate the return value of inlined calls after using the `finish` command. This is a limitation of compiler-generated debugging information; after `finish`, you can step to the next line and print a variable where your program stored the return value.

### 11.2 Tail Call Frames

Function B can call function C in its very last statement. In unoptimized compilation the call of C is immediately followed by return instruction at the end of B code. Optimizing compiler may replace the call and return in function B into one jump to function C instead. Such use of a jump instruction is called *tail call*.

During execution of function C, there will be no indication in the function call stack frames that it was tail-called from B. If function A regularly calls function B which tail-calls function C, then GDB will see A as the caller of C. However, in some cases GDB can determine that C was tail-called from B, and it will then create fictitious call frame for that, with the return address set up as if B called C normally.

This functionality is currently supported only by DWARF 2 debugging format and the compiler has to produce ‘DW_TAG_GNU_call_site’ tags. With GCC, you need to specify ‘-O-g’ during compilation, to get this information.

The `info frame` command (see Section 8.5 [Frame Info], page 100) will indicate the tail call frame kind by text *tail call frame* such as in this sample GDB output:

```
(gdb) x/i $pc - 2
 0x40066b <b(int, double)+11>: jmp 0x400640 <c(int, double)>
(gdb) info frame
Stack level 1, frame at 0x7fffffffda30:
  rip = 0x40066d in b (amd64-entry-value.cc:59); saved rip 0x4004c5
tail call frame, caller of frame at 0x7fffffffda30
  source language c++.
  Arglist at unknown address.
  Locals at unknown address, Previous frame’s sp is 0x7fffffffda30
```

The detection of all the possible code path executions can find them ambiguous. There is no execution history stored (possible Chapter 6 [Reverse Execution], page 83 is never used for this purpose) and the last known caller could have reached the known callee by multiple different jump sequences. In such case GDB still tries to show at least all the unambiguous top tail callers and all the unambiguous bottom tail callees, if any.

`set debug entry-values`

When set to on, enables printing of analysis messages for both frame argument values at function entry and tail calls. It will show all the possible valid tail calls code paths it has considered. It will also print the intersection of them with the final unambiguous (possibly partial or even empty) code path result.
show debug entry-values

Show the current state of analysis messages printing for both frame argument values at function entry and tail calls.

The analysis messages for tail calls can for example show why the virtual tail call frame for function c has not been recognized (due to the indirect reference by variable x):

```c
static void __attribute__((noinline, noclone)) c (void);
void (*) (void) = c;
static void __attribute__((noinline, noclone)) a (void) { x++; }
static void __attribute__((noinline, noclone)) c (void) { a (); }
int main (void) { x (); return 0; }
```

Breakpoint 1, DW_OP_GNU_entry_value resolving cannot find DW_TAG_GNU_call_site 0x40039a in main

```
a () at t.c:3
3 static void __attribute__((noinline, noclone)) a (void) { x++; }
(gdb) bt
#0 a () at t.c:3
#1 0x000000000040039a in main () at t.c:5
```

Another possibility is an ambiguous virtual tail call frames resolution:

```c
int i;
static void __attribute__((noinline, noclone)) f (void) { i++; }
static void __attribute__((noinline, noclone)) e (void) { f (); }
static void __attribute__((noinline, noclone)) d (void) { f (); }
static void __attribute__((noinline, noclone)) c (void) { d (); }
static void __attribute__((noinline, noclone)) b (void)
{ if (i) c (); else e (); }
static void __attribute__((noinline, noclone)) a (void) { b (); }
int main (void) { a (); return 0; }
```

```
tailcall: initial: 0x4004d2(a) 0x4004ce(b) 0x4004b2(c) 0x4004a2(d)
tailcall: compare: 0x4004d2(a) 0x4004cc(b) 0x400492(e)
tailcall: reduced: 0x4004d2(a) |
(gdb) bt
#0 f () at t.c:2
#1 0x00000000004004d2 in a () at t.c:8
#2 0x0000000000400495 in main () at t.c:9
```

Frames #0 and #2 are real, #1 is a virtual tail call frame. The code can have possible execution paths \texttt{main->a->b->c->d->f} or \texttt{main->a->b->e->f}, GDB cannot find which one from the inferior state.

**initial**: state shows some random possible calling sequence GDB has found. It then finds another possible calling sequence - that one is prefixed by \texttt{compare:}. The non-ambiguous intersection of these two is printed as the \texttt{reduced:} calling sequence. That one could have many further \texttt{compare:} and \texttt{reduced:} statements as long as there remain any non-ambiguous sequence entries.

For the frame of function b in both cases there are different possible $\texttt{pc}$ values (0x4004cc or 0x4004ce), therefore this frame is also ambiguous. The only non-ambiguous frame is the one for function a, therefore this one is displayed to the user while the ambiguous frames are omitted.

There can be also reasons why printing of frame argument values at function entry may fail:

```c
int v;
```
static void __attribute__((noinline, noclone)) c (int i) { v++; }
static void __attribute__((noinline, noclone)) a (int i);
static void __attribute__((noinline, noclone)) b (int i) { a (i); }
static void __attribute__((noinline, noclone)) a (int i)
{ if (i) b (i - 1); else c (0); }
int main (void) { a (5); return 0; }

(gdb) bt
#0  c (i=i@entry=0) at t.c:2
#1  0x0000000000400428 in a (DW_OP_GNU_entry_value resolving has found
   function "a" at 0x400420 can call itself via tail calls
   i=<optimized out>) at t.c:6
#2  0x000000000040036e in main () at t.c:7

GDB cannot find out from the inferior state if and how many times did function a call itself (via function b) as these calls would be tail calls. Such tail calls would modify the i variable, therefore GDB cannot be sure the value it knows would be right - GDB prints <optimized out> instead.
12 C Preprocessor Macros

Some languages, such as C and C++, provide a way to define and invoke “preprocessor macros” which expand into strings of tokens. GDB can evaluate expressions containing macro invocations, show the result of macro expansion, and show a macro’s definition, including where it was defined.

You may need to compile your program specially to provide GDB with information about preprocessor macros. Most compilers do not include macros in their debugging information, even when you compile with the ‘-g’ flag. See Section 4.1 [Compilation], page 25.

A program may define a macro at one point, remove that definition later, and then provide a different definition after that. Thus, at different points in the program, a macro may have different definitions, or have no definition at all. If there is a current stack frame, GDB uses the macros in scope at that frame’s source code line. Otherwise, GDB uses the macros in scope at the current listing location; see Section 9.1 [List], page 101.

Whenever GDB evaluates an expression, it always expands any macro invocations present in the expression. GDB also provides the following commands for working with macros explicitly.

**macro expand expression**
**macro exp expression**

Show the results of expanding all preprocessor macro invocations in expression. Since GDB simply expands macros, but does not parse the result, expression need not be a valid expression; it can be any string of tokens.

**macro expand-once expression**
**macro exp1 expression**

(This command is not yet implemented.) Show the results of expanding those preprocessor macro invocations that appear explicitly in expression. Macro invocations appearing in that expansion are left unchanged. This command allows you to see the effect of a particular macro more clearly, without being confused by further expansions. Since GDB simply expands macros, but does not parse the result, expression need not be a valid expression; it can be any string of tokens.

**info macro [-a] [-all] [--] macro**

Show the current definition or all definitions of the named macro, and describe the source location or compiler command-line where that definition was established. The optional double dash is to signify the end of argument processing and the beginning of macro for non C-like macros where the macro may begin with a hyphen.

**info macros location**

Show all macro definitions that are in effect at the location specified by location, and describe the source location or compiler command-line where those definitions were established.

**macro define macro replacement-list**
**macro define macro(arglist) replacement-list**

Introduce a definition for a preprocessor macro named macro, invocations of which are replaced by the tokens given in replacement-list. The first form of
this command defines an “object-like” macro, which takes no arguments; the second form defines a “function-like” macro, which takes the arguments given in arglist.

A definition introduced by this command is in scope in every expression evaluated in GDB, until it is removed with the macro \texttt{undef} command, described below. The definition overrides all definitions for \texttt{macro} present in the program being debugged, as well as any previous user-supplied definition.

\textbf{macro undef macro}

Remove any user-supplied definition for the macro named \texttt{macro}. This command only affects definitions provided with the \texttt{macro define} command, described above; it cannot remove definitions present in the program being debugged.

\textbf{macro list}

List all the macros defined using the \texttt{macro define} command.

Here is a transcript showing the above commands in action. First, we show our source files:

```sh
$ cat sample.c
#include <stdio.h>
#include "sample.h"
#define M 42
#define ADD(x) (M + x)

main ()
{
  #define N 28
  printf ("Hello, world!
");
  #undef N
  printf ("We're so creative.
");
  #define N 1729
  printf ("Goodbye, world!
");
}

$ cat sample.h
#define Q <
```

Now, we compile the program using the GNU C compiler, \texttt{gcc}. We pass the ‘\texttt{-gdwarf-2}’ and ‘\texttt{-g3}’ flags to ensure the compiler includes information about preprocessor macros in the debugging information.

```sh
$ gcc -gdwarf-2 -g3 sample.c -o sample
```

Now, we start GDB on our sample program:

```sh
$ gdb -nw sample
GNU gdb 2002-05-06-cvs
Copyright 2002 Free Software Foundation, Inc.
GDB is free software, ...
(gdb)
```

\footnote{This is the minimum. Recent versions of \texttt{gcc} support ‘\texttt{-gdwarf-3}’ and ‘\texttt{-gdwarf-4}’; we recommend always choosing the most recent version of DWARF.}
We can expand macros and examine their definitions, even when the program is not running. GDB uses the current listing position to decide which macro definitions are in scope:

```
(gdb) list main
3
4   #define M 42
5   #define ADD(x) (M + x)
6
7   main ()
8 {
9   #define N 28
10   printf ("Hello, world!\n");
11   #undef N
12   printf ("We're so creative.\n");
```

In the example above, note that `macro expand-once` expands only the macro invocation explicit in the original text — the invocation of `ADD` — but does not expand the invocation of the macro `M`, which was introduced by `ADD`.

Once the program is running, GDB uses the macro definitions in force at the source line of the current stack frame:

```
(gdb) break main
Breakpoint 1 at 0x8048370: file sample.c, line 10.
(gdb) run
Starting program: /home/jimb/gdb/macros/play/sample
```

At line 10, the definition of the macro `N` at line 9 is in force:

```
$1 = 1
```

As we step over directives that remove `N`'s definition, and then give it a new definition, GDB finds the definition (or lack thereof) in force at each point:

```
(gdb) next
Hello, world!
12   printf ("We're so creative.\n");
```

In the example above, note that `macro expand-once` expands only the macro invocation explicit in the original text — the invocation of `ADD` — but does not expand the invocation of the macro `M`, which was introduced by `ADD`.
The symbol ‘N’ has no definition as a C/C++ preprocessor macro
at /home/jimb/gdb/macros/play/sample.c:12
(gdb) next
We’re so creative.
14 printf("Goodbye, world!\n");
(gdb) info macro N
Defined at /home/jimb/gdb/macros/play/sample.c:13
#define N 1729
(gdb) macro expand N Q M
expands to: 1729 < 42
(gdb) print N Q M
$2 = 0
(gdb)

In addition to source files, macros can be defined on the compilation command line using the ‘-Dname=value’ syntax. For macros defined in such a way, GDB displays the location of their definition as line zero of the source file submitted to the compiler.

(gdb) info macro __STDC__
Defined at /home/jimb/gdb/macros/play/sample.c:0
-D__STDC__=1
(gdb)
13 Tracepoints

In some applications, it is not feasible for the debugger to interrupt the program’s execution long enough for the developer to learn anything helpful about its behavior. If the program’s correctness depends on its real-time behavior, delays introduced by a debugger might cause the program to change its behavior drastically, or perhaps fail, even when the code itself is correct. It is useful to be able to observe the program’s behavior without interrupting it.

Using GDB’s `trace` and `collect` commands, you can specify locations in the program, called `tracepoints`, and arbitrary expressions to evaluate when those tracepoints are reached. Later, using the `tfind` command, you can examine the values those expressions had when the program hit the tracepoints. The expressions may also denote objects in memory—structures or arrays, for example—whose values GDB should record; while visiting a particular tracepoint, you may inspect those objects as if they were in memory at that moment. However, because GDB records these values without interacting with you, it can do so quickly and unobtrusively, hopefully not disturbing the program’s behavior.

The tracepoint facility is currently available only for remote targets. See Chapter 19 [Targets], page 253. In addition, your remote target must know how to collect trace data. This functionality is implemented in the remote stub; however, none of the stubs distributed with GDB support tracepoints as of this writing. The format of the remote packets used to implement tracepoints are described in Section E.6 [Tracepoint Packets], page 644.

It is also possible to get trace data from a file, in a manner reminiscent of corefiles; you specify the filename, and use `tfind` to search through the file. See Section 13.4 [Trace Files], page 179, for more details.

This chapter describes the tracepoint commands and features.

13.1 Commands to Set Tracepoints

Before running such a `trace experiment`, an arbitrary number of tracepoints can be set. A tracepoint is actually a special type of breakpoint (see Section 5.1.1 [Set Breaks], page 46), so you can manipulate it using standard breakpoint commands. For instance, as with breakpoints, tracepoint numbers are successive integers starting from one, and many of the commands associated with tracepoints take the tracepoint number as their argument, to identify which tracepoint to work on.

For each tracepoint, you can specify, in advance, some arbitrary set of data that you want the target to collect in the trace buffer when it hits that tracepoint. The collected data can include registers, local variables, or global data. Later, you can use GDB commands to examine the values these data had at the time the tracepoint was hit.

Tracepoints do not support every breakpoint feature. Ignore counts on tracepoints have no effect, and tracepoints cannot run GDB commands when they are hit. Tracepoints may not be thread-specific either.

Some targets may support `fast tracepoints`, which are inserted in a different way (such as with a jump instead of a trap), that is faster but possibly restricted in where they may be installed.

Regular and fast tracepoints are dynamic tracing facilities, meaning that they can be used to insert tracepoints at (almost) any location in the target. Some targets may also support controlling `static tracepoints` from GDB. With static tracing, a set of instrumentation
points, also known as markers, are embedded in the target program, and can be activated or deactivated by name or address. These are usually placed at locations which facilitate investigating what the target is actually doing. GDB’s support for static tracing includes being able to list instrumentation points, and attach them with GDB defined high level tracepoints that expose the whole range of convenience of GDB’s tracepoints support. Namely, support for collecting registers values and values of global or local (to the instrumentation point) variables; tracepoint conditions and trace state variables. The act of installing a GDB static tracepoint on an instrumentation point, or marker, is referred to as probing a static tracepoint marker.

`gdbserver` supports tracepoints on some target systems. See Section 20.3 [Tracepoints support in `gdbserver`], page 259.

This section describes commands to set tracepoints and associated conditions and actions.

### 13.1.1 Create and Delete Tracepoints

**trace location**

The `trace` command is very similar to the `break` command. Its argument `location` can be any valid location. See Section 9.2 [Specify Location], page 102. The `trace` command defines a tracepoint, which is a point in the target program where the debugger will briefly stop, collect some data, and then allow the program to continue. Setting a tracepoint or changing its actions takes effect immediately if the remote stub supports the `InstallInTrace` feature (see [install tracepoint in tracing], page 635). If remote stub doesn’t support the `InstallInTrace` feature, all these changes don’t take effect until the next `tstart` command, and once a trace experiment is running, further changes will not have any effect until the next trace experiment starts. In addition, GDB supports pending tracepoints—tracepoints whose address is not yet resolved. (This is similar to pending breakpoints.) Pending tracepoints are not downloaded to the target and not installed until they are resolved. The resolution of pending tracepoints requires GDB support—when debugging with the remote target, and GDB disconnects from the remote stub (see [disconnected tracing], page 172), pending tracepoints can not be resolved (and downloaded to the remote stub) while GDB is disconnected.

Here are some examples of using the `trace` command:

```
(gdb) trace foo.c:121    // a source file and line number
(gdb) trace +2          // 2 lines forward
(gdb) trace my_function // first source line of function
(gdb) trace *my_function // EXACT start address of function
(gdb) trace *0x2117c4    // an address
```

You can abbreviate `trace` as `tr`.

**trace location if cond**

Set a tracepoint with condition `cond`; evaluate the expression `cond` each time the tracepoint is reached, and collect data only if the value is nonzero—that is,
if `cond` evaluates as true. See Section 13.1.4 [Tracepoint Conditions], page 167, for more information on tracepoint conditions.

**ftrace location [ if cond ]**

The `ftrace` command sets a fast tracepoint. For targets that support them, fast tracepoints will use a more efficient but possibly less general technique to trigger data collection, such as a jump instruction instead of a trap, or some sort of hardware support. It may not be possible to create a fast tracepoint at the desired location, in which case the command will exit with an explanatory message.

GDB handles arguments to `ftrace` exactly as for `trace`. On 32-bit x86-architecture systems, fast tracepoints normally need to be placed at an instruction that is 5 bytes or longer, but can be placed at 4-byte instructions if the low 64K of memory of the target program is available to install trampolines. Some Unix-type systems, such as GNU/Linux, exclude low addresses from the program’s address space; but for instance with the Linux kernel it is possible to let GDB use this area by doing a `sysctl` command to set the `mmap_min_addr` kernel parameter, as in

```
sudo sysctl -w vm.mmap_min_addr=32768
```

which sets the low address to 32K, which leaves plenty of room for trampolines. The minimum address should be set to a page boundary.

**strace location [ if cond ]**

The `strace` command sets a static tracepoint. For targets that support it, setting a static tracepoint probes a static instrumentation point, or marker, found at `location`. It may not be possible to set a static tracepoint at the desired location, in which case the command will exit with an explanatory message.

GDB handles arguments to `strace` exactly as for `trace`, with the addition that the user can also specify `-m marker` as `location`. This probes the marker identified by the `marker` string identifier. This identifier depends on the static tracepoint backend library your program is using. You can find all the marker identifiers in the ‘ID’ field of the `info static-tracepoint-markers` command output. See Section 13.1.8 [Listing Static Tracepoint Markers], page 171. For example, in the following small program using the UST tracing engine:

```c
main ()
{
    trace_mark(ust, bar33, "str %s", "FOOBAZ");
}
```

the marker id is composed of joining the first two arguments to the `trace_mark` call with a slash, which translates to:

```
(gdb) info static-tracepoint-markers
   Cnt  Enb  ID          Address                             What
        n  ust/bar33  0x0000000000400ddc in main at stexample.c:22
           Data: "str %s"
         [etc...]
```

so you may probe the marker above with:

```
(gdb) strace -m ust/bar33
```
Static tracepoints accept an extra collect action — `collect $sdata`. This collects arbitrary user data passed in the probe point call to the tracing library. In the UST example above, you’ll see that the third argument to `trace_mark` is a printf-like format string. The user data is then the result of running that formatting string against the following arguments. Note that `info static-tracepoint-markers` command output lists that format string in the ‘Data:’ field.

You can inspect this data when analyzing the trace buffer, by printing the `$sdata` variable like any other variable available to GDB. See Section 13.1.6 [Tracepoint Action Lists], page 168.

The convenience variable `$tpnum` records the tracepoint number of the most recently set tracepoint.

```
delete tracepoint [num]
```

Permanently delete one or more tracepoints. With no argument, the default is to delete all tracepoints. Note that the regular `delete` command can remove tracepoints also.

Examples:

```
(gdb) delete trace 1 2 3 // remove three tracepoints
(gdb) delete trace // remove all tracepoints
```

You can abbreviate this command as `del tr`.

### 13.1.2 Enable and Disable Tracepoints

These commands are deprecated; they are equivalent to plain `disable` and `enable`.

```
disable tracepoint [num]
```

Disable tracepoint `num`, or all tracepoints if no argument `num` is given. A disabled tracepoint will have no effect during a trace experiment, but it is not forgotten. You can re-enable a disabled tracepoint using the `enable tracepoint` command. If the command is issued during a trace experiment and the debug target has support for disabling tracepoints during a trace experiment, then the change will be effective immediately. Otherwise, it will be applied to the next trace experiment.

```
enable tracepoint [num]
```

Enable tracepoint `num`, or all tracepoints. If this command is issued during a trace experiment and the debug target supports enabling tracepoints during a trace experiment, then the enabled tracepoints will become effective immediately. Otherwise, they will become effective the next time a trace experiment is run.

### 13.1.3 Tracepoint Passcounts

```
passcount [n [num]]
```

Set the passcount of a tracepoint. The passcount is a way to automatically stop a trace experiment. If a tracepoint’s passcount is `n`, then the trace experiment will be automatically stopped on the `n`’th time that tracepoint is hit. If the tracepoint number `num` is not specified, the `passcount` command sets the
passcount of the most recently defined tracepoint. If no passcount is given, the trace experiment will run until stopped explicitly by the user.

Examples:

```gdb
(gdb) passcount 5 2 // Stop on the 5th execution of
    // tracepoint 2
(gdb) passcount 12 // Stop on the 12th execution of the
    // most recently defined tracepoint.
(gdb) trace foo
(gdb) pass 3
(gdb) trace bar
(gdb) pass 2
(gdb) trace baz
(gdb) pass 1  // Stop tracing when foo has been
    // executed 3 times OR when bar has
    // been executed 2 times
    // OR when baz has been executed 1 time.
```

### 13.1.4 Tracepoint Conditions

The simplest sort of tracepoint collects data every time your program reaches a specified place. You can also specify a condition for a tracepoint. A condition is just a Boolean expression in your programming language (see Section 10.1 [Expressions], page 115). A tracepoint with a condition evaluates the expression each time your program reaches it, and data collection happens only if the condition is true.

Tracepoint conditions can be specified when a tracepoint is set, by using `if` in the arguments to the `trace` command. See Section 13.1.1 [Setting Tracepoints], page 164. They can also be set or changed at any time with the `condition` command, just as with breakpoints.

Unlike breakpoint conditions, GDB does not actually evaluate the conditional expression itself. Instead, GDB encodes the expression into an agent expression (see Appendix F [Agent Expressions], page 675) suitable for execution on the target, independently of GDB. Global variables become raw memory locations, locals become stack accesses, and so forth.

For instance, suppose you have a function that is usually called frequently, but should not be called after an error has occurred. You could use the following tracepoint command to collect data about calls of that function that happen while the error code is propagating through the program; an unconditional tracepoint could end up collecting thousands of useless trace frames that you would have to search through.

```gdb
(gdb) trace normal_operation if errcode > 0
```

### 13.1.5 Trace State Variables

A `trace state variable` is a special type of variable that is created and managed by target-side code. The syntax is the same as that for GDB’s convenience variables (a string prefixed with “$”), but they are stored on the target. They must be created explicitly, using a `tvariable` command. They are always 64-bit signed integers.

Trace state variables are remembered by GDB, and downloaded to the target along with tracepoint information when the trace experiment starts. There are no intrinsic limits on the number of trace state variables, beyond memory limitations of the target.
Although trace state variables are managed by the target, you can use them in print commands and expressions as if they were convenience variables; gdb will get the current value from the target while the trace experiment is running. Trace state variables share the same namespace as other "$" variables, which means that you cannot have trace state variables with names like $23 or $pc, nor can you have a trace state variable and a convenience variable with the same name.

`tvariable $name [ = expression ]`

The `tvariable` command creates a new trace state variable named `$name`, and optionally gives it an initial value of `expression`. The `expression` is evaluated when this command is entered; the result will be converted to an integer if possible, otherwise gdb will report an error. A subsequent `tvariable` command specifying the same name does not create a variable, but instead assigns the supplied initial value to the existing variable of that name, overwriting any previous initial value. The default initial value is 0.

`info tvariables`

List all the trace state variables along with their initial values. Their current values may also be displayed, if the trace experiment is currently running.

`delete tvariable [ $name ... ]`

Delete the given trace state variables, or all of them if no arguments are specified.

13.1.6 Tracepoint Action Lists

`actions [num]`

This command will prompt for a list of actions to be taken when the tracepoint is hit. If the tracepoint number `num` is not specified, this command sets the actions for the one that was most recently defined (so that you can define a tracepoint and then say `actions` without bothering about its number). You specify the actions themselves on the following lines, one action at a time, and terminate the actions list with a line containing just `end`. So far, the only defined actions are `collect`, `teval`, and `while-stepping`.

`actions` is actually equivalent to `commands` (see Section 5.1.7 [Breakpoint Command Lists], page 62), except that only the defined actions are allowed; any other gdb command is rejected.

To remove all actions from a tracepoint, type `actions num` and follow it immediately with `end`.

```
(gdb) collect data // collect some data

(gdb) while-stepping 5 // single-step 5 times, collect data

(gdb) end // signals the end of actions.
```

In the following example, the action list begins with `collect` commands indicating the things to be collected when the tracepoint is hit. Then, in order to single-step and collect additional data following the tracepoint, a `while-stepping` command is used, followed by the list of things to be collected after each step in a sequence of single steps. The `while-stepping` command is ter-
minated by its own separate **end** command. Lastly, the action list is terminated by an **end** command.

(gdb) trace foo
(gdb) actions
Enter actions for tracepoint 1, one per line:
> collect bar,baz
> collect $regs
> while-stepping 12
> collect $pc, arr[i]
> end
end

**collect[/mods] expr1, expr2, ...**

Collect values of the given expressions when the tracepoint is hit. This command accepts a comma-separated list of any valid expressions. In addition to global, static, or local variables, the following special arguments are supported:

$regs        Collect all registers.
$args        Collect all function arguments.
$locals       Collect all local variables.
$_ret         Collect the return address. This is helpful if you want to see more of a backtrace.
$_probe_argc  Collects the number of arguments from the static probe at which the tracepoint is located. See Section 5.1.10 [Static Probe Points], page 65.
$_probe_argn  $n is an integer between 0 and 11. Collects the nth argument from the static probe at which the tracepoint is located. See Section 5.1.10 [Static Probe Points], page 65.
$_sdata       Collect static tracepoint marker specific data. Only available for static tracepoints. See Section 13.1.6 [Tracepoint Action Lists], page 168. On the UST static tracepoints library backend, an instrumentation point resembles a *printf* function call. The tracing library is able to collect user specified data formatted to a character string using the format provided by the programmer that instrumented the program. Other backends have similar mechanisms. Here’s an example of a UST marker call:

    const char master_name[] = "$your_name";
    trace_mark(channel1, marker1, "hello %s", master_name)

In this case, collecting **$_sdata** collects the string ‘hello $yourname’. When analyzing the trace buffer, you can inspect ‘**$_sdata**’ like any other variable available to **GDB**.

You can give several consecutive **collect** commands, each one with a single argument, or one **collect** command with several arguments separated by commas; the effect is the same.
The optional mods changes the usual handling of the arguments. s requests that pointers to chars be handled as strings, in particular collecting the contents of the memory being pointed at, up to the first zero. The upper bound is by default the value of the print elements variable; if s is followed by a decimal number, that is the upper bound instead. So for instance ‘collect/s25 mystr’ collects as many as 25 characters at ‘mystr’.

The command info scope (see Chapter 16 [Symbols], page 217) is particularly useful for figuring out what data to collect.

**teval expr1, expr2, ...**

Evaluate the given expressions when the tracepoint is hit. This command accepts a comma-separated list of expressions. The results are discarded, so this is mainly useful for assigning values to trace state variables (see Section 13.1.5 [Trace State Variables], page 167) without adding those values to the trace buffer, as would be the case if the collect action were used.

**while-stepping n**

Perform n single-step instruction traces after the tracepoint, collecting new data after each step. The while-stepping command is followed by the list of what to collect while stepping (followed by its own end command):

```bash
> while-stepping 12
> collect $regs, myglobal
> end
```

Note that $pc is not automatically collected by while-stepping; you need to explicitly collect that register if you need it. You may abbreviate while-stepping as ws or stepping.

**set default-collect expr1, expr2, ...**

This variable is a list of expressions to collect at each tracepoint hit. It is effectively an additional collect action prepended to every tracepoint action list. The expressions are parsed individually for each tracepoint, so for instance a variable named xyz may be interpreted as a global for one tracepoint, and a local for another, as appropriate to the tracepoint’s location.

**show default-collect**

Show the list of expressions that are collected by default at each tracepoint hit.

### 13.1.7 Listing Tracepoints

**info tracepoints [num...]**

Display information about the tracepoint num. If you don’t specify a tracepoint number, displays information about all the tracepoints defined so far. The format is similar to that used for info breakpoints; in fact, info tracepoints is the same command, simply restricting itself to tracepoints.

A tracepoint’s listing may include additional information specific to tracing:

- its passcount as given by the passcount n command
- the state about installed on target of each location
### Chapter 13: Tracepoints

#### 13.1.8 Listing Static Tracepoint Markers

**info static-tracepoint-markers**

Display information about all static tracepoint markers defined in the program.

For each marker, the following columns are printed:

- **Count**: An incrementing counter, output to help readability. This is not a stable identifier.
- **ID**: The marker ID, as reported by the target.
- **Enabled or Disabled**: Probed markers are tagged with ‘y’. ‘n’ identifies marks that are not enabled.
- **Address**: Where the marker is in your program, as a memory address.
- **What**: Where the marker is in the source for your program, as a file and line number. If the debug information included in the program does not allow GDB to locate the source of the marker, this column will be left blank.

In addition, the following information may be printed for each marker:

- **Data**: User data passed to the tracing library by the marker call. In the UST backend, this is the format string passed as argument to the marker call.
- **Static tracepoints probing the marker**: The list of static tracepoints attached to the marker.

---

(gdb) info static-tracepoint-markers

<table>
<thead>
<tr>
<th>Cnt</th>
<th>ID</th>
<th>Enb</th>
<th>Address</th>
<th>What</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>ust/bar2</td>
<td>y</td>
<td>0x0000000000400e1a in main at stexample.c:25</td>
<td>Data: number1 %d number2 %d Probed by static tracepoints: #2</td>
</tr>
<tr>
<td>2</td>
<td>ust/bar33</td>
<td>n</td>
<td>0x0000000000400c87 in main at stexample.c:24</td>
<td></td>
</tr>
</tbody>
</table>
13.1.9 Starting and Stopping Trace Experiments

**tstart**
This command starts the trace experiment, and begins collecting data. It has
the side effect of discarding all the data collected in the trace buffer during the
previous trace experiment. If any arguments are supplied, they are taken as a
note and stored with the trace experiment’s state. The notes may be arbitrary
text, and are especially useful with disconnected tracing in a multi-user context;
the notes can explain what the trace is doing, supply user contact information,
and so forth.

**tstop**
This command stops the trace experiment. If any arguments are supplied, they
are recorded with the experiment as a note. This is useful if you are stopping
a trace started by someone else, for instance if the trace is interfering with the
system’s behavior and needs to be stopped quickly.

**Note:** a trace experiment and data collection may stop automatically if any
tracepoint’s passcount is reached (see Section 13.1.3 [Tracepoint Passcounts],
page 166), or if the trace buffer becomes full.

**tstatus**
This command displays the status of the current trace data collection.

Here is an example of the commands we described so far:

(gdb) trace gdb.c_test
(gdb) actions
Enter actions for tracepoint #1, one per line.
  > collect $regs,$locals,$args
  > while-stepping 11
     > collect $regs
  > end
  > end
(gdb) tstart
[time passes ...]
(gdb) tstop

You can choose to continue running the trace experiment even if GDB disconnects from
the target, voluntarily or involuntarily. For commands such as detach, the debugger will
ask what you want to do with the trace. But for unexpected terminations (GDB crash,
network outage), it would be unfortunate to lose hard-won trace data, so the variable
disconnected-tracing lets you decide whether the trace should continue running without
GDB.

**set disconnected-tracing on**
**set disconnected-tracing off**
Choose whether a tracing run should continue to run if GDB has disconnected
from the target. Note that detach or quit will ask you directly what to do
about a running trace no matter what this variable’s setting, so the variable is
mainly useful for handling unexpected situations, such as loss of the network.

**show disconnected-tracing**
Show the current choice for disconnected tracing.
When you reconnect to the target, the trace experiment may or may not still be running; it might have filled the trace buffer in the meantime, or stopped for one of the other reasons. If it is running, it will continue after reconnection.

Upon reconnection, the target will upload information about the tracepoints in effect. GDB will then compare that information to the set of tracepoints currently defined, and attempt to match them up, allowing for the possibility that the numbers may have changed due to creation and deletion in the meantime. If one of the target’s tracepoints does not match any in GDB, the debugger will create a new tracepoint, so that you have a number with which to specify that tracepoint. This matching-up process is necessarily heuristic, and it may result in useless tracepoints being created; you may simply delete them if they are of no use.

If your target agent supports a circular trace buffer, then you can run a trace experiment indefinitely without filling the trace buffer; when space runs out, the agent deletes already-collected trace frames, oldest first, until there is enough room to continue collecting. This is especially useful if your tracepoints are being hit too often, and your trace gets terminated prematurely because the buffer is full. To ask for a circular trace buffer, simply set ‘circular-trace-buffer’ to on. You can set this at any time, including during tracing; if the agent can do it, it will change buffer handling on the fly, otherwise it will not take effect until the next run.

```
set circular-trace-buffer on
set circular-trace-buffer off
```

Choose whether a tracing run should use a linear or circular buffer for trace data. A linear buffer will not lose any trace data, but may fill up prematurely, while a circular buffer will discard old trace data, but it will have always room for the latest tracepoint hits.

```
show circular-trace-buffer
```

Show the current choice for the trace buffer. Note that this may not match the agent’s current buffer handling, nor is it guaranteed to match the setting that might have been in effect during a past run, for instance if you are looking at frames from a trace file.

```
set trace-buffer-size n
set trace-buffer-size unlimited
```

Request that the target use a trace buffer of \(n\) bytes. Not all targets will honor the request; they may have a compiled-in size for the trace buffer, or some other limitation. Set to a value of \texttt{unlimited}\ or \texttt{-1}\ to let the target use whatever size it likes. This is also the default.

```
show trace-buffer-size
```

Show the current requested size for the trace buffer. Note that this will only match the actual size if the target supports size-setting, and was able to handle the requested size. For instance, if the target can only change buffer size between runs, this variable will not reflect the change until the next run starts. Use \texttt{tstatus}\ to get a report of the actual buffer size.
set trace-user text
show trace-user
set trace-notes text
  Set the trace run’s notes.
show trace-notes
  Show the trace run’s notes.
set trace-stop-notes text
  Set the trace run’s stop notes. The handling of the note is as for tstop arguments; the set command is convenient way to fix a stop note that is mistaken or incomplete.
show trace-stop-notes
  Show the trace run’s stop notes.

13.1.10 Tracepoint Restrictions

There are a number of restrictions on the use of tracepoints. As described above, tracepoint data gathering occurs on the target without interaction from GDB. Thus the full capabilities of the debugger are not available during data gathering, and then at data examination time, you will be limited by only having what was collected. The following items describe some common problems, but it is not exhaustive, and you may run into additional difficulties not mentioned here.

- Tracepoint expressions are intended to gather objects (lvalues). Thus the full flexibility of GDB’s expression evaluator is not available. You cannot call functions, cast objects to aggregate types, access convenience variables or modify values (except by assignment to trace state variables). Some language features may implicitly call functions (for instance Objective-C fields with accessors), and therefore cannot be collected either.

- Collection of local variables, either individually or in bulk with $locals or $args, during while-stepping may behave erratically. The stepping action may enter a new scope (for instance by stepping into a function), or the location of the variable may change (for instance it is loaded into a register). The tracepoint data recorded uses the location information for the variables that is correct for the tracepoint location. When the tracepoint is created, it is not possible, in general, to determine where the steps of a while-stepping sequence will advance the program—particularly if a conditional branch is stepped.

- Collection of an incompletely-initialized or partially-destroyed object may result in something that GDB cannot display, or displays in a misleading way.

- When GDB displays a pointer to character it automatically dereferences the pointer to also display characters of the string being pointed to. However, collecting the pointer during tracing does not automatically collect the string. You need to explicitly dereference the pointer and provide size information if you want to collect not only the pointer, but the memory pointed to. For example, *ptr@50 can be used to collect the 50 element array pointed to by ptr.

- It is not possible to collect a complete stack backtrace at a tracepoint. Instead, you may collect the registers and a few hundred bytes from the stack pointer with something like *(unsigned char *)$esp@300 (adjust to use the name of the actual stack pointer.
register on your target architecture, and the amount of stack you wish to capture). Then the backtrace command will show a partial backtrace when using a trace frame. The number of stack frames that can be examined depends on the sizes of the frames in the collected stack. Note that if you ask for a block so large that it goes past the bottom of the stack, the target agent may report an error trying to read from an invalid address.

- If you do not collect registers at a tracepoint, GDB can infer that the value of $pc must be the same as the address of the tracepoint and use that when you are looking at a trace frame for that tracepoint. However, this cannot work if the tracepoint has multiple locations (for instance if it was set in a function that was inlined), or if it has a while-stepping loop. In those cases GDB will warn you that it can’t infer $pc, and default it to zero.

13.2 Using the Collected Data

After the tracepoint experiment ends, you use GDB commands for examining the trace data. The basic idea is that each tracepoint collects a trace snapshot every time it is hit and another snapshot every time it single-steps. All these snapshots are consecutively numbered from zero and go into a buffer, and you can examine them later. The way you examine them is to focus on a specific trace snapshot. When the remote stub is focused on a trace snapshot, it will respond to all GDB requests for memory and registers by reading from the buffer which belongs to that snapshot, rather than from real memory or registers of the program being debugged. This means that all GDB commands (print, info registers, backtrace, etc.) will behave as if we were currently debugging the program state as it was when the tracepoint occurred. Any requests for data that are not in the buffer will fail.

13.2.1 tfind n

The basic command for selecting a trace snapshot from the buffer is tfind n, which finds trace snapshot number n, counting from zero. If no argument n is given, the next snapshot is selected.

Here are the various forms of using the tfind command.

tfind start
  Find the first snapshot in the buffer. This is a synonym for tfind 0 (since 0 is the number of the first snapshot).

tfind none
  Stop debugging trace snapshots, resume live debugging.

tfind end
  Same as ‘tfind none’.

tfind
  No argument means find the next trace snapshot.

tfind -
  Find the previous trace snapshot before the current one. This permits retracing earlier steps.

tfind tracepoint num
  Find the next snapshot associated with tracepoint num. Search proceeds forward from the last examined trace snapshot. If no argument num is given, it means find the next snapshot collected for the same tracepoint as the current snapshot.
tfind pc addr
Find the next snapshot associated with the value addr of the program counter. Search proceeds forward from the last examined trace snapshot. If no argument addr is given, it means find the next snapshot with the same value of PC as the current snapshot.

tfind outside addr1, addr2
Find the next snapshot whose PC is outside the given range of addresses (exclusive).

tfind range addr1, addr2
Find the next snapshot whose PC is between addr1 and addr2 (inclusive).

tfind line [file:]n
Find the next snapshot associated with the source line n. If the optional argument file is given, refer to line n in that source file. Search proceeds forward from the last examined trace snapshot. If no argument n is given, it means find the next line other than the one currently being examined; thus saying tfind line repeatedly can appear to have the same effect as stepping from line to line in a live debugging session.

The default arguments for the tfind commands are specifically designed to make it easy to scan through the trace buffer. For instance, tfind with no argument selects the next trace snapshot, and tfind - with no argument selects the previous trace snapshot. So, by giving one tfind command, and then simply hitting RET repeatedly you can examine all the trace snapshots in order. Or, by saying tfind - and then hitting RET repeatedly you can examine the snapshots in reverse order. The tfind line command with no argument selects the snapshot for the next source line executed. The tfind pc command with no argument selects the next snapshot with the same program counter (PC) as the current frame. The tfind tracepoint command with no argument selects the next trace snapshot collected by the same tracepoint as the current one.

In addition to letting you scan through the trace buffer manually, these commands make it easy to construct GDB scripts that scan through the trace buffer and print out whatever collected data you are interested in. Thus, if we want to examine the PC, FP, and SP registers from each trace frame in the buffer, we can say this:

(gdb) tfind start
(gdb) while ($trace_frame != -1)
    > printf "Frame %d, PC = %08X, SP = %08X, FP = %08X\n", \
        $trace_frame, $pc, $sp, $fp
    > tfind
> end

Frame 0, PC = 0020DC64, SP = 0030BF3C, FP = 0030BF44
Frame 1, PC = 0020DC6C, SP = 0030BF38, FP = 0030BF44
Frame 2, PC = 0020DC70, SP = 0030BF34, FP = 0030BF44
Frame 3, PC = 0020DC74, SP = 0030BF30, FP = 0030BF44
Frame 4, PC = 0020DC78, SP = 0030BF2C, FP = 0030BF44
Frame 5, PC = 0020DC7C, SP = 0030BF28, FP = 0030BF44
Frame 6, PC = 0020DC80, SP = 0030BF24, FP = 0030BF44
Frame 7, PC = 0020DC84, SP = 0030BF20, FP = 0030BF44
Frame 8, PC = 0020DC88, SP = 0030BF1C, FP = 0030BF44
Frame 9, PC = 0020DC8E, SP = 0030BF18, FP = 0030BF44
Frame 10, PC = 00203F6C, SP = 0030BE3C, FP = 0030BF14

Or, if we want to examine the variable X at each source line in the buffer:

```
(gdb) tfind start
(gdb) while ($trace_frame != -1)
>   printf "Frame %d, X == %d\n", $trace_frame, X
>   tfind line
> end

Frame 0, X = 1
Frame 7, X = 2
Frame 13, X = 255
```

13.2.2 \texttt{tdump}

This command takes no arguments. It prints all the data collected at the current trace snapshot.

```
(gdb) trace 444
(gdb) actions
Enter actions for tracepoint #2, one per line:
> collect $regs, $locals, $args, gdb_long_test
> end

(gdb) tstart
(gdb) tfind line 444

#0 gdb_test (p1=0x11, p2=0x22, p3=0x33, p4=0x44, p5=0x55, p6=0x66) at gdb_test.c:444
444 printp( ", arguments = 0x%016x 0x%016x 0x%016x 0x%016x 0x%016x 0x%016x
```

```
(gdb) tdump
Data collected at tracepoint 2, trace frame 1:
d0 0xc4aa0085 -995491707
d1 0x18 24
d2 0x80 128
d3 0x33 51
d4 0x71aae3d 119204413
d5 0x22 34
d6 0xe0 224
d7 0x380035 3670069
da 0x19e24a 1696330
db 0x300068 50333288
dc 0x100 256
dd 0x322000 3284992
d0 0x3000698 50333336
d1 0x1ad3cc 1758156
d2 0x30bf3c 0x30bf3c
d3 0x30bf34 0x30bf34
d4 0x0 0
d5 0x20b2c8 0x20b2c8
d6 0x0 0
d7 0x0 0
d8 0x0 0
```

```
p = 0x20e5b4 "gdb-test"
p1 = (void *) 0x11
p2 = (void *) 0x22
p3 = (void *) 0x33
p4 = (void *) 0x44
```
tdump works by scanning the tracepoint’s current collection actions and printing the value of each expression listed. So tdump can fail, if after a run, you change the tracepoint’s actions to mention variables that were not collected during the run.

Also, for tracepoints with while-stepping loops, tdump uses the collected value of $pc to distinguish between trace frames that were collected at the tracepoint hit, and frames that were collected while stepping. This allows it to correctly choose whether to display the basic list of collections, or the collections from the body of the while-stepping loop. However, if $pc was not collected, then tdump will always attempt to dump using the basic collection list, and may fail if a while-stepping frame does not include all the same data that is collected at the tracepoint hit.

13.2.3 save tracepoints filename

This command saves all current tracepoint definitions together with their actions and pass-counts, into a file ‘filename’ suitable for use in a later debugging session. To read the saved tracepoint definitions, use the source command (see Section 23.1.3 [Command Files], page 318). The save-tracepoints command is a deprecated alias for save tracepoints.

13.3 Convenience Variables for Tracepoints

(int) $trace_frame
The current trace snapshot (a.k.a. frame) number, or -1 if no snapshot is selected.

(int) $tracepoint
The tracepoint for the current trace snapshot.

(int) $trace_line
The line number for the current trace snapshot.

(char []) $trace_file
The source file for the current trace snapshot.

(char []) $trace_func
The name of the function containing $tracepoint.

Note: $trace_file is not suitable for use in printf, use output instead.

Here’s a simple example of using these convenience variables for stepping through all the trace snapshots and printing some of their data. Note that these are not the same as trace state variables, which are managed by the target.

(gdb) tfind start

(gdb) while $trace_frame !=-1
> output $trace_file
> printf ", line %d (tracepoint %d)\n", $trace_line, $tracepoint
> tfind
> end
13.4 Using Trace Files

In some situations, the target running a trace experiment may no longer be available; perhaps it crashed, or the hardware was needed for a different activity. To handle these cases, you can arrange to dump the trace data into a file, and later use that file as a source of trace data, via the `target tfile` command.

```
tsave [-r] filename
```

Save the trace data to `filename`. By default, this command assumes that `filename` refers to the host filesystem, so if necessary GDB will copy raw trace data up from the target and then save it. If the target supports it, you can also supply the optional argument `-r` (“remote”) to direct the target to save the data directly into `filename` in its own filesystem, which may be more efficient if the trace buffer is very large. (Note, however, that `target tfile` can only read from files accessible to the host.) By default, this command will save trace frame in tfile format. You can supply the optional argument `-ctf` to save data in CTF format. The Common Trace Format (CTF) is proposed as a trace format that can be shared by multiple debugging and tracing tools. Please go to http://www.efficios.com/ctf to get more information.

```
ttarget tfile filename
ttarget ctf dirname
```

Use the file named `filename` or directory named `dirname` as a source of trace data. Commands that examine data work as they do with a live target, but it is not possible to run any new trace experiments. `tstatus` will report the state of the trace run at the moment the data was saved, as well as the current trace frame you are examining. Both `filename` and `dirname` must be on a filesystem accessible to the host.

```
(gdb) target ctf ctf.ctf
(gdb) tfind
    Found trace frame 0, tracepoint 2
    39    ++a; /* set tracepoint 1 here */
(gdb) tdump
    Data collected at tracepoint 2, trace frame 0:
    i = 0
    a = 0
    b = 1 \001
    c = {"123", "456", "789", "123", "456", "789"}
    d = {{{a = 1, b = 2}, {a = 3, b = 4}}, {{a = 5, b = 6}, {a = 7, b = 8}}}
    (gdb) p b
    $1 = 1
```
14 Debugging Programs That Use Overlays

If your program is too large to fit completely in your target system’s memory, you can sometimes use overlays to work around this problem. GDB provides some support for debugging programs that use overlays.

14.1 How Overlays Work

Suppose you have a computer whose instruction address space is only 64 kilobytes long, but which has much more memory which can be accessed by other means: special instructions, segment registers, or memory management hardware, for example. Suppose further that you want to adapt a program which is larger than 64 kilobytes to run on this system.

One solution is to identify modules of your program which are relatively independent, and need not call each other directly; call these modules overlays. Separate the overlays from the main program, and place their machine code in the larger memory. Place your main program in instruction memory, but leave at least enough space there to hold the largest overlay as well.

Now, to call a function located in an overlay, you must first copy that overlay’s machine code from the large memory into the space set aside for it in the instruction memory, and then jump to its entry point there.

The diagram (see [A code overlay], page 181) shows a system with separate data and instruction address spaces. To map an overlay, the program copies its code from the larger address space to the instruction address space. Since the overlays shown here all use the same mapped address, only one may be mapped at a time. For a system with a single address space for data and instructions, the diagram would be similar, except that the program variables and heap would share an address space with the main program and the overlay area.
An overlay loaded into instruction memory and ready for use is called a mapped overlay; its mapped address is its address in the instruction memory. An overlay not present (or only partially present) in instruction memory is called unmapped; its load address is its address in the larger memory. The mapped address is also called the virtual memory address, or VMA; the load address is also called the load memory address, or LMA.

Unfortunately, overlays are not a completely transparent way to adapt a program to limited instruction memory. They introduce a new set of global constraints you must keep in mind as you design your program:

- Before calling or returning to a function in an overlay, your program must make sure that overlay is actually mapped. Otherwise, the call or return will transfer control to the right address, but in the wrong overlay, and your program will probably crash.
- If the process of mapping an overlay is expensive on your system, you will need to choose your overlays carefully to minimize their effect on your program’s performance.
- The executable file you load onto your system must contain each overlay’s instructions, appearing at the overlay’s load address, not its mapped address. However, each overlay’s instructions must be relocated and its symbols defined as if the overlay were at its mapped address. You can use GNU linker scripts to specify different load and relocation addresses for pieces of your program; see Section “Overlay Description” in Using ld: the GNU linker.
- The procedure for loading executable files onto your system must be able to load their contents into the larger address space as well as the instruction and data spaces.

The overlay system described above is rather simple, and could be improved in many ways:

- If your system has suitable bank switch registers or memory management hardware, you could use those facilities to make an overlay’s load area contents simply appear at their mapped address in instruction space. This would probably be faster than copying the overlay to its mapped area in the usual way.
- If your overlays are small enough, you could set aside more than one overlay area, and have more than one overlay mapped at a time.
- You can use overlays to manage data, as well as instructions. In general, data overlays are even less transparent to your design than code overlays: whereas code overlays only require care when you call or return to functions, data overlays require care every time you access the data. Also, if you change the contents of a data overlay, you must copy its contents back out to its load address before you can copy a different data overlay into the same mapped area.

### 14.2 Overlay Commands

To use GDB’s overlay support, each overlay in your program must correspond to a separate section of the executable file. The section’s virtual memory address and load memory address must be the overlay’s mapped and load addresses. Identifying overlays with sections allows GDB to determine the appropriate address of a function or variable, depending on whether the overlay is mapped or not.

GDB’s overlay commands all start with the word overlay; you can abbreviate this as ov or ovly. The commands are:
overlay off
Disable GDB’s overlay support. When overlay support is disabled, GDB assumes that all functions and variables are always present at their mapped addresses. By default, GDB’s overlay support is disabled.

overlay manual
Enable manual overlay debugging. In this mode, GDB relies on you to tell it which overlays are mapped, and which are not, using the overlay map-overlay and overlay unmap-overlay commands described below.

overlay map-overlay overlay
Tell GDB that overlay is now mapped; overlay must be the name of the object file section containing the overlay. When an overlay is mapped, GDB assumes it can find the overlay’s functions and variables at their mapped addresses. GDB assumes that any other overlays whose mapped ranges overlap that of overlay are now unmapped.

overlay unmap-overlay overlay
Tell GDB that overlay is no longer mapped; overlay must be the name of the object file section containing the overlay. When an overlay is unmapped, GDB assumes it can find the overlay’s functions and variables at their load addresses.

overlay auto
Enable automatic overlay debugging. In this mode, GDB consults a data structure the overlay manager maintains in the inferior to see which overlays are mapped. For details, see Section 14.3 [Automatic Overlay Debugging], page 184.

overlay load-target
overlay load
Re-read the overlay table from the inferior. Normally, GDB re-reads the table GDB automatically each time the inferior stops, so this command should only be necessary if you have changed the overlay mapping yourself using GDB. This command is only useful when using automatic overlay debugging.

overlay list-overlays
overlay list
Display a list of the overlays currently mapped, along with their mapped addresses, load addresses, and sizes.

Normally, when GDB prints a code address, it includes the name of the function the address falls in:

```
(gdb) print main
$3 = {int ()} 0x11a0 <main>
```

When overlay debugging is enabled, GDB recognizes code in unmapped overlays, and prints the names of unmapped functions with asterisks around them. For example, if foo is a function in an unmapped overlay, GDB prints it this way:

```
(gdb) overlay list
No sections are mapped.
(gdb) print foo
```
When `foo`'s overlay is mapped, GDB prints the function's name normally:

```gdb
(gdb) overlay list
Section .ov.foo.text, loaded at 0x100000 - 0x100034,
       mapped at 0x1016 - 0x104a
(gdb) print foo
$6 = {int (int)} 0x1016 <foo>
```

When overlay debugging is enabled, GDB can find the correct address for functions and variables in an overlay, whether or not the overlay is mapped. This allows most GDB commands, like `break` and `disassemble`, to work normally, even on unmapped code. However, GDB's breakpoint support has some limitations:

- You can set breakpoints in functions in unmapped overlays, as long as GDB can write to the overlay at its load address.
- GDB cannot set hardware or simulator-based breakpoints in unmapped overlays. However, if you set a breakpoint at the end of your overlay manager (and tell GDB which overlays are now mapped, if you are using manual overlay management), GDB will re-set its breakpoints properly.

### 14.3 Automatic Overlay Debugging

GDB can automatically track which overlays are mapped and which are not, given some simple co-operation from the overlay manager in the inferior. If you enable automatic overlay debugging with the `overlay auto` command (see [Section 14.2 Overlay Commands](#overlay-auto)), GDB looks in the inferior's memory for certain variables describing the current state of the overlays.

Here are the variables your overlay manager must define to support GDB's automatic overlay debugging:

- `_ovly_table`:
  
  This variable must be an array of the following structures:

  ```c
  struct
  {
    /* The overlay's mapped address. */
    unsigned long vma;

    /* The size of the overlay, in bytes. */
    unsigned long size;

    /* The overlay's load address. */
    unsigned long lma;

    /* Non-zero if the overlay is currently mapped; zero otherwise. */
    unsigned long mapped;
  }
  
  `_novlys`:
  
  This variable must be a four-byte signed integer, holding the total number of elements in `_ovly_table`.

  To decide whether a particular overlay is mapped or not, GDB looks for an entry in `_ovly_table` whose `vma` and `lma` members equal the VMA and LMA of the overlay's section
in the executable file. When GDB finds a matching entry, it consults the entry’s mapped member to determine whether the overlay is currently mapped.

In addition, your overlay manager may define a function called _ovly_debug_event. If this function is defined, GDB will silently set a breakpoint there. If the overlay manager then calls this function whenever it has changed the overlay table, this will enable GDB to accurately keep track of which overlays are in program memory, and update any breakpoints that may be set in overlays. This will allow breakpoints to work even if the overlays are kept in ROM or other non-writable memory while they are not being executed.

### 14.4 Overlay Sample Program

When linking a program which uses overlays, you must place the overlays at their load addresses, while relocating them to run at their mapped addresses. To do this, you must write a linker script (see Section “Overlay Description” in Using ld: the GNU linker). Unfortunately, since linker scripts are specific to a particular host system, target architecture, and target memory layout, this manual cannot provide portable sample code demonstrating GDB’s overlay support.

However, the GDB source distribution does contain an overlaid program, with linker scripts for a few systems, as part of its test suite. The program consists of the following files from ‘gdb/testsuite/gdb.base’:

- ‘overlays.c’
  The main program file.
- ‘ovlymgr.c’
  A simple overlay manager, used by ‘overlays.c’.
- ‘foo.c’
- ‘bar.c’
- ‘baz.c’
- ‘grbx.c’
  Overlay modules, loaded and used by ‘overlays.c’.
- ‘d10v.ld’
- ‘m32r.ld’
  Linker scripts for linking the test program on the d10v-elf and m32r-elf targets.

You can build the test program using the d10v-elf GCC cross-compiler like this:

```bash
$ d10v-elf-gcc -g -c overlays.c
$ d10v-elf-gcc -g -c ovlymgr.c
$ d10v-elf-gcc -g -c foo.c
$ d10v-elf-gcc -g -c bar.c
$ d10v-elf-gcc -g -c baz.c
$ d10v-elf-gcc -g -c grbx.c
$ d10v-elf-gcc -g overlays.o ovlymgr.o foo.o bar.o baz.o grbx.o -Wl,-Td10v.ld -o overlays
```

The build process is identical for any other architecture, except that you must substitute the appropriate compiler and linker script for the target system for d10v-elf-gcc and d10v.ld.
15 Using GDB with Different Languages

Although programming languages generally have common aspects, they are rarely expressed in the same manner. For instance, in ANSI C, dereferencing a pointer \( p \) is accomplished by \( *p \), but in Modula-2, it is accomplished by \( p^\). Values can also be represented (and displayed) differently. Hex numbers in C appear as ‘0x1ae’, while in Modula-2 they appear as ‘1AEH’.

Language-specific information is built into GDB for some languages, allowing you to express operations like the above in your program’s native language, and allowing GDB to output values in a manner consistent with the syntax of your program’s native language. The language you use to build expressions is called the working language.

15.1 Switching Between Source Languages

There are two ways to control the working language—either have GDB set it automatically, or select it manually yourself. You can use the set language command for either purpose. On startup, GDB defaults to setting the language automatically. The working language is used to determine how expressions you type are interpreted, how values are printed, etc.

In addition to the working language, every source file that GDB knows about has its own working language. For some object file formats, the compiler might indicate which language a particular source file is in. However, most of the time GDB infers the language from the name of the file. The language of a source file controls whether C++ names are demangled—this way backtrace can show each frame appropriately for its own language. There is no way to set the language of a source file from within GDB, but you can set the language associated with a filename extension. See Section 15.2 [Displaying the Language], page 188.

This is most commonly a problem when you use a program, such as cfront or f2c, that generates C but is written in another language. In that case, make the program use #line directives in its C output; that way GDB will know the correct language of the source code of the original program, and will display that source code, not the generated C code.

15.1.1 List of Filename Extensions and Languages

If a source file name ends in one of the following extensions, then GDB infers that its language is the one indicated.

- `.ada'
- `.ads'
- `.adb'
- `.a'  Ada source file.
- `.c'
- `.C'
- `.cc'
- `.cp'
- `.cpp'
- `.cxx'
- `.c++'  C++ source file
15.1.2 Setting the Working Language

If you allow GDB to set the language automatically, expressions are interpreted the same way in your debugging session and your program. If you wish, you may set the language manually. To do this, issue the command `set language lang`, where `lang` is the name of a language, such as `c` or `modula-2`. For a list of the supported languages, type `set language`.

Setting the language manually prevents GDB from updating the working language automatically. This can lead to confusion if you try to debug a program when the working language is not the same as the source language, when an expression is acceptable to both languages—but means different things. For instance, if the current source file were written in C, and GDB was parsing Modula-2, a command such as:

```bash
print a = b + c
```

might not have the effect you intended. In C, this means to add `b` and `c` and place the result in `a`. The result printed would be the value of `a`. In Modula-2, this means to compare `a` to the result of `b+c`, yielding a `BOOLEAN` value.

15.1.3 Having GDB Infer the Source Language

To have GDB set the working language automatically, use `set language local` or `set language auto`. GDB then infers the working language. That is, when your program stops in a frame (usually by encountering a breakpoint), GDB sets the working language to the language recorded for the function in that frame. If the language for a frame is unknown (that is, if the function or block corresponding to the frame was defined in a source file that does not have a recognized extension), the current working language is not changed, and GDB issues a warning.

This may not seem necessary for most programs, which are written entirely in one source language. However, program modules and libraries written in one source language can be used by a main program written in a different source language. Using `set language auto` in this case frees you from having to set the working language manually.

15.2 Displaying the Language

The following commands help you find out which language is the working language, and also what language source files were written in.
show language
Display the current working language. This is the language you can use with commands such as `print` to build and compute expressions that may involve variables in your program.

info frame
Display the source language for this frame. This language becomes the working language if you use an identifier from this frame. See Section 8.5 [Information about a Frame], page 100, to identify the other information listed here.

info source
Display the source language of this source file. See Chapter 16 [Examining the Symbol Table], page 217, to identify the other information listed here.

In unusual circumstances, you may have source files with extensions not in the standard list. You can then set the extension associated with a language explicitly:

```
set extension-language ext language
```

Tell GDB that source files with extension `ext` are to be assumed as written in the source language `language`.

info extensions
List all the filename extensions and the associated languages.

### 15.3 Type and Range Checking

Some languages are designed to guard you against making seemingly common errors through a series of compile- and run-time checks. These include checking the type of arguments to functions and operators and making sure mathematical overflows are caught at run time. Checks such as these help to ensure a program’s correctness once it has been compiled by eliminating type mismatches and providing active checks for range errors when your program is running.

By default GDB checks for these errors according to the rules of the current source language. Although GDB does not check the statements in your program, it can check expressions entered directly into GDB for evaluation via the `print` command, for example.

#### 15.3.1 An Overview of Type Checking

Some languages, such as C and C++, are strongly typed, meaning that the arguments to operators and functions have to be of the correct type, otherwise an error occurs. These checks prevent type mismatch errors from ever causing any run-time problems. For example,

```
int klass::my_method(char *b) { return b ? 1 : 2; }
```

```
(gdb) print obj.my_method (0)
$1 = 2
```

but

```
(gdb) print obj.my_method (0x1234)
Cannot resolve method klass::my_method to any overloaded instance
```

The second example fails because in C++ the integer constant ‘0x1234’ is not type-compatible with the pointer parameter type.
For the expressions you use in GDB commands, you can tell GDB to not enforce strict type checking or to treat any mismatches as errors and abandon the expression; When type checking is disabled, GDB successfully evaluates expressions like the second example above.

Even if type checking is off, there may be other reasons related to type that prevent GDB from evaluating an expression. For instance, GDB does not know how to add an int and a struct foo. These particular type errors have nothing to do with the language in use and usually arise from expressions which make little sense to evaluate anyway.

GDB provides some additional commands for controlling type checking:

```
set check type on
set check type off
Set strict type checking on or off. If any type mismatches occur in evaluating an expression while type checking is on, GDB prints a message and aborts evaluation of the expression.

show check type
Show the current setting of type checking and whether GDB is enforcing strict type checking rules.
```

15.3.2 An Overview of Range Checking

In some languages (such as Modula-2), it is an error to exceed the bounds of a type; this is enforced with run-time checks. Such range checking is meant to ensure program correctness by making sure computations do not overflow, or indices on an array element access do not exceed the bounds of the array.

For expressions you use in GDB commands, you can tell GDB to treat range errors in one of three ways: ignore them, always treat them as errors and abandon the expression, or issue warnings but evaluate the expression anyway.

A range error can result from numerical overflow, from exceeding an array index bound, or when you type a constant that is not a member of any type. Some languages, however, do not treat overflows as an error. In many implementations of C, mathematical overflow causes the result to “wrap around” to lower values—for example, if \( m \) is the largest integer value, and \( s \) is the smallest, then

\[
\text{\( m + 1 \Rightarrow s \)}
\]

This, too, is specific to individual languages, and in some cases specific to individual compilers or machines. See Section 15.4 [Supported Languages], page 191, for further details on specific languages.

GDB provides some additional commands for controlling the range checker:

```
set check range auto
Set range checking on or off based on the current working language. See Section 15.4 [Supported Languages], page 191, for the default settings for each language.

set check range on
set check range off
Set range checking on or off, overriding the default setting for the current working language. A warning is issued if the setting does not match the language
default. If a range error occurs and range checking is on, then a message is printed and evaluation of the expression is aborted.

```
set check range warn
```

Output messages when the GDB range checker detects a range error, but attempt to evaluate the expression anyway. Evaluating the expression may still be impossible for other reasons, such as accessing memory that the process does not own (a typical example from many Unix systems).

```
show range
```

Show the current setting of the range checker, and whether or not it is being set automatically by GDB.

## 15.4 Supported Languages

GDB supports C, C++, D, Go, Objective-C, Fortran, Java, OpenCL C, Pascal, assembly, Modula-2, and Ada. Some GDB features may be used in expressions regardless of the language you use: the GDB @$ and :: operators, and the ‘{type}addr’ construct (see Section 10.1 [Expressions], page 115) can be used with the constructs of any supported language.

The following sections detail to what degree each source language is supported by GDB. These sections are not meant to be language tutorials or references, but serve only as a reference guide to what the GDB expression parser accepts, and what input and output formats should look like for different languages. There are many good books written on each of these languages; please look to these for a language reference or tutorial.

### 15.4.1 C and C++

Since C and C++ are so closely related, many features of GDB apply to both languages. Whenever this is the case, we discuss those languages together.

The C++ debugging facilities are jointly implemented by the C++ compiler and GDB. Therefore, to debug your C++ code effectively, you must compile your C++ programs with a supported C++ compiler, such as GNU g++, or the HP ANSI C++ compiler (aCC).

#### 15.4.1.1 C and C++ Operators

Operators must be defined on values of specific types. For instance, + is defined on numbers, but not on structures. Operators are often defined on groups of types.

For the purposes of C and C++, the following definitions hold:

- **Integral types** include int with any of its storage-class specifiers; char; enum; and, for C++, bool.
- **Floating-point types** include float, double, and long double (if supported by the target platform).
- **Pointer types** include all types defined as (type *).
- **Scalar types** include all of the above.

The following operators are supported. They are listed here in order of increasing precedence:

- The comma or sequencing operator. Expressions in a comma-separated list are evaluated from left to right, with the result of the entire expression being the last expression evaluated.
Assignment. The value of an assignment expression is the value assigned. Defined on scalar types.

**op=**

Used in an expression of the form `a op= b`, and translated to `a = a op b`. `op=` and `=` have the same precedence. The operator `op` is any one of the operators `|`, `^`, `&`, `<<`, `>>`, `+`, `-`, `*`, `/`, `%`.

**?:**

The ternary operator. `a ? b : c` can be thought of as: if `a` then `b` else `c`. The argument `a` should be of an integral type.

**||**

Logical OR. Defined on integral types.

**&&**

Logical AND. Defined on integral types.

**|**

Bitwise OR. Defined on integral types.

**^**

Bitwise exclusive-OR. Defined on integral types.

**&**

Bitwise AND. Defined on integral types.

**==, !=**

Equality and inequality. Defined on scalar types. The value of these expressions is 0 for false and non-zero for true.

**<, >, <=, >=**

Less than, greater than, less than or equal, greater than or equal. Defined on scalar types. The value of these expressions is 0 for false and non-zero for true.

**<<, >>**

Left shift, and right shift. Defined on integral types.

**@**

The GDB “artificial array” operator (see Section 10.1 [Expressions], page 115).

**+, -**

Addition and subtraction. Defined on integral types, floating-point types and pointer types.

***, /, %**

Multiplication, division, and modulus. Multiplication and division are defined on integral and floating-point types. Modulus is defined on integral types.

**++, --**

Increment and decrement. When appearing before a variable, the operation is performed before the variable is used in an expression; when appearing after it, the variable’s value is used before the operation takes place.

*****

Pointer dereferencing. Defined on pointer types. Same precedence as `++`.

**&**

Address operator. Defined on variables. Same precedence as `++`.

For debugging C++, GDB implements a use of ‘&’ beyond what is allowed in the C++ language itself: you can use ‘&(&ref)’ to examine the address where a C++ reference variable (declared with ‘&ref’) is stored.

**-**

Negative. Defined on integral and floating-point types. Same precedence as `++`.

**!**

Logical negation. Defined on integral types. Same precedence as `++`.

**~**

Bitwise complement operator. Defined on integral types. Same precedence as `++`.

**., ->**

Structure member, and pointer-to-structure member. For convenience, GDB regards the two as equivalent, choosing whether to dereference a pointer based on the stored type information. Defined on `struct` and `union` data.
Dereferences of pointers to members.

[ ] Array indexing. \texttt{a[i]} is defined as \texttt{*\{a+i\}}. Same precedence as \texttt{->}.

( ) Function parameter list. Same precedence as \texttt{->}.

:: C++ scope resolution operator. Defined on \texttt{struct}, \texttt{union}, and \texttt{class} types.

:: Doubled colons also represent the \texttt{gdb} scope operator (see Section 10.1 [Expressions], page 115). Same precedence as ::, above.

If an operator is redefined in the user code, \texttt{gdb} usually attempts to invoke the redefined version instead of using the operator’s predefined meaning.

15.4.1.2 C and C++ Constants

\texttt{gdb} allows you to express the constants of C and C++ in the following ways:

- Integer constants are a sequence of digits. Octal constants are specified by a leading \texttt{’0’} (i.e. zero), and hexadecimal constants by a leading \texttt{’0x’} or \texttt{’0X’}. Constants may also end with a letter \texttt{’l’}, specifying that the constant should be treated as a \texttt{long} value.

- Floating point constants are a sequence of digits, followed by a decimal point, followed by a sequence of digits, and optionally followed by an exponent. An exponent is of the form: \texttt{’e[+]lnnn’}, where \texttt{nnn} is another sequence of digits. The \texttt{’+’} is optional for positive exponents. A floating-point constant may also end with a letter \texttt{’f’} or \texttt{’F’}, specifying that the constant should be treated as being of the \texttt{float} (as opposed to the default \texttt{double}) type; or with a letter \texttt{’l’} or \texttt{’L’}, which specifies a \texttt{long double} constant.

- Enumerated constants consist of enumerated identifiers, or their integral equivalents.

- Character constants are a single character surrounded by single quotes (’), or a number—the ordinal value of the corresponding character (usually its ASCII value). Within quotes, the single character may be represented by a letter or by escape sequences, which are of the form \texttt{’\nnn’}, where \texttt{nnn} is the octal representation of the character’s ordinal value; or of the form \texttt{’\x’}, where \texttt{x} is a predefined special character—for example, \texttt{’\n’} for newline.

Wide character constants can be written by prefixing a character constant with \texttt{’L’}, as in C. For example, \texttt{’L’x’} is the wide form of \texttt{’x’}. The target wide character set is used when computing the value of this constant (see Section 10.20 [Character Sets], page 149).

- String constants are a sequence of character constants surrounded by double quotes ("). Any valid character constant (as described above) may appear. Double quotes within the string must be preceded by a backslash, so for instance \texttt{”a\b’c”} is a string of five characters.

Wide string constants can be written by prefixing a string constant with \texttt{’L’}, as in C. The target wide character set is used when computing the value of this constant (see Section 10.20 [Character Sets], page 149).

- Pointer constants are an integral value. You can also write pointers to constants using the C operator \texttt{’&’}.

- Array constants are comma-separated lists surrounded by braces \{‘\} and \{‘\}; for example, \{1,2,3\} is a three-element array of integers, \{1,2,3,4,5,6\} is a
three-by-two array, and `{"hi", "there", "fred"}` is a three-element array of pointers.

### 15.4.1.3 C++ Expressions

GDB expression handling can interpret most C++ expressions.

**Warning:** GDB can only debug C++ code if you use the proper compiler and the proper debug format. Currently, GDB works best when debugging C++ code that is compiled with the most recent version of GCC possible. The DWARF debugging format is preferred; GCC defaults to this on most popular platforms. Other compilers and/or debug formats are likely to work badly or not at all when using GDB to debug C++ code. See Section 4.1 [Compilation], page 25.

1. Member function calls are allowed; you can use expressions like
   
   ```
   count = aml->GetOriginal(x, y)
   ```

2. While a member function is active (in the selected stack frame), your expressions have the same namespace available as the member function; that is, GDB allows implicit references to the class instance pointer `this` following the same rules as C++. using declarations in the current scope are also respected by GDB.

3. You can call overloaded functions; GDB resolves the function call to the right definition, with some restrictions. GDB does not perform overload resolution involving user-defined type conversions, calls to constructors, or instantiations of templates that do not exist in the program. It also cannot handle ellipsis argument lists or default arguments. It does perform integral conversions and promotions, floating-point promotions, arithmetic conversions, pointer conversions, conversions of class objects to base classes, and standard conversions such as those of functions or arrays to pointers; it requires an exact match on the number of function arguments.

   Overload resolution is always performed, unless you have specified `set overload-resolution off`. See Section 15.4.1.7 [GDB Features for C++], page 195.

   You must specify `set overload-resolution off` in order to use an explicit function signature to call an overloaded function, as in
   
   ```p 'foo(char,int)'('x', 13)```

   The GDB command-completion facility can simplify this; see Section 3.2 [Command Completion], page 19.

4. GDB understands variables declared as C++ references; you can use them in expressions just as you do in C++ source—they are automatically dereferenced.

   In the parameter list shown when GDB displays a frame, the values of reference variables are not displayed (unlike other variables); this avoids clutter, since references are often used for large structures. The address of a reference variable is always shown, unless you have specified `set print address off`.

5. GDB supports the C++ name resolution operator `::`—your expressions can use it just as expressions in your program do. Since one scope may be defined in another, you can use `::` repeatedly if necessary, for example in an expression like `scope1::scope2::name`.

   GDB also allows resolving name scope by reference to source files, in both C and C++ debugging (see Section 10.3 [Program Variables], page 117).

6. GDB performs argument-dependent lookup, following the C++ specification.
15.4.1.4 C and C++ Defaults

If you allow GDB to set range checking automatically, it defaults to \texttt{off} whenever the working language changes to C or C++. This happens regardless of whether you or GDB selects the working language.

If you allow GDB to set the language automatically, it recognizes source files whose names end with ‘.c’, ‘.C’, or ‘.cc’, etc, and when GDB enters code compiled from one of these files, it sets the working language to C or C++. See Section 15.1.3 [Having GDB Infer the Source Language], page 188, for further details.

15.4.1.5 C and C++ Type and Range Checks

By default, when GDB parses C or C++ expressions, strict type checking is used. However, if you turn type checking off, GDB will allow certain non-standard conversions, such as promoting integer constants to pointers.

Range checking, if turned on, is done on mathematical operations. Array indices are not checked, since they are often used to index a pointer that is not itself an array.

15.4.1.6 GDB and C

The \texttt{set print union} and \texttt{show print union} commands apply to the \texttt{union} type. When set to ‘on’, any \texttt{union} that is inside a \texttt{struct} or \texttt{class} is also printed. Otherwise, it appears as ‘\{\ldots\}’.

The \texttt{@} operator aids in the debugging of dynamic arrays, formed with pointers and a memory allocation function. See Section 10.1 [Expressions], page 115.

15.4.1.7 GDB Features for C++

Some GDB commands are particularly useful with C++, and some are designed specifically for use with C++. Here is a summary:

\textbf{breakpoint menus}

When you want a breakpoint in a function whose name is overloaded, GDB has the capability to display a menu of possible breakpoint locations to help you specify which function definition you want. See Section 10.2 [Ambiguous Expressions], page 116.

\textbf{rbreak regex}

Setting breakpoints using regular expressions is helpful for setting breakpoints on overloaded functions that are not members of any special classes. See Section 5.1.1 [Setting Breakpoints], page 46.

\textbf{catch throw}
\textbf{catch rethrow}
\textbf{catch catch}

Debug C++ exception handling using these commands. See Section 5.1.3 [Setting Catchpoints], page 55.

\textbf{ptype typename}

Print inheritance relationships as well as other information for type \texttt{typename}. See Chapter 16 [Examining the Symbol Table], page 217.
info vtbl expression.
The info vtbl command can be used to display the virtual method tables of
the object computed by expression. This shows one entry per virtual table;
there may be multiple virtual tables when multiple inheritance is in use.

demangle name
Demangle name. See Chapter 16 [Symbols], page 217, for a more complete
description of the demangle command.

set print demangle
show print demangle
set print asm-demangle
show print asm-demangle
Control whether C++ symbols display in their source form, both when displaying
code as C++ source and when displaying disassembles. See Section 10.8 [Print
Settings], page 125.

set print object
show print object
Choose whether to print derived (actual) or declared types of objects. See
Section 10.8 [Print Settings], page 125.

set print vtbl
show print vtbl
Control the format for printing virtual function tables. See Section 10.8 [Print
Settings], page 125. (The vtbl commands do not work on programs compiled
with the HP ANSI C++ compiler (aCC).)

set overload-resolution on
Enable overload resolution for C++ expression evaluation. The default is on. For
overloaded functions, GDB evaluates the arguments and searches for a function
whose signature matches the argument types, using the standard C++ conver-
sion rules (see Section 15.4.1.3 [C++ Expressions], page 194, for details). If it
cannot find a match, it emits a message.

set overload-resolution off
Disable overload resolution for C++ expression evaluation. For overloaded func-
tions that are not class member functions, GDB chooses the first function of
the specified name that it finds in the symbol table, whether or not its argu-
ments are of the correct type. For overloaded functions that are class member
functions, GDB searches for a function whose signature exactly matches the
argument types.

show overload-resolution
Show the current setting of overload resolution.

Overloaded symbol names
You can specify a particular definition of an overloaded symbol, using the same
notation that is used to declare such symbols in C++: type symbol(types)
rather than just symbol. You can also use the GDB command-line word com-
pletion facilities to list the available choices, or to finish the type list for you.
See Section 3.2 [Command Completion], page 19, for details on how to do this.
15.4.1.8 Decimal Floating Point format

GDB can examine, set and perform computations with numbers in decimal floating point format, which in the C language correspond to the _Decimal32, _Decimal64 and _Decimal128 types as specified by the extension to support decimal floating-point arithmetic.

There are two encodings in use, depending on the architecture: BID (Binary Integer Decimal) for x86 and x86-64, and DPD (Densely Packed Decimal) for PowerPC and S/390. GDB will use the appropriate encoding for the configured target.

Because of a limitation in ‘libdecnumber’, the library used by GDB to manipulate decimal floating point numbers, it is not possible to convert (using a cast, for example) integers wider than 32-bit to decimal float.

In addition, in order to imitate GDB’s behaviour with binary floating point computations, error checking in decimal float operations ignores underflow, overflow and divide by zero exceptions.

In the PowerPC architecture, GDB provides a set of pseudo-registers to inspect _Decimal128 values stored in floating point registers. See Section 21.4.7 [PowerPC], page 296 for more details.

15.4.2 D

GDB can be used to debug programs written in D and compiled with GDC, LDC or DMD compilers. Currently GDB supports only one D specific feature — dynamic arrays.

15.4.3 Go

GDB can be used to debug programs written in Go and compiled with ‘gccgo’ or ‘6g’ compilers.

Here is a summary of the Go-specific features and restrictions:

**The current Go package**

The name of the current package does not need to be specified when specifying global variables and functions.

For example, given the program:

```go
package main
var myglob = "Shall we?"
func main () {
    // ...
}
```

When stopped inside main either of these work:

(gdb) p myglob
(gdb) p main.myglob

**Builtin Go types**

The string type is recognized by GDB and is printed as a string.

**Builtin Go functions**

The GDB expression parser recognizes the unsafe.Sizeof function and handles it internally.
Restrictions on Go expressions

All Go operators are supported except &^,. The Go _ “blank identifier” is not supported. Automatic dereferencing of pointers is not supported.

15.4.4 Objective-C

This section provides information about some commands and command options that are useful for debugging Objective-C code. See also Chapter 16 [Symbols], page 217, and Chapter 16 [Symbols], page 217, for a few more commands specific to Objective-C support.

15.4.4.1 Method Names in Commands

The following commands have been extended to accept Objective-C method names as line specifications:

- clear
- break
- info line
- jump
- list

A fully qualified Objective-C method name is specified as

```
-[Class methodName]
```

where the minus sign is used to indicate an instance method and a plus sign (not shown) is used to indicate a class method. The class name Class and method name methodName are enclosed in brackets, similar to the way messages are specified in Objective-C source code. For example, to set a breakpoint at the create instance method of class Fruit in the program currently being debugged, enter:

```
break -[Fruit create]
```

To list ten program lines around the initialize class method, enter:

```
list +[NSText initialize]
```

In the current version of GDB, the plus or minus sign is required. In future versions of GDB, the plus or minus sign will be optional, but you can use it to narrow the search. It is also possible to specify just a method name:

```
break create
```

You must specify the complete method name, including any colons. If your program’s source files contain more than one create method, you’ll be presented with a numbered list of classes that implement that method. Indicate your choice by number, or type ‘0’ to exit if none apply.

As another example, to clear a breakpoint established at the makeKeyAndOrderFront: method of the NSWindow class, enter:

```
clear -[NSWindow makeKeyAndOrderFront:]
```

15.4.4.2 The Print Command With Objective-C

The print command has also been extended to accept methods. For example:

```
print -[object hash]
```

will tell GDB to send the hash message to object and print the result. Also, an additional command has been added, print-object or po for short, which is meant to print the
description of an object. However, this command may only work with certain Objective-C libraries that have a particular hook function, \_NSPrintForDebugger, defined.

### 15.4.5 OpenCL C

This section provides information about GDBs OpenCL C support.

#### 15.4.5.1 OpenCL C Datatypes

GDB supports the built-in scalar and vector datatypes specified by OpenCL 1.1. In addition the half- and double-precision floating point data types of the cl\_KHR\_fp\_16 and cl\_KHR\_fp\_64 OpenCL extensions are also known to GDB.

#### 15.4.5.2 OpenCL C Expressions

GDB supports accesses to vector components including the access as lvalue where possible. Since OpenCL C is based on C99 most C expressions supported by GDB can be used as well.

#### 15.4.5.3 OpenCL C Operators

GDB supports the operators specified by OpenCL 1.1 for scalar and vector data types.

### 15.4.6 Fortran

GDB can be used to debug programs written in Fortran, but it currently supports only the features of Fortran 77 language.

Some Fortran compilers (GNU Fortran 77 and Fortran 95 compilers among them) append an underscore to the names of variables and functions. When you debug programs compiled by those compilers, you will need to refer to variables and functions with a trailing underscore.

#### 15.4.6.1 Fortran Operators and Expressions

Operators must be defined on values of specific types. For instance, + is defined on numbers, but not on characters or other non-arithmetic types. Operators are often defined on groups of types.

**

The exponentiation operator. It raises the first operand to the power of the second one.

:

The range operator. Normally used in the form of array(low:high) to represent a section of array.

%

The access component operator. Normally used to access elements in derived types. Also suitable for unions. As unions aren’t part of regular Fortran, this can only happen when accessing a register that uses a gdbarch-defined union type.

#### 15.4.6.2 Fortran Defaults

Fortran symbols are usually case-insensitive, so GDB by default uses case-insensitive matches for Fortran symbols. You can change that with the ‘set case-insensitive’ command, see Chapter 16 [Symbols], page 217, for the details.
15.4.6.3 Special Fortran Commands

GDB has some commands to support Fortran-specific features, such as displaying common blocks.

```plaintext
info common [common-name]
```

This command prints the values contained in the Fortran COMMON block whose name is common-name. With no argument, the names of all COMMON blocks visible at the current program location are printed.

15.4.7 Pascal

Debugging Pascal programs which use sets, subranges, file variables, or nested functions does not currently work. GDB does not support entering expressions, printing values, or similar features using Pascal syntax.

The Pascal-specific command `set print pascal_static-members` controls whether static members of Pascal objects are displayed. See Section 10.8 [Print Settings], page 125.

15.4.8 Modula-2

The extensions made to GDB to support Modula-2 only support output from the GNU Modula-2 compiler (which is currently being developed). Other Modula-2 compilers are not currently supported, and attempting to debug executables produced by them is most likely to give an error as GDB reads in the executable’s symbol table.

15.4.8.1 Operators

Operators must be defined on values of specific types. For instance, + is defined on numbers, but not on structures. Operators are often defined on groups of types. For the purposes of Modula-2, the following definitions hold:

- **Integral types** consist of `INTEGER`, `CARDINAL`, and their subranges.
- **Character types** consist of `CHAR` and its subranges.
- **Floating-point types** consist of `REAL`.
- **Pointer types** consist of anything declared as `POINTER TO` type.
- **Scalar types** consist of all of the above.
- **Set types** consist of `SET` and `BITSET` types.
- **Boolean types** consist of `BOOLEAN`.

The following operators are supported, and appear in order of increasing precedence:

- `,` Function argument or array index separator.
- `:=` Assignment. The value of `var := value` is `value`.
- `<, >` Less than, greater than on integral, floating-point, or enumerated types.
- `<=, =>` Less than or equal to, greater than or equal to on integral, floating-point and enumerated types, or set inclusion on set types. Same precedence as `<`.
- `=, <>, #` Equality and two ways of expressing inequality, valid on scalar types. Same precedence as `<`. In GDB scripts, only `<>` is available for inequality, since `#` conflicts with the script comment character.
IN
Set membership. Defined on set types and the types of their members. Same precedence as <.

OR
Boolean disjunction. Defined on boolean types.

AND, &
Boolean conjunction. Defined on boolean types.

@
The GDB “artificial array” operator (see Section 10.1 [Expressions], page 115).

+, -
Addition and subtraction on integral and floating-point types, or union and difference on set types.

*
Multiplication on integral and floating-point types, or set intersection on set types.

/
Division on floating-point types, or symmetric set difference on set types. Same precedence as *.

DIV, MOD
Integer division and remainder. Defined on integral types. Same precedence as *.

-
Negative. Defined on INTEGER and REAL data.

^,
Pointer dereferencing. Defined on pointer types.

NOT
Boolean negation. Defined on boolean types. Same precedence as ^.

.,
RECORD field selector. Defined on RECORD data. Same precedence as ^.

[]
Array indexing. Defined on ARRAY data. Same precedence as ^.

()
Procedure argument list. Defined on PROCEDURE objects. Same precedence as ^.

::, ,
GDB and Modula-2 scope operators.

Warning: Set expressions and their operations are not yet supported, so GDB treats the use of the operator IN, or the use of operators +, -, *, /, =, , <>, #, <=, and >= on sets as an error.

15.4.8.2 Built-in Functions and Procedures
Modula-2 also makes available several built-in procedures and functions. In describing these, the following metavariables are used:

a represents an ARRAY variable.

c represents a CHAR constant or variable.

i represents a variable or constant of integral type.

m represents an identifier that belongs to a set. Generally used in the same function with the metavariable s. The type of s should be SET OF mtype (where mtype is the type of m).

n represents a variable or constant of integral or floating-point type.

r represents a variable or constant of floating-point type.

t represents a type.
\( v \) represents a variable.
\( x \) represents a variable or constant of one of many types. See the explanation of the function for details.

All Modula-2 built-in procedures also return a result, described below.

- `ABS(n)` Returns the absolute value of \( n \).
- `CAP(c)` If \( c \) is a lower case letter, it returns its upper case equivalent, otherwise it returns its argument.
- `CHR(i)` Returns the character whose ordinal value is \( i \).
- `DEC(v)` Decrements the value in the variable \( v \) by one. Returns the new value.
- `DEC(v, i)` Decrements the value in the variable \( v \) by \( i \). Returns the new value.
- `EXCL(m, s)` Removes the element \( m \) from the set \( s \). Returns the new set.
- `FLOAT(i)` Returns the floating point equivalent of the integer \( i \).
- `HIGH(a)` Returns the index of the last member of \( a \).
- `INC(v)` Increments the value in the variable \( v \) by one. Returns the new value.
- `INC(v, i)` Increments the value in the variable \( v \) by \( i \). Returns the new value.
- `INCL(m, s)` Adds the element \( m \) to the set \( s \) if it is not already there. Returns the new set.
- `MAX(t)` Returns the maximum value of the type \( t \).
- `MIN(t)` Returns the minimum value of the type \( t \).
- `ODD(i)` Returns boolean TRUE if \( i \) is an odd number.
- `ORD(x)` Returns the ordinal value of its argument. For example, the ordinal value of a character is its ASCII value (on machines supporting the ASCII character set). The argument \( x \) must be of an ordered type, which include integral, character and enumerated types.
- `SIZE(x)` Returns the size of its argument. The argument \( x \) can be a variable or a type.
- `TRUNC(r)` Returns the integral part of \( r \).
- `TSIZE(x)` Returns the size of its argument. The argument \( x \) can be a variable or a type.
- `VAL(t, i)` Returns the member of the type \( t \) whose ordinal value is \( i \).

**Warning:** Sets and their operations are not yet supported, so GDB treats the use of procedures `INCL` and `EXCL` as an error.

### 15.4.8.3 Constants

GDB allows you to express the constants of Modula-2 in the following ways:

- Integer constants are simply a sequence of digits. When used in an expression, a constant is interpreted to be type-compatible with the rest of the expression. Hexadecimal integers are specified by a trailing ‘H’, and octal integers by a trailing ‘B’.
Floating point constants appear as a sequence of digits, followed by a decimal point and another sequence of digits. An optional exponent can then be specified, in the form \( E[+|-]nnn \), where \([+|-]nnn\) is the desired exponent. All of the digits of the floating point constant must be valid decimal (base 10) digits.

Character constants consist of a single character enclosed by a pair of like quotes, either single (’) or double ("). They may also be expressed by their ordinal value (their ASCII value, usually) followed by a ‘C’.

String constants consist of a sequence of characters enclosed by a pair of like quotes, either single (’) or double ("). Escape sequences in the style of C are also allowed. See Section 15.4.1.2 [C and C++ Constants], page 193, for a brief explanation of escape sequences.

Enumerated constants consist of an enumerated identifier.

Boolean constants consist of the identifiers TRUE and FALSE.

Pointer constants consist of integral values only.

Set constants are not yet supported.

### 15.4.8.4 Modula-2 Types

Currently GDB can print the following data types in Modula-2 syntax: array types, record types, set types, pointer types, procedure types, enumerated types, subrange types and base types. You can also print the contents of variables declared using these type. This section gives a number of simple source code examples together with sample GDB sessions.

The first example contains the following section of code:

```modula2
VAR
  s: SET OF CHAR ;
  r: [20..40] ;
```

and you can request GDB to interrogate the type and value of \( r \) and \( s \).

```plaintext
(gdb) print s
{'A'..'C', 'Z'}
(gdb) ptype s
SET OF CHAR
(gdb) print r
21
(gdb) ptype r
[20..40]
```

Likewise if your source code declares \( s \) as:

```modula2
VAR
  s: SET ['A'..'Z'] ;
```

then you may query the type of \( s \) by:

```plaintext
(gdb) ptype s
type = SET ['A'..'Z']
```

Note that at present you cannot interactively manipulate set expressions using the debugger.

The following example shows how you might declare an array in Modula-2 and how you can interact with GDB to print its type and contents:

```modula2
VAR
  s: ARRAY [-10..10] OF CHAR ;
```
(gdb) ptype s
ARRAY [-10..10] OF CHAR

Note that the array handling is not yet complete and although the type is printed
correctly, expression handling still assumes that all arrays have a lower bound of zero and
not -10 as in the example above.

Here are some more type related Modula-2 examples:

```modula2
TYPE
colour = (blue, red, yellow, green) ;
t = [blue..yellow] ;
VAR
s: t ;
BEGIN
s := blue ;
```

The gdb interaction shows how you can query the data type and value of a variable.

```gdb
(gdb) print s
$1 = blue
(gdb) ptype t
type = [blue..yellow]
```

In this example a Modula-2 array is declared and its contents displayed. Observe that the
contents are written in the same way as their C counterparts.

```modula2
VAR
s: ARRAY [1..5] OF CARDINAL ;
BEGIN
s[1] := 1 ;
(gdb) print s
$1 = {1, 0, 0, 0, 0}
(gdb) ptype s
type = ARRAY [1..5] OF CARDINAL
```

The Modula-2 language interface to gdb also understands pointer types as shown in this
example:

```modula2
VAR
s: POINTER TO ARRAY [1..5] OF CARDINAL ;
BEGIN
NEW(s) ;
s^[1] := 1 ;
```

and you can request that gdb describes the type of s.

```gdb
(gdb) ptype s
type = POINTER TO ARRAY [1..5] OF CARDINAL
```

GDB handles compound types as we can see in this example. Here we combine array
types, record types, pointer types and subrange types:

```modula2
TYPE
foo = RECORD
  f1: CARDINAL ;
  f2: CHAR ;
  f3: myarray ;
END ;

myarray = ARRAY myrange OF CARDINAL ;
myrange = [-2..2] ;
VAR
s: POINTER TO ARRAY myrange OF foo ;
```

and you can ask GDB to describe the type of s as shown below.
(gdb) ptype s
    type = POINTER TO ARRAY [-2..2] OF foo = RECORD
        f1 : CARDINAL;
        f2 : CHAR;
        f3 : ARRAY [-2..2] OF CARDINAL;
    END

15.4.8.5 Modula-2 Defaults

If type and range checking are set automatically by GDB, they both default to on whenever the working language changes to Modula-2. This happens regardless of whether you or GDB selected the working language.

If you allow GDB to set the language automatically, then entering code compiled from a file whose name ends with `.mod' sets the working language to Modula-2. See Section 15.1.3 [Having GDB Infer the Source Language], page 188, for further details.

15.4.8.6 Deviations from Standard Modula-2

A few changes have been made to make Modula-2 programs easier to debug. This is done primarily via loosening its type strictness:

- Unlike in standard Modula-2, pointer constants can be formed by integers. This allows you to modify pointer variables during debugging. (In standard Modula-2, the actual address contained in a pointer variable is hidden from you; it can only be modified through direct assignment to another pointer variable or expression that returned a pointer.)
- C escape sequences can be used in strings and characters to represent non-printable characters. GDB prints out strings with these escape sequences embedded. Single non-printable characters are printed using the `CHR(nn)' format.
- The assignment operator (`:=') returns the value of its right-hand argument.
- All built-in procedures both modify and return their argument.

15.4.8.7 Modula-2 Type and Range Checks

Warning: in this release, GDB does not yet perform type or range checking.

GDB considers two Modula-2 variables type equivalent if:

- They are of types that have been declared equivalent via a `TYPE t1 = t2' statement
- They have been declared on the same line. (Note: This is true of the GNU Modula-2 compiler, but it may not be true of other compilers.)

As long as type checking is enabled, any attempt to combine variables whose types are not equivalent is an error.

Range checking is done on all mathematical operations, assignment, array index bounds, and all built-in functions and procedures.

15.4.8.8 The Scope Operators :: and .

There are a few subtle differences between the Modula-2 scope operator (`.') and the GDB scope operator (`::'). The two have similar syntax:

    module . id
scope :: id

where scope is the name of a module or a procedure, module the name of a module, and id is any declared identifier within your program, except another module.

Using the :: operator makes GDB search the scope specified by scope for the identifier id. If it is not found in the specified scope, then GDB searches all scopes enclosing the one specified by scope.

Using the . operator makes GDB search the current scope for the identifier specified by id that was imported from the definition module specified by module. With this operator, it is an error if the identifier id was not imported from definition module module, or if id is not an identifier in module.

15.4.8.9 GDB and Modula-2

Some GDB commands have little use when debugging Modula-2 programs. Five subcommands of set print and show print apply specifically to C and C++: ‘vtbl’, ‘demangle’, ‘asm-demangle’, ‘object’, and ‘union’. The first four apply to C++, and the last to the C union type, which has no direct analogue in Modula-2.

The @ operator (see Section 10.1 [Expressions], page 115), while available with any language, is not useful with Modula-2. Its intent is to aid the debugging of dynamic arrays, which cannot be created in Modula-2 as they can in C or C++. However, because an address can be specified by an integral constant, the construct ‘{type}adrexp’ is still useful.

In GDB scripts, the Modula-2 inequality operator # is interpreted as the beginning of a comment. Use <> instead.

15.4.9 Ada

The extensions made to GDB for Ada only support output from the GNU Ada (GNAT) compiler. Other Ada compilers are not currently supported, and attempting to debug executables produced by them is most likely to be difficult.

15.4.9.1 Introduction

The Ada mode of GDB supports a fairly large subset of Ada expression syntax, with some extensions. The philosophy behind the design of this subset is

- That GDB should provide basic literals and access to operations for arithmetic, dereferencing, field selection, indexing, and subprogram calls, leaving more sophisticated computations to subprograms written into the program (which therefore may be called from GDB).
- That type safety and strict adherence to Ada language restrictions are not particularly important to the GDB user.
- That brevity is important to the GDB user.

Thus, for brevity, the debugger acts as if all names declared in user-written packages are directly visible, even if they are not visible according to Ada rules, thus making it unnecessary to fully qualify most names with their packages, regardless of context. Where this causes ambiguity, GDB asks the user’s intent.

The debugger will start in Ada mode if it detects an Ada main program. As for other languages, it will enter Ada mode when stopped in a program that was translated from an Ada source file.
While in Ada mode, you may use ‘--’ for comments. This is useful mostly for documenting command files. The standard GDB comment (‘#’) still works at the beginning of a line in Ada mode, but not in the middle (to allow based literals).

The debugger supports limited overloading. Given a subprogram call in which the function symbol has multiple definitions, it will use the number of actual parameters and some information about their types to attempt to narrow the set of definitions. It also makes very limited use of context, preferring procedures to functions in the context of the call command, and functions to procedures elsewhere.

15.4.9.2 Omissions from Ada

Here are the notable omissions from the subset:

- Only a subset of the attributes are supported:
  - 'First, 'Last, and 'Length on array objects (not on types and subtypes).
  - 'Min and 'Max.
  - 'Pos and 'Val.
  - 'Tag.
  - 'Range on array objects (not subtypes), but only as the right operand of the membership (in) operator.
  - 'Access, 'Unchecked_Access, and 'Unrestricted_Access (a GNAT extension).
  - 'Address.

- The names in Characters.Latin_1 are not available and concatenation is not implemented. Thus, escape characters in strings are not currently available.

- Equality tests (‘=’ and ‘/=’) on arrays test for bitwise equality of representations. They will generally work correctly for strings and arrays whose elements have integer or enumeration types. They may not work correctly for arrays whose element types have user-defined equality, for arrays of real values (in particular, IEEE-conformant floating point, because of negative zeroes and NaNs), and for arrays whose elements contain unused bits with indeterminate values.

- The other component-by-component array operations (and, or, xor, not, and relational tests other than equality) are not implemented.

- There is limited support for array and record aggregates. They are permitted only on the right sides of assignments, as in these examples:

  (gdb) set An_Array := (1, 2, 3, 4, 5, 6)
  (gdb) set An_Array := (1, others => 0)
  (gdb) set An_Array := (0|4 => 1, 1..3 => 2, 5 => 6)
  (gdb) set A_2D_Array := ((1, 2, 3), (4, 5, 6), (7, 8, 9))
  (gdb) set A_Record := (1, "Peter", True);
  (gdb) set A_Record := (Name => "Peter", Id => 1, Alive => True)

Changing a discriminant’s value by assigning an aggregate has an undefined effect if that discriminant is used within the record. However, you can first modify discriminants by directly assigning to them (which normally would not be allowed in Ada), and then performing an aggregate assignment. For example, given a variable A_Rec declared to have a type such as:

```ada
type Rec (Len : Small_Integer := 0) is record
  Id : Integer;
```

Vals : IntArray (1 .. Len);
end record;

you can assign a value with a different size of Vals with two assignments:

\begin{verbatim}
(gdb) set A_Rec.Len := 4
(gdb) set A_Rec := (Id => 42, Vals => (1, 2, 3, 4))
\end{verbatim}

As this example also illustrates, GDB is very loose about the usual rules concerning aggregates. You may leave out some of the components of an array or record aggregate (such as the Len component in the assignment to A_Rec above); they will retain their original values upon assignment. You may freely use dynamic values as indices in component associations. You may even use overlapping or redundant component associations, although which component values are assigned in such cases is not defined.

- Calls to dispatching subprograms are not implemented.
- The overloading algorithm is much more limited (i.e., less selective) than that of real Ada. It makes only limited use of the context in which a subexpression appears to resolve its meaning, and it is much looser in its rules for allowing type matches. As a result, some function calls will be ambiguous, and the user will be asked to choose the proper resolution.
- The new operator is not implemented.
- Entry calls are not implemented.
- Aside from printing, arithmetic operations on the native VAX floating-point formats are not supported.
- It is not possible to slice a packed array.
- The names True and False, when not part of a qualified name, are interpreted as if implicitly prefixed by Standard, regardless of context. Should your program redefine these names in a package or procedure (at best a dubious practice), you will have to use fully qualified names to access their new definitions.

\subsection{Additions to Ada}

As it does for other languages, GDB makes certain generic extensions to Ada (see Section 10.1 [Expressions], page 115):

- If the expression \( E \) is a variable residing in memory (typically a local variable or array element) and \( N \) is a positive integer, then \( E@N \) displays the values of \( E \) and the \( N-1 \) adjacent variables following it in memory as an array. In Ada, this operator is generally not necessary, since its prime use is in displaying parts of an array, and slicing will usually do this in Ada. However, there are occasional uses when debugging programs in which certain debugging information has been optimized away.
- \( B::\text{var} \) means “the variable named \text{var} that appears in function or file \( B \).” When \( B \) is a file name, you must typically surround it in single quotes.
- The expression \{\text{type}\} \text{addr} means “the variable of type \text{type} that appears at address \text{addr}.”
- A name starting with ‘$’ is a convenience variable (see Section 10.11 [Convenience Vars], page 137) or a machine register (see Section 10.13 [Registers], page 141).

In addition, GDB provides a few other shortcuts and outright additions specific to Ada:
• The assignment statement is allowed as an expression, returning its right-hand operand as its value. Thus, you may enter
  
  (gdb) set x := y + 3
  (gdb) print A(tmp := y + 1)

• The semicolon is allowed as an “operator,” returning as its value the value of its right-hand operand. This allows, for example, complex conditional breaks:
  
  (gdb) break f
  (gdb) condition 1 (report(i); k += 1; A(k) > 100)

• Rather than use catenation and symbolic character names to introduce special characters into strings, one may instead use a special bracket notation, which is also used to print strings. A sequence of characters of the form \('["XX"]' within a string or character literal denotes the (single) character whose numeric encoding is XX in hexadecimal. The sequence of characters \('["**"]' also denotes a single quotation mark in strings. For example,

  "One line.["0a"]Next line.["0a"]"

contains an ASCII newline character (Ada.Characters.Latin_1.LF) after each period.

• The subtype used as a prefix for the attributes 'Pos, 'Min, and 'Max is optional (and is ignored in any case). For example, it is valid to write
  
  (gdb) print 'max(x, y)

• When printing arrays, GDB uses positional notation when the array has a lower bound of 1, and uses a modified named notation otherwise. For example, a one-dimensional array of three integers with a lower bound of 3 might print as

  (3 => 10, 17, 1)

That is, in contrast to valid Ada, only the first component has a => clause.

• You may abbreviate attributes in expressions with any unique, multi-character subsequence of their names (an exact match gets preference). For example, you may use a'len, a'gth, or a'lh in place of a'length.

• Since Ada is case-insensitive, the debugger normally maps identifiers you type to lower case. The GNAT compiler uses upper-case characters for some of its internal identifiers, which are normally of no interest to users. For the rare occasions when you actually have to look at them, enclose them in angle brackets to avoid the lower-case mapping. For example,

  (gdb) print <JMPBUF_SAVE>[0]

• Printing an object of class-wide type or dereferencing an access-to-class-wide value will display all the components of the object’s specific type (as indicated by its run-time tag). Likewise, component selection on such a value will operate on the specific type of the object.

15.4.9.4 Stopping at the Very Beginning

It is sometimes necessary to debug the program during elaboration, and before reaching the main procedure. As defined in the Ada Reference Manual, the elaboration code is invoked from a procedure called adainit. To run your program up to the beginning of elaboration, simply use the following two commands: tbreak adainit and run.
15.4.9.5 Ada Exceptions

A command is provided to list all Ada exceptions:

```
  info exceptions
  info exceptions regexp
```

The `info exceptions` command allows you to list all Ada exceptions defined within the program being debugged, as well as their addresses. With a regular expression, `regexp`, as argument, only those exceptions whose names match `regexp` are listed.

Below is a small example, showing how the command can be used, first without argument, and next with a regular expression passed as an argument.

```
(gdb) info exceptions
All defined Ada exceptions:
constraint_error: 0x613da0
program_error: 0x613d20
storage_error: 0x613ce0
tasking_error: 0x613ca0
const.aint_global_e: 0x613b00
(gdb) info exceptions const.aint
All Ada exceptions matching regular expression "const.aint":
constraint_error: 0x613da0
const.aint_global_e: 0x613b00
```

It is also possible to ask GDB to stop your program’s execution when an exception is raised. For more details, see Section 5.1.3 [Set Catchpoints], page 55.

15.4.9.6 Extensions for Ada Tasks

Support for Ada tasks is analogous to that for threads (see Section 4.10 [Threads], page 36). GDB provides the following task-related commands:

```
info tasks
```

This command shows a list of current Ada tasks, as in the following example:

```
(gdb) info tasks
   ID  TID P-ID Pri State     Name
      1  8088000  0  15 Child Activation Wait main_task
      2  80a4000  1  15 Accept Statement  b
      3  809a800  1  15 Child Activation Wait a
   *  4  80ae800  3  15 Runnable c
```

In this listing, the asterisk before the last task indicates it to be the task currently being inspected.

- **ID** Represents GDB’s internal task number.
- **TID** The Ada task ID.
- **P-ID** The parent’s task ID (GDB’s internal task number).
- **Pri** The base priority of the task.
- **State** Current state of the task.
Unactivated
The task has been created but has not been activated. It cannot be executing.

Runnable
The task is not blocked for any reason known to Ada. (It may be waiting for a mutex, though.) It is conceptually "executing" in normal mode.

Terminated
The task is terminated, in the sense of ARM 9.3 (5). Any dependents that were waiting on terminate alternatives have been awakened and have terminated themselves.

Child Activation Wait
The task is waiting for created tasks to complete activation.

Accept Statement
The task is waiting on an accept or selective wait statement.

Waiting on entry call
The task is waiting on an entry call.

Async Select Wait
The task is waiting to start the abortable part of an asynchronous select statement.

Delay Sleep
The task is waiting on a select statement with only a delay alternative open.

Child Termination Wait
The task is sleeping having completed a master within itself, and is waiting for the tasks dependent on that master to become terminated or waiting on a terminate Phase.

Wait Child in Term Alt
The task is sleeping waiting for tasks on terminate alternatives to finish terminating.

Accepting RV with taskno
The task is accepting a rendez-vous with the task taskno.

Name
Name of the task in the program.

info task taskno
This command shows detailed informations on the specified task, as in the following example:
(gdb) info tasks
ID   TID  P-ID  Pri   State   Name
 1  8077880  0  15  Child Activation Wait  main_task
* 2  807c468  1  15  Runnable  task_1

(gdb) info task 2
Ada Task: 0x807c468
Name: task_1
Thread: 0x807f378
Parent: 1 (main_task)
Base Priority: 15
State: Runnable

task
This command prints the ID of the current task.

(gdb) info tasks
ID   TID  P-ID  Pri   State   Name
 1  8077870  0  15  Child Activation Wait  main_task
* 2  807c458  1  15  Runnable  task

(gdb) task
[Current task is 2]
taskno
This command is like the thread threadno command (see Section 4.10 [Threads], page 36). It switches the context of debugging from the current task to the given task.

(gdb) info tasks
ID   TID  P-ID  Pri   State   Name
 1  8077870  0  15  Child Activation Wait  main_task
* 2  807c458  1  15  Runnable  t

(gdb) task 1
[Switching to task 1]
#0 0x8067726 in pthread_cond_wait ()
(gdb) bt
#0 0x8067726 in pthread_cond_wait ()
#1 0x8065714 in system.os_interface.pthread_cond_wait ()
#2 0x805cb63 in system.task_primitives.operations.sleep ()
#3 0x806153e in system.tasking.stages.activate_tasks ()
#4 0x804aacc in un () at un.adb:5

break location task taskno
break location task taskno if ...

These commands are like the break ... thread ... command (see Section 5.5 [Thread Stops], page 75). The location argument specifies source lines, as described in Section 9.2 [Specify Location], page 102.

Use the qualifier ‘task taskno’ with a breakpoint command to specify that you only want GDB to stop the program when a particular Ada task reaches this breakpoint. The taskno is one of the numeric task identifiers assigned by GDB, shown in the first column of the ‘info tasks’ display.

If you do not specify ‘task taskno’ when you set a breakpoint, the breakpoint applies to all tasks of your program.

You can use the task qualifier on conditional breakpoints as well; in this case, place ‘task taskno’ before the breakpoint condition (before the if).
For example,

```
(gdb) info tasks
  ID  TID  P-ID  Pri  State         Name
1  140022020  0  15  Child Activation Wait  main_task
2  140045060  1  15  Accept/Select Wait   t2
3  140044840  1  15  Runnable            t1
* 4  140056040  1  15  Runnable            t3
```

```
(gdb) b 15 task 2
Breakpoint 5 at 0x120044cb0: file test_task_debug.adb, line 15.
(gdb) cont
Continuing.
task # 1 running
task # 2 running
```

```
(gdb) info tasks
  ID  TID  P-ID  Pri  State         Name
1  140022020  0  15  Child Activation Wait  main_task
* 2  140045060  1  15  Runnable            t2
3  140044840  1  15  Runnable            t1
4  140056040  1  15  Delay Sleep          t3
```

### 15.4.9.7 Tasking Support when Debugging Core Files

When inspecting a core file, as opposed to debugging a live program, tasking support may be limited or even unavailable, depending on the platform being used. For instance, on x86-linux, the list of tasks is available, but task switching is not supported.

On certain platforms, the debugger needs to perform some memory writes in order to provide Ada tasking support. When inspecting a core file, this means that the core file must be opened with read-write privileges, using the command "set write on" (see Section 17.6 [Patching], page 230). Under these circumstances, you should make a backup copy of the core file before inspecting it with gdb.

### 15.4.9.8 Tasking Support when using the Ravenscar Profile

The Ravenscar Profile is a subset of the Ada tasking features, specifically designed for systems with safety-critical real-time requirements.

```
set ravenscar task-switching on
```

Allows task switching when debugging a program that uses the Ravenscar Profile. This is the default.

```
set ravenscar task-switching off
```

Turn off task switching when debugging a program that uses the Ravenscar Profile. This is mostly intended to disable the code that adds support for the Ravenscar Profile, in case a bug in either GDB or in the Ravenscar runtime is preventing GDB from working properly. To be effective, this command should be run before the program is started.

```
show ravenscar task-switching
```

Show whether it is possible to switch from task to task in a program using the Ravenscar Profile.
15.4.9.9 Known Peculiarities of Ada Mode

Besides the omissions listed previously (see Section 15.4.9.2 [Omissions from Ada], page 207), we know of several problems with and limitations of Ada mode in gdb, some of which will be fixed with planned future releases of the debugger and the GNU Ada compiler.

- Static constants that the compiler chooses not to materialize as objects in storage are invisible to the debugger.
- Named parameter associations in function argument lists are ignored (the argument lists are treated as positional).
- Many useful library packages are currently invisible to the debugger.
- Fixed-point arithmetic, conversions, input, and output is carried out using floating-point arithmetic, and may give results that only approximate those on the host machine.
- The GNAT compiler never generates the prefix `Standard` for any of the standard symbols defined by the Ada language. gdb knows about this: it will strip the prefix from names when you use it, and will never look for a name you have so qualified among local symbols, nor match against symbols in other packages or subprograms. If you have defined entities anywhere in your program other than parameters and local variables whose simple names match names in `Standard`, GNAT’s lack of qualification here can cause confusion. When this happens, you can usually resolve the confusion by qualifying the problematic names with package `Standard` explicitly.

Older versions of the compiler sometimes generate erroneous debugging information, resulting in the debugger incorrectly printing the value of affected entities. In some cases, the debugger is able to work around an issue automatically. In other cases, the debugger is able to work around the issue, but the work-around has to be specifically enabled.

```bash
set ada trust-PAD-over-XVS on
```

Configure gdb to strictly follow the GNAT encoding when computing the value of Ada entities, particularly when PAD and PAD____XVS types are involved (see `ada/exp_dbg.ads` in the GCC sources for a complete description of the encoding used by the GNAT compiler). This is the default.

```bash
set ada trust-PAD-over-XVS off
```

This is related to the encoding using by the GNAT compiler. If gdb sometimes prints the wrong value for certain entities, changing `ada trust-PAD-over-XVS` to `off` activates a work-around which may fix the issue. It is always safe to set `ada trust-PAD-over-XVS` to `off`, but this incurs a slight performance penalty, so it is recommended to leave this setting to `on` unless necessary.

Internally, the debugger also relies on the compiler following a number of conventions known as the ‘GNAT Encoding’, all documented in `gcc/ada/exp_dbg.ads` in the GCC sources. This encoding describes how the debugging information should be generated for certain types. In particular, this convention makes use of descriptive types, which are artificial types generated purely to help the debugger.

These encodings were defined at a time when the debugging information format used was not powerful enough to describe some of the more complex types available in Ada. Since DWARF allows us to express nearly all Ada features, the long-term goal is to slowly replace
these descriptive types by their pure DWARF equivalent. To facilitate that transition, a
new maintenance option is available to force the debugger to ignore those descriptive types. It allows the user to quickly evaluate how well GDB works without them.

```
maintenance ada set ignore-descriptive-types [on|off]
```

Control whether the debugger should ignore descriptive types. The default is not to ignore descriptives types (off).

```
maintenance ada show ignore-descriptive-types
```

Show if descriptive types are ignored by GDB.

15.5 Unsupported Languages

In addition to the other fully-supported programming languages, GDB also provides a pseudo-language, called minimal. It does not represent a real programming language, but provides a set of capabilities close to what the C or assembly languages provide. This should allow most simple operations to be performed while debugging an application that uses a language currently not supported by GDB.

If the language is set to auto, GDB will automatically select this language if the current frame corresponds to an unsupported language.
Chapter 16: Examining the Symbol Table

16 Examining the Symbol Table

The commands described in this chapter allow you to inquire about the symbols (names of variables, functions and types) defined in your program. This information is inherent in the text of your program and does not change as your program executes. GDB finds it in your program’s symbol table, in the file indicated when you started GDB (see Section 2.1.1 [Choosing Files], page 12), or by one of the file-management commands (see Section 18.1 [Commands to Specify Files], page 237).

Occasionally, you may need to refer to symbols that contain unusual characters, which GDB ordinarily treats as word delimiters. The most frequent case is in referring to static variables in other source files (see Section 10.3 [Program Variables], page 117). File names are recorded in object files as debugging symbols, but GDB would ordinarily parse a typical file name, like ‘foo.c’, as the three words ‘foo’ ‘.’ ‘c’. To allow GDB to recognize ‘foo.c’ as a single symbol, enclose it in single quotes; for example,

```plaintext
p 'foo.c':x
```

looks up the value of x in the scope of the file ‘foo.c’.

```plaintext
set case-sensitive on
set case-sensitive off
set case-sensitive auto
```

Normally, when GDB looks up symbols, it matches their names with case sensitivity determined by the current source language. Occasionally, you may wish to control that. The command `set case-sensitive` lets you do that by specifying `on` for case-sensitive matches or `off` for case-insensitive ones. If you specify `auto`, case sensitivity is reset to the default suitable for the source language. The default is case-sensitive matches for all languages except for Fortran, for which the default is case-insensitive matches.

```plaintext
show case-sensitive
```

This command shows the current setting of case sensitivity for symbols lookups.

```plaintext
set print type methods
set print type methods on
set print type methods off
```

Normally, when GDB prints a class, it displays any methods declared in that class. You can control this behavior either by passing the appropriate flag to `ptype`, or using `set print type methods`. Specifying `on` will cause GDB to display the methods; this is the default. Specifying `off` will cause GDB to omit the methods.

```plaintext
show print type methods
```

This command shows the current setting of method display when printing classes.

```plaintext
set print type typedefs
set print type typedefs on
set print type typedefs off
```

Normally, when GDB prints a class, it displays any typedefs defined in that class. You can control this behavior either by passing the appropriate flag to `ptype`,
or using `set print type typedefs`. Specifying `on` will cause GDB to display the typedef definitions; this is the default. Specifying `off` will cause GDB to omit the typedef definitions. Note that this controls whether the typedef definition itself is printed, not whether typedef names are substituted when printing other types.

**show print type typedefs**
This command shows the current setting of typedef display when printing classes.

**info address symbol**
Describe where the data for `symbol` is stored. For a register variable, this says which register it is kept in. For a non-register local variable, this prints the stack-frame offset at which the variable is always stored.

Note the contrast with `print &symbol`, which does not work at all for a register variable, and for a stack local variable prints the exact address of the current instantiation of the variable.

**info symbol addr**
Print the name of a symbol which is stored at the address `addr`. If no symbol is stored exactly at `addr`, GDB prints the nearest symbol and an offset from it:

```
(gdb) info symbol 0x54320
_initialize_vx + 396 in section .text
```

This is the opposite of the `info address` command. You can use it to find out the name of a variable or a function given its address.

For dynamically linked executables, the name of executable or shared library containing the symbol is also printed:

```
(gdb) info symbol 0x400225
_start + 5 in section .text of /tmp/a.out
(gdb) info symbol 0x2aaaac2811cf
__read_nocancel + 6 in section .text of /usr/lib64/libc.so.6
```

**demangle [-l language] [--] name**
Demangle `name`. If `language` is provided it is the name of the language to demangle `name` in. Otherwise `name` is demangled in the current language.

The `--` option specifies the end of options, and is useful when `name` begins with a dash.

The parameter `demangle-style` specifies how to interpret the kind of mangling used. See Section 10.8 [Print Settings], page 125.

**whatis[/flags] [arg]**
Print the data type of `arg`, which can be either an expression or a name of a data type. With no argument, print the data type of `$`, the last value in the value history.

If `arg` is an expression (see Section 10.1 [Expressions], page 115), it is not actually evaluated, and any side-effecting operations (such as assignments or function calls) inside it do not take place.

If `arg` is a variable or an expression, `whatis` prints its literal type as it is used in the source code. If the type was defined using a `typedef`, `whatis` will not
print the data type underlying the `typedef`. If the type of the variable or the expression is a compound data type, such as `struct` or `class`, `whatis` never prints their fields or methods. It just prints the `struct/class` name (a.k.a. its tag). If you want to see the members of such a compound data type, use `ptype`.

If `arg` is a type name that was defined using `typedef`, `whatis` unrolls only one level of that `typedef`. Unrolling means that `whatis` will show the underlying type used in the `typedef` declaration of `arg`. However, if that underlying type is also a `typedef`, `whatis` will not unroll it.

For C code, the type names may also have the form ‘`class class-name`’, ‘`struct struct-tag`’, ‘`union union-tag`’ or ‘`enum enum-tag`’.

`flags` can be used to modify how the type is displayed. Available flags are:

- **r**: Display in “raw” form. Normally, `GDB` substitutes template parameters and typedefs defined in a class when printing the class’ members. The `/r` flag disables this.
- **m**: Do not print methods defined in the class.
- **M**: Print methods defined in the class. This is the default, but the flag exists in case you change the default with `set print type methods`.
- **t**: Do not print typedefs defined in the class. Note that this controls whether the typedef definition itself is printed, not whether typedef names are substituted when printing other types.
- **T**: Print typedefs defined in the class. This is the default, but the flag exists in case you change the default with `set print type typedefs`.

`ptype[/flags] [arg]`

`ptype` accepts the same arguments as `whatis`, but prints a detailed description of the type, instead of just the name of the type. See Section 10.1 [Expressions], page 115.

Contrary to `whatis`, `ptype` always unrolls any typedefs in its argument declaration, whether the argument is a variable, expression, or a data type. This means that `ptype` of a variable or an expression will not print literally its type as present in the source code—use `whatis` for that. typedefs at the pointer or reference targets are also unrolled. Only typedefs of fields, methods and inner class typedefs of structs, classes and unions are not unrolled even with `ptype`.

For example, for this variable declaration:

```c
 typedef double real_t;
 struct complex { real_t real; double imag; };
 typedef struct complex complex_t;
 complex_t var;
 real_t *real_pointer_var;
```

the two commands give this output:
(gdb) whatis var
    type = complex_t
(gdb) ptype var
    type = struct complex {
            real_t real;
            double imag;
    }
(gdb) whatis complex_t
    type = struct complex
(gdb) whatis struct complex
    type = struct complex
(gdb) ptype struct complex
    type = struct complex {
            real_t real;
            double imag;
    }
(gdb) whatis real_pointer_var
    type = real_t *
(gdb) ptype real_pointer_var
    type = double *

As with whatis, using ptype without an argument refers to the type of $\$, the last value in the value history.

Sometimes, programs use opaque data types or incomplete specifications of complex data structure. If the debug information included in the program does not allow GDB to display a full declaration of the data type, it will say ‘<incomplete type>’. For example, given these declarations:

```
struct foo;
struct foo *fooptr;
```

but no definition for struct foo itself, GDB will say:

```
(gdb) ptype foo
    $1 = <incomplete type>
```

“Incomplete type” is C terminology for data types that are not completely specified.

**info types regexp**

**info types**

Print a brief description of all types whose names match the regular expression regexp (or all types in your program, if you supply no argument). Each complete typename is matched as though it were a complete line; thus, ‘i type value’ gives information on all types in your program whose names include the string value, but ‘i type ~value$’ gives information only on types whose complete name is value.

This command differs from ptype in two ways: first, like whatis, it does not print a detailed description; second, it lists all source files where a type is defined.

**info type-printers**

Versions of GDB that ship with Python scripting enabled may have “type printers” available. When using ptype or whatis, these printers are consulted when the name of a type is needed. See Section 23.2.2.8 [Type Printing API], page 340, for more information on writing type printers.
The commands can be used to enable or disable type printers.

**info scope location**
List all the variables local to a particular scope. This command accepts a `location` argument—a function name, a source line, or an address preceded by a `*`, and prints all the variables local to the scope defined by that location. (See Section 9.2 [Specify Location], page 102, for details about supported forms of `location`.) For example:

```
(gdb) info scope command_line_handler
Scope for command_line_handler:
Symbol rl is an argument at stack/frame offset 8, length 4.
Symbol linebuffer is in static storage at address 0x150a18, length 4.
Symbol linelength is in static storage at address 0x150a1c, length 4.
Symbol p is a local variable in register $esi, length 4.
Symbol p1 is a local variable in register $ebx, length 4.
Symbol nline is a local variable in register $edx, length 4.
Symbol repeat is a local variable at frame offset -8, length 4.
```

This command is especially useful for determining what data to collect during a trace experiment, see Section 13.1.6 [Tracepoint Actions], page 168.

**info source**
Show information about the current source file—that is, the source file for the function containing the current point of execution:
- the name of the source file, and the directory containing it,
- the directory it was compiled in,
- its length, in lines,
- which programming language it is written in,
- if the debug information provides it, the program that compiled the file (which may include, e.g., the compiler version and command line arguments),
- whether the executable includes debugging information for that file, and if so, what format the information is in (e.g., STABS, Dwarf 2, etc.), and
- whether the debugging information includes information about preprocessor macros.

**info sources**
Print the names of all source files in your program for which there is debugging information, organized into two lists: files whose symbols have already been read, and files whose symbols will be read when needed.

**info functions**
Print the names and data types of all defined functions.

**info functions regexp**
Print the names and data types of all defined functions whose names contain a match for regular expression `regexp`. Thus, `info fun step` finds all functions
whose names include `step`; `info fun ^step` finds those whose names start with `step`. If a function name contains characters that conflict with the regular expression language (e.g. `operator*()`), they may be quoted with a backslash.

`info variables`
Print the names and data types of all variables that are defined outside of functions (i.e. excluding local variables).

`info variables regexp`
Print the names and data types of all variables (except for local variables) whose names contain a match for regular expression `regexp`.

`info classes`

`info classes regexp`
Display all Objective-C classes in your program, or (with the `regexp` argument) all those matching a particular regular expression.

`info selectors`

`info selectors regexp`
Display all Objective-C selectors in your program, or (with the `regexp` argument) all those matching a particular regular expression.

`set opaque-type-resolution on`
Tell GDB to resolve opaque types. An opaque type is a type declared as a pointer to a `struct`, `class`, or `union`—for example, `struct MyType`—that is used in one source file although the full declaration of `struct MyType` is in another source file. The default is on.

A change in the setting of this subcommand will not take effect until the next time symbols for a file are loaded.

`set opaque-type-resolution off`
Tell GDB not to resolve opaque types. In this case, the type is printed as follows:

```
{<no data fields>}
```

`show opaque-type-resolution`
Show whether opaque types are resolved or not.

`set print symbol-loading`
`set print symbol-loading full`
`set print symbol-loading brief`
`set print symbol-loading off`
The `set print symbol-loading` command allows you to control the printing of messages when GDB loads symbol information. By default a message is printed for the executable and one for each shared library, and normally this is what you want. However, when debugging apps with large numbers of shared libraries these messages can be annoying. When set to `brief` a message is printed for each executable, and when GDB loads a collection of shared libraries at once it will only print one message regardless of the number of shared libraries. When set to `off` no messages are printed.

`show print symbol-loading`
Show whether messages will be printed when a GDB command entered from the keyboard causes symbol information to be loaded.
Write a dump of debugging symbol data into the file filename. These commands are used to debug the GDB symbol-reading code. Only symbols with debugging data are included. If you use ‘maint print symbols’, GDB includes all the symbols for which it has already collected full details: that is, filename reflects symbols for only those files whose symbols GDB has read. You can use the command info sources to find out which files these are. If you use ‘maint print psymbols’ instead, the dump shows information about symbols that GDB only knows partially—that is, symbols defined in files that GDB has skimmed, but not yet read completely. Finally, ‘maint print msymbols’ dumps just the minimal symbol information required for each object file from which GDB has read some symbols. See Section 18.1 [Commands to Specify Files], page 237, for a discussion of how GDB reads symbols (in the description of symbol-file).

List the struct symtab or struct partial_symtab structures whose names match regexp. If regexp is not given, list them all. The output includes expressions which you can copy into a GDB debugging this one to examine a particular structure in more detail. For example:

```
(gdb) maint info psymtabs dwarf2read
  { objfile /home/gnu/build/gdb/gdb
    ((struct objfile *) 0x82e69d0)
    { psymtab /home/gnu/src/gdb/dwarf2read.c
      ((struct partial_symtab *) 0x8474b10)
      readin no
      fullname (null)
      text addresses 0x814d3c8 -- 0x8158074
      globals (* (struct partial_symbol **) 0x8507a08 @ 9)
      statics (* (struct partial_symbol **) 0x40e95b78 @ 2882)
      dependencies (none)
    }
  }
(gdb) maint info symtabs
(gdb)
```

We see that there is one partial symbol table whose filename contains the string ‘dwarf2read’, belonging to the ‘gdb’ executable; and we see that GDB has not read in any symtabs yet at all. If we set a breakpoint on a function, that will cause GDB to read the symtab for the compilation unit containing that function:

```
(gdb) break dwarf2_psymtab_to_symtab
Breakpoint 1 at 0x814e5da: file /home/gnu/src/gdb/dwarf2read.c, line 1574.
(gdb) maint info symtabs
  { objfile /home/gnu/build/gdb/gdb
    ((struct objfile *) 0x82e69d0)
    { symtab /home/gnu/src/gdb/dwarf2read.c
      ((struct symtab *) 0x86c1f38)
      dirname (null)
      fullname (null)
      blockvector ((struct blockvector *) 0x86c1bd0) (primary)
    }
  }
(gdb)
```
linetable ((struct linetable *) 0x8370fa0)
debugformat DWARF 2
}
}
(gdb)

maint set symbol-cache-size size
Set the size of the symbol cache to size. The default size is intended to be good enough for debugging most applications. This option exists to allow for experimenting with different sizes.

maint show symbol-cache-size
Show the size of the symbol cache.

maint print symbol-cache
Print the contents of the symbol cache. This is useful when debugging symbol cache issues.

maint print symbol-cache-statistics
Print symbol cache usage statistics. This helps determine how well the cache is being utilized.

maint flush-symbol-cache
Flush the contents of the symbol cache, all entries are removed. This command is useful when debugging the symbol cache. It is also useful when collecting performance data.
Once you think you have found an error in your program, you might want to find out for certain whether correcting the apparent error would lead to correct results in the rest of the run. You can find the answer by experiment, using the GDB features for altering execution of the program.

For example, you can store new values into variables or memory locations, give your program a signal, restart it at a different address, or even return prematurely from a function.

### 17.1 Assignment to Variables

To alter the value of a variable, evaluate an assignment expression. See Section 10.1 [Expressions], page 115. For example,

```plaintext
print x=4
```

stores the value 4 into the variable `x`, and then prints the value of the assignment expression (which is 4). See Chapter 15 [Using GDB with Different Languages], page 187, for more information on operators in supported languages.

If you are not interested in seeing the value of the assignment, use the `set` command instead of the `print` command. `set` is really the same as `print` except that the expression’s value is not printed and is not put in the value history (see Section 10.10 [Value History], page 136). The expression is evaluated only for its effects.

If the beginning of the argument string of the `set` command appears identical to a `set` subcommand, use the `set variable` command instead of just `set`. This command is identical to `set` except for its lack of subcommands. For example, if your program has a variable `width`, you get an error if you try to set a new value with just ‘`set width=13`’, because GDB has the command `set width`:

```plaintext
(gdb) whatis width  
  type = double  
(gdb) p width  
  $4 = 13  
(gdb) set width=47  
  Invalid syntax in expression.
```

The invalid expression, of course, is ‘`=47’’. In order to actually set the program’s variable `width`, use

```plaintext
(gdb) set var width=47
```

Because the `set` command has many subcommands that can conflict with the names of program variables, it is a good idea to use the `set variable` command instead of just `set`. For example, if your program has a variable `g`, you run into problems if you try to set a new value with just ‘`set g=4`’, because GDB has the command `set gnutarget`, abbreviated `set g`:  

```plaintext
(gdb) set g=4
```
The program variable \texttt{g} did not change, and you silently set the \texttt{gnutarget} to an invalid value. In order to set the variable \texttt{g}, use

\begin{verbatim}
(gdb) set var g=4
\end{verbatim}

GDB allows more implicit conversions in assignments than C; you can freely store an integer value into a pointer variable or vice versa, and you can convert any structure to any other structure that is the same length or shorter.

To store values into arbitrary places in memory, use the ‘\{ ... \}’ construct to generate a value of specified type at a specified address (see Section 10.1 [Expressions], page 115). For example, \{int\}0x83040 refers to memory location 0x83040 as an integer (which implies a certain size and representation in memory), and

\begin{verbatim}
set \{int\}0x83040 = 4
\end{verbatim}

stores the value 4 into that memory location.

\section*{17.2 Continuing at a Different Address}

Ordinarily, when you continue your program, you do so at the place where it stopped, with the \texttt{continue} command. You can instead continue at an address of your own choosing, with the following commands:

\begin{verbatim}
jump location
j location
\end{verbatim}

Resume execution at \textit{location}. Execution stops again immediately if there is a breakpoint there. See Section 9.2 [Specify Location], page 102, for a description of the different forms of \textit{location}. It is common practice to use the \texttt{tbreak} command in conjunction with \texttt{jump}. See Section 5.1.1 [Setting Breakpoints], page 46.

The \texttt{jump} command does not change the current stack frame, or the stack pointer, or the contents of any memory location or any register other than the program counter. If \textit{location} is in a different function from the one currently executing, the results may be bizarre if the two functions expect different patterns of arguments or of local variables. For this reason, the \texttt{jump} command requests confirmation if the specified line is not in the function currently executing. However, even bizarre results are predictable if you are well acquainted with the machine-language code of your program.
On many systems, you can get much the same effect as the `jump` command by storing a new value into the register `$pc`. The difference is that this does not start your program running; it only changes the address of where it will run when you continue. For example,

```plaintext
set $pc = 0x485
```

makes the next `continue` command or stepping command execute at address `0x485`, rather than at the address where your program stopped. See Section 5.2 [Continuing and Stepping], page 68.

The most common occasion to use the `jump` command is to back up—perhaps with more breakpoints set—over a portion of a program that has already executed, in order to examine its execution in more detail.

### 17.3 Giving your Program a Signal

`signal signal`

Resume execution where your program is stopped, but immediately give it the signal `signal`. The `signal` can be the name or the number of a signal. For example, on many systems `signal 2` and `signal SIGINT` are both ways of sending an interrupt signal.

Alternatively, if `signal` is zero, continue execution without giving a signal. This is useful when your program stopped on account of a signal and would ordinarily see the signal when resumed with the `continue` command; `signal 0` causes it to resume without a signal.

**Note:** When resuming a multi-threaded program, `signal` is delivered to the currently selected thread, not the thread that last reported a stop. This includes the situation where a thread was stopped due to a signal. So if you want to continue execution suppressing the signal that stopped a thread, you should select that same thread before issuing the `signal 0` command. If you issue the `signal 0` command with another thread as the selected one, GDB detects that and asks for confirmation.

Invoking the `signal` command is not the same as invoking the `kill` utility from the shell. Sending a signal with `kill` causes GDB to decide what to do with the signal depending on the signal handling tables (see Section 5.4 [Signals], page 73). The `signal` command passes the signal directly to your program.

`signal` does not repeat when you press RET a second time after executing the command.

`queue-signal signal`

Queue `signal` to be delivered immediately to the current thread when execution of the thread resumes. The `signal` can be the name or the number of a signal. For example, on many systems `signal 2` and `signal SIGINT` are both ways of sending an interrupt signal. The handling of the signal must be set to pass the signal to the program, otherwise GDB will report an error. You can control the handling of signals from GDB with the `handle` command (see Section 5.4 [Signals], page 73).

Alternatively, if `signal` is zero, any currently queued signal for the current thread is discarded and when execution resumes no signal will be delivered. This is
useful when your program stopped on account of a signal and would ordinarily see the signal when resumed with the `continue` command.

This command differs from the `signal` command in that the signal is just queued, execution is not resumed. And `queue-signal` cannot be used to pass a signal whose handling state has been set to `nopass` (see Section 5.4 [Signals], page 73).

See [stepping into signal handlers], page 74, for information on how stepping commands behave when the thread has a signal queued.

### 17.4 Returning from a Function

```
return
```

**return**

You can cancel execution of a function call with the `return` command. If you give an expression argument, its value is used as the function’s return value.

When you use `return`, GDB discards the selected stack frame (and all frames within it). You can think of this as making the discarded frame return prematurely. If you wish to specify a value to be returned, give that value as the argument to `return`.

This pops the selected stack frame (see Section 8.4 [Selecting a Frame], page 99), and any other frames inside of it, leaving its caller as the innermost remaining frame. That frame becomes selected. The specified value is stored in the registers used for returning values of functions.

The `return` command does not resume execution; it leaves the program stopped in the state that would exist if the function had just returned. In contrast, the `finish` command (see Section 5.2 [Continuing and Stepping], page 68) resumes execution until the selected stack frame returns naturally.

GDB needs to know how the expression argument should be set for the inferior. The concrete registers assignment depends on the OS ABI and the type being returned by the selected stack frame. For example, it is common for OS ABI to return floating point values in FPU registers while integer values in CPU registers. Still some ABIs return even floating point values in CPU registers. Larger integer widths (such as `long long int`) also have specific placement rules. GDB already knows the OS ABI from its current target so it needs to find out also the type being returned to make the assignment into the right register(s).

Normally, the selected stack frame has debug info. GDB will always use the debug info instead of the implicit type of expression when the debug info is available. For example, if you type `return -1`, and the function in the current stack frame is declared to return a `long long int`, GDB transparently converts the implicit `int` value of `-1` into a `long long int`:

```
Breakpoint 1, func () at gdb.base/return-nodebug.c:29
29    return 31;
(gdb) return -1
```

Instead, if the selected stack frame does not have a debug info, e.g., if the function was compiled without debug info, GDB has to find out the type to return from user. Specifying
a different type by mistake may set the value in different inferior registers than the caller code expects. For example, typing `return -1` with its implicit type `int` would set only a part of a `long long int` result for a debug info less function (on 32-bit architectures). Therefore the user is required to specify the return type by an appropriate cast explicitly:

```
Breakpoint 2, 0x0040050b in func ()
(gdb) return -1
Return value type not available for selected stack frame.
Please use an explicit cast of the value to return.
(gdb) return (long long int) -1
Make selected stack frame return now? (y or n) y
#0 0x00400526 in main ()
```

### 17.5 Calling Program Functions

**print expr**

Evaluate the expression `expr` and display the resulting value. The expression may include calls to functions in the program being debugged.

**call expr**

Evaluate the expression `expr` without displaying `void` returned values.

You can use this variant of the `print` command if you want to execute a function from your program that does not return anything (a.k.a. a void function), but without cluttering the output with `void` returned values that GDB will otherwise print. If the result is not void, it is printed and saved in the value history.

It is possible for the function you call via the `print` or `call` command to generate a signal (e.g., if there's a bug in the function, or if you passed it incorrect arguments). What happens in that case is controlled by the `set unwindonsignal` command.

Similarly, with a C++ program it is possible for the function you call via the `print` or `call` command to generate an exception that is not handled due to the constraints of the dummy frame. In this case, any exception that is raised in the frame, but has an out-of-frame exception handler will not be found. GDB builds a dummy-frame for the inferior function call, and the unwinder cannot seek for exception handlers outside of this dummy-frame. What happens in that case is controlled by the `set unwind-on-terminating-exception` command.

**set unwindonsignal**

Set unwinding of the stack if a signal is received while in a function that GDB called in the program being debugged. If set to on, GDB unwinds the stack it created for the call and restores the context to what it was before the call. If set to off (the default), GDB stops in the frame where the signal was received.

**show unwindonsignal**

Show the current setting of stack unwinding in the functions called by GDB.

**set unwind-on-terminating-exception**

Set unwinding of the stack if a C++ exception is raised, but left unhandled while in a function that GDB called in the program being debugged. If set to on (the default), GDB unwinds the stack it created for the call and restores the context to what it was before the call. If set to off, GDB the exception is delivered to the default C++ exception handler and the inferior terminated.
show unwind-on-terminating-exception

Show the current setting of stack unwinding in the functions called by GDB.

Sometimes, a function you wish to call is actually a weak alias for another function. In such case, GDB might not pick up the type information, including the types of the function arguments, which causes GDB to call the inferior function incorrectly. As a result, the called function will function erroneously and may even crash. A solution to that is to use the name of the aliased function instead.

17.6 Patching Programs

By default, GDB opens the file containing your program’s executable code (or the corefile) read-only. This prevents accidental alterations to machine code; but it also prevents you from intentionally patching your program’s binary.

If you’d like to be able to patch the binary, you can specify that explicitly with the set write command. For example, you might want to turn on internal debugging flags, or even to make emergency repairs.

set write on
set write off

If you specify ‘set write on’, GDB opens executable and core files for both reading and writing; if you specify set write off (the default), GDB opens them read-only.

If you have already loaded a file, you must load it again (using the exec-file or core-file command) after changing set write, for your new setting to take effect.

show write

Display whether executable files and core files are opened for writing as well as reading.

17.7 Compiling and injecting code in GDB

GDB supports on-demand compilation and code injection into programs running under GDB. GCC 5.0 or higher built with ‘libgcc1.so’ must be installed for this functionality to be enabled. This functionality is implemented with the following commands.

compile code source-code
compile code -raw -- source-code

Compile source-code with the compiler language found as the current language in GDB (see Chapter 15 [Languages], page 187). If compilation and injection is not supported with the current language specified in GDB, or the compiler does not support this feature, an error message will be printed. If source-code compiles and links successfully, GDB will load the object-code emitted, and execute it within the context of the currently selected inferior. It is important to note that the compiled code is executed immediately. After execution, the compiled code is removed from GDB and any new types or variables you have defined will be deleted.

The command allows you to specify source-code in two ways. The simplest method is to provide a single line of code to the command. E.g.:
Chapter 17: Altering Execution

```c
compile code printf ("hello world\n");
```

If you specify options on the command line as well as source code, they may conflict. The `--` delimiter can be used to separate options from actual source code. E.g.:

```c
compile code -r -- printf ("hello world\n");
```

Alternatively you can enter source code as multiple lines of text. To enter this mode, invoke the `compile code` command without any text following the command. This will start the multiple-line editor and allow you to type as many lines of source code as required. When you have completed typing, enter `end` on its own line to exit the editor.

```c
compile code
>printf ("hello\n");
>printf ("world\n");
>end
```

Specifying `--raw`, prohibits GDB from wrapping the provided source-code in a callable scope. In this case, you must specify the entry point of the code by defining a function named `_gdb_expr_`. The `--raw` code cannot access variables of the inferior. Using `--raw` option may be needed for example when source-code requires `#include` lines which may conflict with inferior symbols otherwise.

```c
compile file filename
```

Like `compile code`, but take the source code from `filename`.

```c
compile file /home/user/example.c
```

```c
compile print expr
```

```c
compile print /f expr
```

Compile and execute `expr` with the compiler language found as the current language in GDB (see Chapter 15 [Languages], page 187). By default the value of `expr` is printed in a format appropriate to its data type; you can choose a different format by specifying `'/f'`, where `f` is a letter specifying the format; see Section 10.5 [Output Formats], page 120.

```c
compile print
```

```c
compile print /f
```

Alternatively you can enter the expression (source code producing it) as multiple lines of text. To enter this mode, invoke the `compile print` command without any text following the command. This will start the multiple-line editor.

The process of compiling and injecting the code can be inspected using:

```c
set debug compile
```

Turns on or off display of GDB process of compiling and injecting the code. The default is off.

```c
show debug compile
```

Displays the current state of displaying GDB process of compiling and injecting the code.
17.7.1 Compilation options for the compile command

GDB needs to specify the right compilation options for the code to be injected, in part to make its ABI compatible with the inferior and in part to make the injected code compatible with GDB’s injecting process.

The options used, in increasing precedence:

target architecture and OS options (**gdbarch**)

These options depend on target processor type and target operating system, usually they specify at least 32-bit (**-m32**) or 64-bit (**-m64**) compilation option.

compilation options recorded in the target

GCC (since version 4.7) stores the options used for compilation into **DW_AT_producer** part of DWARF debugging information according to the GCC option **-grecord-gcc-switches**. One has to explicitly specify **-g** during inferior compilation otherwise GCC produces no DWARF. This feature is only relevant for platforms where **-g** produces DWARF by default, otherwise one may try to enforce DWARF by using **-gdwarf-4**.

compilation options set by **set compile-args**

You can override compilation options using the following command:

**set compile-args**

Set compilation options used for compiling and injecting code with the compile commands. These options override any conflicting ones from the target architecture and/or options stored during inferior compilation.

**show compile-args**

Displays the current state of compilation options override. This does not show all the options actually used during compilation, use [set debug compile], page 231 for that.

17.7.2 Caveats when using the compile command

There are a few caveats to keep in mind when using the compile command. As the caveats are different per language, the table below highlights specific issues on a per language basis.

C code examples and caveats

When the language in GDB is set to ‘C’, the compiler will attempt to compile the source code with a ‘C’ compiler. The source code provided to the compile command will have much the same access to variables and types as it normally would if it were part of the program currently being debugged in GDB.

Below is a sample program that forms the basis of the examples that follow. This program has been compiled and loaded into GDB, much like any other normal debugging session.

```c
void function1 (void)
{
    int i = 42;
    printf ("function 1\n");
}

void function2 (void)
```

```c
```
Chapter 17: Altering Execution

```c
{  
    int j = 12;
    function1 ();
}

int main(void)
{
    int k = 6;
    int *p;
    function2 ();
    return 0;
}
```

For the purposes of the examples in this section, the program above has been compiled, loaded into GDB, stopped at the function `main`, and GDB is awaiting input from the user.

To access variables and types for any program in GDB, the program must be compiled and packaged with debug information. The `compile` command is not an exception to this rule. Without debug information, you can still use the `compile` command, but you will be very limited in what variables and types you can access.

So with that in mind, the example above has been compiled with debug information enabled. The `compile` command will have access to all variables and types (except those that may have been optimized out). Currently, as GDB has stopped the program in the `main` function, the `compile` command would have access to the variable `k`. You could invoke the `compile` command and type some source code to set the value of `k`. You can also read it, or do anything with that variable you would normally do in C. Be aware that changes to inferior variables in the `compile` command are persistent. In the following example:

```c
compile code k = 3;
```

the variable `k` is now 3. It will retain that value until something else in the example program changes it, or another `compile` command changes it.

Normal scope and access rules apply to source code compiled and injected by the `compile` command. In the example, the variables `j` and `k` are not accessible yet, because the program is currently stopped in the `main` function, where these variables are not in scope. Therefore, the following command

```c
compile code j = 3;
```

will result in a compilation error message.

Once the program is continued, execution will bring these variables in scope, and they will become accessible; then the code you specify via the `compile` command will be able to access them.

You can create variables and types with the `compile` command as part of your source code. Variables and types that are created as part of the `compile` command are not visible to the rest of the program for the duration of its run. This example is valid:

```c
compile code int ff = 5; printf ("ff is %d\n", ff);
```

However, if you were to type the following into GDB after that command has completed:
compile code printf ("ff is %d\n", ff);

a compiler error would be raised as the variable ff no longer exists. Object
code generated and injected by the compile command is removed when its
execution ends. Caution is advised when assigning to program variables values
of variables created by the code submitted to the compile command. This
eexample is valid:

    compile code int ff = 5; k = ff;

The value of the variable ff is assigned to k. The variable k does not require the
existence of ff to maintain the value it has been assigned. However, pointers
require particular care in assignment. If the source code compiled with the
 compile command changed the address of a pointer in the example program,
perhaps to a variable created in the compile command, that pointer would
point to an invalid location when the command exits. The following example
would likely cause issues with your debugged program:

    compile code int ff = 5; p = &ff;

In this example, p would point to ff when the compile command is executing
the source code provided to it. However, as variables in the (example) program
persist with their assigned values, the variable p would point to an invalid
location when the command exists. A general rule should be followed in that
you should either assign NULL to any assigned pointers, or restore a valid location
to the pointer before the command exits.

Similar caution must be exercised with any structs, unions, and typedefs defined
in compile command. Types defined in the compile command will no longer
be available in the next compile command. Therefore, if you cast a variable
to a type defined in the compile command, care must be taken to ensure that
any future need to resolve the type can be achieved.

(gdb) compile code static struct a { int a; } v = { 42 }; argv = &v;
(gdb) compile code printf ("%d\n", ((struct a *) argv)->a);
gdb command line:1:36: error: dereferencing pointer to incomplete type struct a
Compilation failed.
(gdb) compile code struct a { int a; }; printf ("%d\n", ((struct a *) argv)->a);
42

Variables that have been optimized away by the compiler are not accessible to
the code submitted to the compile command. Access to those variables will
generate a compiler error which GDB will print to the console.

17.7.3 Compiler search for the compile command

GDB needs to find GCC for the inferior being debugged which may not be obvious for remote
targets of different architecture than where GDB is running. Environment variable PATH
(PATH from shell that executed GDB, not the one set by GDB command set environment).
See Section 4.4 [Environment], page 30. PATH on GDB host is searched for GCC binary
matching the target architecture and operating system.

Specifically PATH is searched for binaries matching regular expression arch(-[^-]*-)
-os-gcc according to the inferior target being debugged. arch is processor name — multiarch
is supported, so for example both i386 and x86_64 targets look for pattern (x86_64|i.86)
and both \texttt{s390} and \texttt{s390x} targets look for pattern \texttt{s390x\?}. \texttt{os} is currently supported only for pattern \texttt{linux(-gnu)\?}. 
18 GDB Files

GDB needs to know the file name of the program to be debugged, both in order to read its symbol table and in order to start your program. To debug a core dump of a previous run, you must also tell GDB the name of the core dump file.

18.1 Commands to Specify Files

You may want to specify executable and core dump file names. The usual way to do this is at start-up time, using the arguments to GDB’s start-up commands (see Chapter 2 [Getting In and Out of GDB], page 11).

Occasionally it is necessary to change to a different file during a GDB session. Or you may run GDB and forget to specify a file you want to use. Or you are debugging a remote target via gdbserver (see Section 20.3 [Using the gdbserver Program], page 259). In these situations the GDB commands to specify new files are useful.

*file filename*

Use `filename` as the program to be debugged. It is read for its symbols and for the contents of pure memory. It is also the program executed when you use the `run` command. If you do not specify a directory and the file is not found in the GDB working directory, GDB uses the environment variable `PATH` as a list of directories to search, just as the shell does when looking for a program to run. You can change the value of this variable, for both GDB and your program, using the `path` command.

You can load unlinked object `.o` files into GDB using the `file` command. You will not be able to “run” an object file, but you can disassemble functions and inspect variables. Also, if the underlying BFD functionality supports it, you could use `gdb -write` to patch object files using this technique. Note that GDB can neither interpret nor modify relocations in this case, so branches and some initialized variables will appear to go to the wrong place. But this feature is still handy from time to time.

*file* with no argument makes GDB discard any information it has on both executable file and the symbol table.

*exec-file [filename]*

Specify that the program to be run (but not the symbol table) is found in `filename`. GDB searches the environment variable `PATH` if necessary to locate your program. Omitting `filename` means to discard information on the executable file.

*symbol-file [filename]*

Read symbol table information from file `filename`. `PATH` is searched when necessary. Use the `file` command to get both symbol table and program to run from the same file.

*symbol-file* with no argument clears out GDB information on your program’s symbol table.

The `symbol-file` command causes GDB to forget the contents of some breakpoints and auto-display expressions. This is because they may contain pointers
to the internal data recording symbols and data types, which are part of the old symbol table data being discarded inside GDB.

symbol-file does not repeat if you press RET again after executing it once.

When GDB is configured for a particular environment, it understands debugging information in whatever format is the standard generated for that environment; you may use either a GNU compiler, or other compilers that adhere to the local conventions. Best results are usually obtained from GNU compilers; for example, using GCC you can generate debugging information for optimized code.

For most kinds of object files, with the exception of old SVR3 systems using COFF, the symbol-file command does not normally read the symbol table in full right away. Instead, it scans the symbol table quickly to find which source files and which symbols are present. The details are read later, one source file at a time, as they are needed.

The purpose of this two-stage reading strategy is to make GDB start up faster. For the most part, it is invisible except for occasional pauses while the symbol table details for a particular source file are being read. (The set verbose command can turn these pauses into messages if desired. See Section 22.8 [Optional Warnings and Messages], page 307.)

We have not implemented the two-stage strategy for COFF yet. When the symbol table is stored in COFF format, symbol-file reads the symbol table data in full right away. Note that “stabs-in-COFF” still does the two-stage strategy, since the debug info is actually in stabs format.

symbol-file [-readnow | filename]
file [-readnow | filename]

You can override the GDB two-stage strategy for reading symbol tables by using the ‘-readnow’ option with any of the commands that load symbol table information, if you want to be sure GDB has the entire symbol table available.

core-file [filename]
core

Specify the whereabouts of a core dump file to be used as the “contents of memory”. Traditionally, core files contain only some parts of the address space of the process that generated them; GDB can access the executable file itself for other parts.

core-file with no argument specifies that no core file is to be used.

Note that the core file is ignored when your program is actually running under GDB. So, if you have been running your program and you wish to debug a core file instead, you must kill the subprocess in which the program is running. To do this, use the kill command (see Section 4.8 [Killing the Child Process], page 33).

add-symbol-file filename address
add-symbol-file filename address [-readnow]
add-symbol-file filename address -s section address ...

The add-symbol-file command reads additional symbol table information from the file filename. You would use this command when filename has been dynamically loaded (by some other means) into the program that is running.
The address should give the memory address at which the file has been loaded; GDB cannot figure this out for itself. You can additionally specify an arbitrary number of `-s section address' pairs, to give an explicit section name and base address for that section. You can specify any address as an expression.

The symbol table of the file filename is added to the symbol table originally read with the symbol-file command. You can use the add-symbol-file command any number of times; the new symbol data thus read is kept in addition to the old.

Changes can be reverted using the command remove-symbol-file.

Although filename is typically a shared library file, an executable file, or some other object file which has been fully relocated for loading into a process, you can also load symbolic information from relocatable `.o' files, as long as:
- the file's symbolic information refers only to linker symbols defined in that file, not to symbols defined by other object files,
- every section the file's symbolic information refers to has actually been loaded into the inferior, as it appears in the file, and
- you can determine the address at which every section was loaded, and provide these to the add-symbol-file command.

Some embedded operating systems, like Sun Chorus and VxWorks, can load relocatable files into an already running program; such systems typically make the requirements above easy to meet. However, it's important to recognize that many native systems use complex link procedures (.linkonce section factoring and C++ constructor table assembly, for example) that make the requirements difficult to meet. In general, one cannot assume that using add-symbol-file to read a relocatable object file's symbolic information will have the same effect as linking the relocatable object file into the program in the normal way.

add-symbol-file does not repeat if you press RET after using it.

```
remove-symbol-file filename
remove-symbol-file -a address
```

Remove a symbol file added via the add-symbol-file command. The file to remove can be identified by its filename or by an address that lies within the boundaries of this symbol file in memory. Example:

```
(gdb) add-symbol-file /home/user/gdb/mylib.so 0x7fffffff7ff9480
add symbol table from file "/home/user/gdb/mylib.so" at
   .text_addr = 0x7fffffff7ff9480
(y or n) y
Reading symbols from /home/user/gdb/mylib.so...done.
(gdb) remove-symbol-file -a 0x7fffffff7ff9480
Remove symbol table from file "/home/user/gdb/mylib.so"? (y or n) y
(gdb)
```

remove-symbol-file does not repeat if you press RET after using it.

```
add-symbol-file-from-memory address
```

Load symbols from the given address in a dynamically loaded object file whose image is mapped directly into the inferior's memory. For example, the Linux kernel maps a syscall DSO into each process's address space; this DSO provides
kernel-specific code for some system calls. The argument can be any expression whose evaluation yields the address of the file’s shared object file header. For this command to work, you must have used symbol-file or exec-file commands in advance.

section section addr

The section command changes the base address of the named section of the exec file to addr. This can be used if the exec file does not contain section addresses, (such as in the a.out format), or when the addresses specified in the file itself are wrong. Each section must be changed separately. The info files command, described below, lists all the sections and their addresses.

info files
info target

info files and info target are synonymous; both print the current target (see Chapter 19 [Specifying a Debugging Target], page 253), including the names of the executable and core dump files currently in use by GDB, and the files from which symbols were loaded. The command help target lists all possible targets rather than current ones.

maint info sections

Another command that can give you extra information about program sections is maint info sections. In addition to the section information displayed by info files, this command displays the flags and file offset of each section in the executable and core dump files. In addition, maint info sections provides the following command options (which may be arbitrarily combined):

ALLOBJ Display sections for all loaded object files, including shared libraries.
sections Display info only for named sections.

section-flags

Display info only for sections for which section-flags are true. The section flags that GDB currently knows about are:

ALLOC Section will have space allocated in the process when loaded. Set for all sections except those containing debug information.

LOAD Section will be loaded from the file into the child process memory. Set for pre-initialized code and data, clear for .bss sections.

RELOC Section needs to be relocated before loading.

READONLY Section cannot be modified by the child process.

CODE Section contains executable code only.

DATA Section contains data only (no executable code).

ROM Section will reside in ROM.
CONSTRUCTOR
Section contains data for constructor/destructor lists.

HAS_CONTENTS
Section is not empty.

NEVER_LOAD
An instruction to the linker to not output the section.

COFF_SHARED_LIBRARY
A notification to the linker that the section contains COFF shared library information.

IS_COMMON
Section contains common symbols.

set trust-readonly-sections on
Tell GDB that readonly sections in your object file really are read-only (i.e. that their contents will not change). In that case, GDB can fetch values from these sections out of the object file, rather than from the target program. For some targets (notably embedded ones), this can be a significant enhancement to debugging performance.

The default is off.

set trust-readonly-sections off
Tell GDB not to trust readonly sections. This means that the contents of the section might change while the program is running, and must therefore be fetched from the target when needed.

show trust-readonly-sections
Show the current setting of trusting readonly sections.

All file-specifying commands allow both absolute and relative file names as arguments. GDB always converts the file name to an absolute file name and remembers it that way.

GDB supports GNU/Linux, MS-Windows, HP-UX, SunOS, SVr4, Irix, and IBM RS/6000 AIX shared libraries.

On MS-Windows GDB must be linked with the Expat library to support shared libraries. See [Expat], page 591.

GDB automatically loads symbol definitions from shared libraries when you use the run command, or when you examine a core file. (Before you issue the run command, GDB does not understand references to a function in a shared library, however—unless you are debugging a core file).

On HP-UX, if the program loads a library explicitly, GDB automatically loads the symbols at the time of the shl_load call.

There are times, however, when you may wish to not automatically load symbol definitions from shared libraries, such as when they are particularly large or there are many of them.

To control the automatic loading of shared library symbols, use the commands:
set auto-solib-add mode

If `mode` is `on`, symbols from all shared object libraries will be loaded automatically when the inferior begins execution, you attach to an independently started inferior, or when the dynamic linker informs GDB that a new library has been loaded. If `mode` is `off`, symbols must be loaded manually, using the `sharedlibrary` command. The default value is `on`.

If your program uses lots of shared libraries with debug info that takes large amounts of memory, you can decrease the GDB memory footprint by preventing it from automatically loading the symbols from shared libraries. To that end, type `set auto-solib-add off` before running the inferior, then load each library whose debug symbols you do need with `sharedlibrary regexp`, where `regexp` is a regular expression that matches the libraries whose symbols you want to be loaded.

show auto-solib-add

Display the current autoloading mode.

To explicitly load shared library symbols, use the `sharedlibrary` command:

info share regex
info sharedlibrary regex

Print the names of the shared libraries which are currently loaded that match `regex`. If `regex` is omitted then print all shared libraries that are loaded.

info dll regex

This is an alias of `info sharedlibrary`.

sharedlibrary regex
share regex

Load shared object library symbols for files matching a Unix regular expression. As with files loaded automatically, it only loads shared libraries required by your program for a core file or after typing `run`. If `regex` is omitted all shared libraries required by your program are loaded.

nosharedlibrary

Unload all shared object library symbols. This discards all symbols that have been loaded from all shared libraries. Symbols from shared libraries that were loaded by explicit user requests are not discarded.

Sometimes you may wish that GDB stops and gives you control when any of shared library events happen. The best way to do this is to use `catch load` and `catch unload` (see Section 5.1.3 [Set Catchpoints], page 55).

GDB also supports the the `set stop-on-solib-events` command for this. This command exists for historical reasons. It is less useful than setting a catchpoint, because it does not allow for conditions or commands as a catchpoint does.

set stop-on-solib-events

This command controls whether GDB should give you control when the dynamic linker notifies it about some shared library event. The most common event of interest is loading or unloading of a new shared library.
show stop-on-solib-events

Show whether GDB stops and gives you control when shared library events happen.

Shared libraries are also supported in many cross or remote debugging configurations. GDB needs to have access to the target’s libraries; this can be accomplished either by providing copies of the libraries on the host system, or by asking GDB to automatically retrieve the libraries from the target. If copies of the target libraries are provided, they need to be the same as the target libraries, although the copies on the target can be stripped as long as the copies on the host are not.

For remote debugging, you need to tell GDB where the target libraries are, so that it can load the correct copies—otherwise, it may try to load the host’s libraries. GDB has two variables to specify the search directories for target libraries.

set sysroot path

Use path as the system root for the program being debugged. Any absolute shared library paths will be prefixed with path; many runtime loaders store the absolute paths to the shared library in the target program’s memory. When starting processes remotely, and when attaching to already-running processes (local or remote), their executable filenames will be prefixed with path if reported to GDB as absolute by the operating system. If you use set sysroot to find executables and shared libraries, they need to be laid out in the same way that they are on the target, with e.g. a ‘/bin’, ‘/lib’ and ‘/usr/lib’ hierarchy under path.

If path starts with the sequence ‘target:’ and the target system is remote then GDB will retrieve the target binaries from the remote system. This is only supported when using a remote target that supports the remote get command (see Section 20.2 [Sending files to a remote system], page 259). The part of path following the initial ‘target:’ (if present) is used as system root prefix on the remote file system. If path starts with the sequence ‘remote:’ this is converted to the sequence ‘target:’ by set sysroot. If you want to specify a local system root using a directory that happens to be named ‘target:’ or ‘remote:’, you need to use some equivalent variant of the name like ‘./target:’.

For targets with an MS-DOS based filesystem, such as MS-Windows and SymbianOS, GDB tries prefixing a few variants of the target absolute file name with path. But first, on Unix hosts, GDB converts all backslash directory separators into forward slashes, because the backslash is not a directory separator on Unix:

\texttt{c:\foo\bar.dll} \Rightarrow \texttt{c:/foo/bar.dll}

Then, GDB attempts prefixing the target file name with path, and looks for the resulting file name in the host file system:

\texttt{c:/foo/bar.dll} \Rightarrow \texttt{/path/to/sysroot/c:/foo/bar.dll}

If that does not find the binary, GDB tries removing the ‘:’ character from the drive spec, both for convenience, and, for the case of the host file system not supporting file names with colons:

\texttt{c:/foo/bar.dll} \Rightarrow \texttt{/path/to/sysroot/c:/foo/bar.dll}

1 Historically the functionality to retrieve binaries from the remote system was provided by prefixing path with ‘remote:’
c:/foo/bar.dll ⇒ /path/to/sysroot/c/foo/bar.dll

This makes it possible to have a system root that mirrors a target with more than one drive. E.g., you may want to setup your local copies of the target system shared libraries like so (note ‘c’ vs ‘z’):

‘/path/to/sysroot/c/sys/bin/foo.dll’
‘/path/to/sysroot/c/sys/bin/bar.dll’
‘/path/to/sysroot/z/sys/bin/bar.dll’

and point the system root at ‘/path/to/sysroot’, so that GDB can find the correct copies of both ‘c:\sys\bin\foo.dll’, and ‘z:\sys\bin\bar.dll’.

If that still does not find the binary, GDB tries removing the whole drive spec from the target file name:

\[ c:/foo/bar.dll ⇒ /path/to/sysroot/foo/bar.dll \]

This last lookup makes it possible to not care about the drive name, if you don’t want or need to.

The set solib-absolute-prefix command is an alias for set sysroot.

You can set the default system root by using the configure-time ‘--with-sysroot’ option. If the system root is inside GDB’s configured binary prefix (set with ‘--prefix’ or ‘--exec-prefix’), then the default system root will be updated automatically if the installed GDB is moved to a new location.

show sysroot
Display the current executable and shared library prefix.

set solib-search-path path
If this variable is set, path is a colon-separated list of directories to search for shared libraries. ‘solib-search-path’ is used after ‘sysroot’ fails to locate the library, or if the path to the library is relative instead of absolute. If you want to use ‘solib-search-path’ instead of ‘sysroot’, be sure to set ‘sysroot’ to a nonexistent directory to prevent GDB from finding your host’s libraries. ‘sysroot’ is preferred; setting it to a nonexistent directory may interfere with automatic loading of shared library symbols.

show solib-search-path
Display the current shared library search path.

set target-file-system-kind kind
Set assumed file system kind for target reported file names.

Shared library file names as reported by the target system may not make sense as is on the system GDB is running on. For example, when remote debugging a target that has MS-DOS based file system semantics, from a Unix host, the target may be reporting to GDB a list of loaded shared libraries with file names such as ‘c:\Windows\kernel32.dll’. On Unix hosts, there’s no concept of drive letters, so the ‘c:\’ prefix is not normally understood as indicating an absolute file name, and neither is the backslash normally considered a directory separator character. In that case, the native file system would interpret this whole absolute file name as a relative file name with no directory components. This would make it impossible to point GDB at a copy of the remote target’s shared libraries on the host using set sysroot, and impractical with set solib-search-path.
Setting `target-file-system-kind` to `dos-based` tells GDB to interpret such file names similarly to how the target would, and to map them to file names valid on GDB's native file system semantics. The value of `kind` can be "auto", in addition to one of the supported file system kinds. In that case, GDB tries to determine the appropriate file system variant based on the current target's operating system (see Section 22.6 [Configuring the Current ABI], page 301). The supported file system settings are:

- **unix**: Instruct GDB to assume the target file system is of Unix kind. Only file names starting the forward slash (`/`) character are considered absolute, and the directory separator character is also the forward slash.

- **dos-based**: Instruct GDB to assume the target file system is DOS based. File names starting with either a forward slash, or a drive letter followed by a colon (e.g., `c:`), are considered absolute, and both the slash (`/`) and the backslash (`\`) characters are considered directory separators.

- **auto**: Instruct GDB to use the file system kind associated with the target operating system (see Section 22.6 [Configuring the Current ABI], page 301). This is the default.

When processing file names provided by the user, GDB frequently needs to compare them to the file names recorded in the program's debug info. Normally, GDB compares just the base names of the files as strings, which is reasonably fast even for very large programs. (The base name of a file is the last portion of its name, after stripping all the leading directories.) This shortcut in comparison is based upon the assumption that files cannot have more than one base name. This is usually true, but references to files that use symlinks or similar filesystem facilities violate that assumption. If your program records files using such facilities, or if you provide file names to GDB using symlinks etc., you can set `basenames-may-differ` to `true` to instruct GDB to completely canonicalize each pair of file names it needs to compare. This will make file-name comparisons accurate, but at a price of a significant slowdown.

- **set basenames-may-differ**: Set whether a source file may have multiple base names.

- **show basenames-may-differ**: Show whether a source file may have multiple base names.

### 18.2 File Caching

To speed up file loading, and reduce memory usage, GDB will reuse the `bfd` objects used to track open files. See Section “BFD” in *The Binary File Descriptor Library*. The following commands allow visibility and control of the caching behavior.

- **maint info bfds**: This prints information about each `bfd` object that is known to GDB.
maint set bfd-sharing
maint show bfd-sharing
Control whether bfd objects can be shared. When sharing is enabled GDB reuses already open bfd objects rather than reopening the same file. Turning sharing off does not cause already shared bfd objects to be unshared, but all future files that are opened will create a new bfd object. Similarly, re-enabling sharing does not cause multiple existing bfd objects to be collapsed into a single shared bfd object.

set debug bfd-cache level
Turns on debugging of the bfd cache, setting the level to level.

show debug bfd-cache
Show the current debugging level of the bfd cache.

18.3 Debugging Information in Separate Files
GDB allows you to put a program’s debugging information in a file separate from the executable itself, in a way that allows GDB to find and load the debugging information automatically. Since debugging information can be very large—sometimes larger than the executable code itself—some systems distribute debugging information for their executables in separate files, which users can install only when they need to debug a problem.

GDB supports two ways of specifying the separate debug info file:

• The executable contains a debug link that specifies the name of the separate debug info file. The separate debug file’s name is usually ‘executable.debug’, where executable is the name of the corresponding executable file without leading directories (e.g., ‘ls.debug’ for ‘/usr/bin/ls’). In addition, the debug link specifies a 32-bit Cyclic Redundancy Check (CRC) checksum for the debug file, which GDB uses to validate that the executable and the debug file came from the same build.

• The executable contains a build ID, a unique bit string that is also present in the corresponding debug info file. (This is supported only on some operating systems, when using the ELF or PE file formats for binary files and the GNU Binutils.) For more details about this feature, see the description of the ‘--build-id’ command-line option in Section “Command Line Options” in The GNU Linker. The debug info file’s name is not specified explicitly by the build ID, but can be computed from the build ID, see below.

Depending on the way the debug info file is specified, GDB uses two different methods of looking for the debug file:

• For the “debug link” method, GDB looks up the named file in the directory of the executable file, then in a subdirectory of that directory named ‘.debug’, and finally under each one of the global debug directories, in a subdirectory whose name is identical to the leading directories of the executable’s absolute file name.

• For the “build ID” method, GDB looks in the ‘.build-id’ subdirectory of each one of the global debug directories for a file named ‘nn/nnnnnnnn.debug’, where nn are the first 2 hex characters of the build ID bit string, and nnnnnnnn are the rest of the bit string. (Real build ID strings are 32 or more hex characters, not 10.)
So, for example, suppose you ask GDB to debug ‘/usr/bin/ls’, which has a debug link that specifies the file ‘ls.debug’, and a build ID whose value in hex is abcdef1234. If the list of the global debug directories includes ‘/usr/lib/debug’, then GDB will look for the following debug information files, in the indicated order:

- ‘/usr/lib/debug/.build-id/ab/cdef1234.debug’
- ‘/usr/bin/ls.debug’
- ‘/usr/bin/.debug/ls.debug’
- ‘/usr/lib/debug/usr/bin/ls.debug’.

Global debugging info directories default to what is set by GDB configure option ‘--with-separate-debug-dir’. During GDB run you can also set the global debugging info directories, and view the list GDB is currently using.

`set debug-file-directory directories`  
Set the directories which GDB searches for separate debugging information files to `directory`. Multiple path components can be set concatenating them by a path separator.

`show debug-file-directory`  
Show the directories GDB searches for separate debugging information files.

A debug link is a special section of the executable file named `.gnu_debuglink`. The section must contain:

- A filename, with any leading directory components removed, followed by a zero byte,
- zero to three bytes of padding, as needed to reach the next four-byte boundary within the section, and
- a four-byte CRC checksum, stored in the same endianness used for the executable file itself. The checksum is computed on the debugging information file’s full contents by the function given below, passing zero as the `crc` argument.

Any executable file format can carry a debug link, as long as it can contain a section named `.gnu_debuglink` with the contents described above.

The build ID is a special section in the executable file (and in other ELF binary files that GDB may consider). This section is often named `.note.gnu.build-id`, but that name is not mandatory. It contains unique identification for the built files—the ID remains the same across multiple builds of the same build tree. The default algorithm SHA1 produces 160 bits (40 hexadecimal characters) of the content for the build ID string. The same section with an identical value is present in the original built binary with symbols, in its stripped variant, and in the separate debugging information file.

The debugging information file itself should be an ordinary executable, containing a full set of linker symbols, sections, and debugging information. The sections of the debugging information file should have the same names, addresses, and sizes as the original file, but they need not contain any data—much like a `.bss` section in an ordinary executable.

The GNU binary utilities (Binutils) package includes the ‘objcopy’ utility that can produce the separated executable / debugging information file pairs using the following commands:
objcopy --only-keep-debug foo foo.debug
strip -g foo

These commands remove the debugging information from the executable file ‘foo’ and place it in the file ‘foo.debug’. You can use the first, second or both methods to link the two files:

- The debug link method needs the following additional command to also leave behind a debug link in ‘foo’:
  
  objcopy --add-gnu-debuglink=foo.debug foo

  Ulrich Drepper’s ‘elfutils’ package, starting with version 0.53, contains a version of the strip command such that the command strip foo -f foo.debug has the same functionality as the two objcopy commands and the ln -s command above, together.

- Build ID gets embedded into the main executable using ld --build-id or the GCC counterpart gcc -Wl,--build-id. Build ID support plus compatibility fixes for debug files separation are present in GNU binary utilities (Binutils) package since version 2.18.

The CRC used in .gnu_debuglink is the CRC-32 defined in IEEE 802.3 using the polynomial:

\[
\begin{align*}
x^{32} + x^{26} + x^{23} + x^{22} + x^{16} + x^{12} + x^{11} \\
+ x^{10} + x^{8} + x^{7} + x^{5} + x^{4} + x^{2} + x + 1
\end{align*}
\]

The function is computed byte at a time, taking the least significant bit of each byte first. The initial pattern 0xffffffff is used, to ensure leading zeros affect the CRC and the final result is inverted to ensure trailing zeros also affect the CRC.

Note: This is the same CRC polynomial as used in handling the Remote Serial Protocol qCRC packet (see [qCRC packet], page 622). However in the case of the Remote Serial Protocol, the CRC is computed most significant bit first, and the result is not inverted, so trailing zeros have no effect on the CRC value.

To complete the description, we show below the code of the function which produces the CRC used in .gnu_debuglink. Inverting the initially supplied crc argument means that an initial call to this function passing in zero will start computing the CRC using 0xffffffff.

```c
unsigned long
gnu_debuglink_crc32 (unsigned long crc,
                        unsigned char *buf, size_t len)
{
    static const unsigned long crc32_table[256] =
    {
        0x00000000, 0x77073096, 0xee0e612c, 0x990951ba, 0x076dc419,
        0x706af48f, 0xe963a535, 0x9e6495a3, 0x0edb8832, 0x79dcb8a4,
        0xe0d5e91e, 0x97d2d988, 0x09b64c2b, 0x7eb17cbd, 0xe7b82d07,
        0x90bf1d91, 0x1db71064, 0x6ab020f2, 0xf3b97148, 0x84be41de,
        0x1adad47d, 0x6ddde4eb, 0xf4d4b551, 0x83d385c7, 0x136c9856,
        0x646ba8c0, 0xfdd2f97a, 0x8a65c9ec, 0x14015c4f, 0x63066cd9,
        0xfaf0f3d3, 0x8d080df5, 0x3b6e20c8, 0x4c69105e, 0xd6504e4,
        0xa267172, 0x3c03e4d1, 0x4b04d447, 0xd20d85f4, 0xa05ab56b,
        0x35b5a8fa, 0x42b2986c, 0xdabbca9d, 0xacbcf940, 0x32d86ec3,
        0x45dfc575, 0xdcd60dcf, 0xabd13d59, 0x26d930ac, 0x51de003a,
        0xc8d75180, 0xbfd06116, 0x21b4f4b5, 0x56b3c423, 0xc7ba9599,
        0xbb8daa50f, 0x2820b89e, 0x5f0558f8, 0xc60dc9b2, 0xb10e9294,
        0x2f6f7c87, 0x58684c11, 0xc1611db7, 0xb6b6ed3d, 0x76dc4190,
        0x01db7106, 0x98d220bc, 0xcedf510a, 0x71b18589, 0x06b6b51f,
        0x9fbf84a5, 0xe8b8d433, 0x7807c9a2, 0x0f00f934, 0x9609a88e,
    }
```
This computation does not apply to the “build ID” method.

18.4 Debugging information in a special section

Some systems ship pre-built executables and libraries that have a special `.gnu_debugdata` section. This feature is called MiniDebugInfo. This section holds an LZMA-compressed object and is used to supply extra symbols for backtraces.

The intent of this section is to provide extra minimal debugging information for use in simple backtraces. It is not intended to be a replacement for full separate debugging information (see Section 18.3 [Separate Debug Files], page 246). The example below shows
the intended use; however, GDB does not currently put restrictions on what sort of debugging
information might be included in the section.

GDB has support for this extension. If the section exists, then it is used provided that
no other source of debugging information can be found, and that GDB was configured with
LZMA support.

This section can be easily created using `objcopy` and other standard utilities:

```
# Extract the dynamic symbols from the main binary, there is no need
# to also have these in the normal symbol table.
mn -D binary --format=posix --defined-only 
  | awk '{ print $1 }' | sort > dynsymsf

# Extract all the text (i.e. function) symbols from the debuginfo.
# (Note that we actually also accept "D" symbols, for the benefit
# of platforms like PowerPC64 that use function descriptors.)
mn binary --format=posix --defined-only 
  | awk '{ if ($2 == "T" || $2 == "t" || $2 == "D") print $1 }' 
  | sort > funcsymfs

# Keep all the function symbols not already in the dynamic symbol
# table.
comm -13 dynsymsf funcsymfs > keep_symbols

# Separate full debug info into debug binary.
objcopy --only-keep-debug binary debug

# Copy the full debuginfo, keeping only a minimal set of symbols and
# removing some unnecessary sections.
objcopy -S --remove-section .gdb_index --remove-section .comment 
  --keep-symbols=keep_symbols debug mini_debuginfo

# Drop the full debug info from the original binary.
strip --strip-all -R .comment binary

# Inject the compressed data into the .gnu_debugdata section of the
# original binary.
xz mini_debuginfo
objcopy --add-section .gnu_debugdata=mini_debuginfo.xz binary
```

### 18.5 Index Files Speed Up GDB

When GDB finds a symbol file, it scans the symbols in the file in order to construct an
internal symbol table. This lets most GDB operations work quickly—at the cost of a delay
early on. For large programs, this delay can be quite lengthy, so GDB provides a way to
build an index, which speeds up startup.

The index is stored as a section in the symbol file. GDB can write the index to a file,
then you can put it into the symbol file using `objcopy`.

To create an index file, use the `save gdb-index` command:

```
save gdb-index directory
```

Create an index file for each symbol file currently known by GDB. Each file is
named after its corresponding symbol file, with `.gdb-index` appended, and is
written into the given `directory`. 
Once you have created an index file you can merge it into your symbol file, here named ‘symfile’, using objcopy:

```bash
$ objcopy --add-section .gdb_index=symfile.gdb-index \
   --set-section-flags .gdb_index=readonly symfile symfile
```

GDB will normally ignore older versions of ‘.gdb_index’ sections that have been deprecated. Usually they are deprecated because they are missing a new feature or have performance issues. To tell GDB to use a deprecated index section anyway specify `set use-deprecated-index-sections on`. The default is `off`. This can speed up startup, but may result in some functionality being lost. See Appendix J [Index Section Format], page 701.

**Warning:** Setting `use-deprecated-index-sections` to `on` must be done before gdb reads the file. The following will not work:

```bash
$ gdb -ex "set use-deprecated-index-sections on" <program>
```

Instead you must do, for example,

```bash
$ gdb -iex "set use-deprecated-index-sections on" <program>
```

There are currently some limitations on indices. They only work when for DWARF debugging information, not stabs. And, they do not currently work for programs using Ada.

### 18.6 Errors Reading Symbol Files

While reading a symbol file, GDB occasionally encounters problems, such as symbol types it does not recognize, or known bugs in compiler output. By default, GDB does not notify you of such problems, since they are relatively common and primarily of interest to people debugging compilers. If you are interested in seeing information about ill-constructed symbol tables, you can either ask GDB to print only one message about each such type of problem, no matter how many times the problem occurs; or you can ask GDB to print more messages, to see how many times the problems occur, with the `set complaints` command (see Section 22.8 [Optional Warnings and Messages], page 307).

The messages currently printed, and their meanings, include:

**inner block not inside outer block in symbol**

The symbol information shows where symbol scopes begin and end (such as at the start of a function or a block of statements). This error indicates that an inner scope block is not fully contained in its outer scope blocks.

GDB circumvents the problem by treating the inner block as if it had the same scope as the outer block. In the error message, `symbol` may be shown as “(don’t know)” if the outer block is not a function.

**block at address out of order**

The symbol information for symbol scope blocks should occur in order of increasing addresses. This error indicates that it does not do so.

GDB does not circumvent this problem, and has trouble locating symbols in the source file whose symbols it is reading. (You can often determine what source file is affected by specifying `set verbose on`. See Section 22.8 [Optional Warnings and Messages], page 307.)
bad block start address patched
The symbol information for a symbol scope block has a start address smaller than the address of the preceding source line. This is known to occur in the SunOS 4.1.1 (and earlier) C compiler.
GDB circumvents the problem by treating the symbol scope block as starting on the previous source line.

bad string table offset in symbol n
Symbol number n contains a pointer into the string table which is larger than the size of the string table.
GDB circumvents the problem by considering the symbol to have the name foo, which may cause other problems if many symbols end up with this name.

unknown symbol type 0xnn
The symbol information contains new data types that GDB does not yet know how to read. 0xnn is the symbol type of the uncomprehended information, in hexadecimal.
GDB circumvents the error by ignoring this symbol information. This usually allows you to debug your program, though certain symbols are not accessible. If you encounter such a problem and feel like debugging it, you can debug gdb with itself, breakpoint on complain, then go up to the function read_dbx_symtab and examine *bufp to see the symbol.

stub type has NULL name
GDB could not find the full definition for a struct or class.

const/volatile indicator missing (ok if using g++ v1.x), got...
The symbol information for a C++ member function is missing some information that recent versions of the compiler should have output for it.

info mismatch between compiler and debugger
GDB could not parse a type specification output by the compiler.

18.7 GDB Data Files
GDB will sometimes read an auxiliary data file. These files are kept in a directory known as the data directory.
You can set the data directory’s name, and view the name GDB is currently using.

set data-directory directory
Set the directory which GDB searches for auxiliary data files to directory.

show data-directory
Show the directory GDB searches for auxiliary data files.

You can set the default data directory by using the configure-time ‘--with-gdb-datadir’ option. If the data directory is inside GDB’s configured binary prefix (set with ‘--prefix’ or ‘--exec-prefix’), then the default data directory will be updated automatically if the installed GDB is moved to a new location.
The data directory may also be specified with the --data-directory command line option. See Section 2.1.2 [Mode Options], page 13.
19 Specifying a Debugging Target

A target is the execution environment occupied by your program.

Often, GDB runs in the same host environment as your program; in that case, the debugging target is specified as a side effect when you use the `file` or `core` commands. When you need more flexibility—for example, running GDB on a physically separate host, or controlling a standalone system over a serial port or a realtime system over a TCP/IP connection—you can use the `target` command to specify one of the target types configured for GDB (see Section 19.2 [Commands for Managing Targets], page 253).

It is possible to build GDB for several different target architectures. When GDB is built like that, you can choose one of the available architectures with the `set architecture` command.

```
set architecture arch
```

This command sets the current target architecture to `arch`. The value of `arch` can be "auto", in addition to one of the supported architectures.

```
show architecture
```

Show the current target architecture.

```
set processor processor
```

These are alias commands for, respectively, `set architecture` and `show architecture`.

19.1 Active Targets

There are multiple classes of targets such as: processes, executable files or recording sessions. Core files belong to the process class, making core file and process mutually exclusive. Otherwise, GDB can work concurrently on multiple active targets, one in each class. This allows you to (for example) start a process and inspect its activity, while still having access to the executable file after the process finishes. Or if you start process recording (see Chapter 6 [Reverse Execution], page 83) and `reverse-step` there, you are presented a virtual layer of the recording target, while the process target remains stopped at the chronologically last point of the process execution.

Use the `core-file` and `exec-file` commands to select a new core file or executable target (see Section 18.1 [Commands to Specify Files], page 237). To specify as a target a process that is already running, use the `attach` command (see Section 4.7 [Debugging an Already-running Process], page 32).

19.2 Commands for Managing Targets

```
target type parameters
```

Connects the GDB host environment to a target machine or process. A target is typically a protocol for talking to debugging facilities. You use the argument `type` to specify the type or protocol of the target machine.

Further `parameters` are interpreted by the target protocol, but typically include things like device names or host names to connect with, process numbers, and baud rates.
The **target** command does not repeat if you press **RET** again after executing the command.

**help target**

Displays the names of all targets available. To display targets currently selected, use either **info target** or **info files** (see Section 18.1 [Commands to Specify Files], page 237).

**help target name**

Describe a particular target, including any parameters necessary to select it.

**set gnutarget args**

GDB uses its own library BFD to read your files. GDB knows whether it is reading an executable, a core, or a .o file; however, you can specify the file format with the **set gnutarget** command. Unlike most **target** commands, with **gnutarget** the **target** refers to a program, not a machine.

*Warning:* To specify a file format with **set gnutarget**, you must know the actual BFD name.

See Section 18.1 [Commands to Specify Files], page 237.

**show gnutarget**

Use the **show gnutarget** command to display what file format **gnutarget** is set to read. If you have not set **gnutarget**, GDB will determine the file format for each file automatically, and **show gnutarget** displays ‘**The current BFD target is “auto”**’.

Here are some common targets (available, or not, depending on the GDB configuration):

**target exec program**

An executable file. ‘**target exec program**’ is the same as ‘**exec-file program**’.

**target core filename**

A core dump file. ‘**target core filename**’ is the same as ‘**core-file filename**’.

**target remote medium**

A remote system connected to GDB via a serial line or network connection. This command tells GDB to use its own remote protocol over **medium** for debugging. See Chapter 20 [Remote Debugging], page 257.

For example, if you have a board connected to ‘**/dev/ttya**’ on the machine running GDB, you could say:

```bash
target remote /dev/ttya
```

**target remote** supports the **load** command. This is only useful if you have some other way of getting the stub to the target system, and you can put it somewhere in memory where it won’t get clobbered by the download.

**target sim [simargs] ...**

Builtin CPU simulator. GDB includes simulators for most architectures. In general,

```bash
target sim
load
```
run
works; however, you cannot assume that a specific memory map, device drivers, or even basic I/O is available, although some simulators do provide these. For info about any processor-specific simulator details, see the appropriate section in Section 21.3 [Embedded Processors], page 285.

target native
Setup for local/native process debugging. Useful to make the run command spawn native processes (likewise attach, etc.) even when set auto-connect-native-target is off (see [set auto-connect-native-target], page 28).

Different targets are available on different configurations of GDB; your configuration may have more or fewer targets.

Many remote targets require you to download the executable’s code once you’ve successfully established a connection. You may wish to control various aspects of this process.

set hash
This command controls whether a hash mark ‘#’ is displayed while downloading a file to the remote monitor. If on, a hash mark is displayed after each S-record is successfully downloaded to the monitor.

show hash
Show the current status of displaying the hash mark.

set debug monitor
Enable or disable display of communications messages between GDB and the remote monitor.

show debug monitor
Show the current status of displaying communications between GDB and the remote monitor.

load filename
Depending on what remote debugging facilities are configured into GDB, the load command may be available. Where it exists, it is meant to make filename (an executable) available for debugging on the remote system—by downloading, or dynamic linking, for example. load also records the filename symbol table in GDB, like the add-symbol-file command.

If your GDB does not have a load command, attempting to execute it gets the error message “You can’t do that when your target is ...”

The file is loaded at whatever address is specified in the executable. For some object file formats, you can specify the load address when you link the program; for other formats, like a.out, the object file format specifies a fixed address.

Depending on the remote side capabilities, GDB may be able to load programs into flash memory.
load does not repeat if you press RET again after using it.

19.3 Choosing Target Byte Order

Some types of processors, such as the MIPS, PowerPC, and Renesas SH, offer the ability to run either big-endian or little-endian byte orders. Usually the executable or symbol will include a bit to designate the endian-ness, and you will not need to worry about which to
use. However, you may still find it useful to adjust GDB’s idea of processor endian-ness manually.

- **set endian big**
  
  Instruct GDB to assume the target is big-endian.

- **set endian little**
  
  Instruct GDB to assume the target is little-endian.

- **set endian auto**
  
  Instruct GDB to use the byte order associated with the executable.

- **show endian**
  
  Display GDB’s current idea of the target byte order.

Note that these commands merely adjust interpretation of symbolic data on the host, and that they have absolutely no effect on the target system.
20 Debugging Remote Programs

If you are trying to debug a program running on a machine that cannot run GDB in the usual way, it is often useful to use remote debugging. For example, you might use remote debugging on an operating system kernel, or on a small system which does not have a general purpose operating system powerful enough to run a full-featured debugger.

Some configurations of GDB have special serial or TCP/IP interfaces to make this work with particular debugging targets. In addition, GDB comes with a generic serial protocol (specific to GDB, but not specific to any particular target system) which you can use if you write the remote stubs—the code that runs on the remote system to communicate with GDB.

Other remote targets may be available in your configuration of GDB; use `help target` to list them.

20.1 Connecting to a Remote Target

GDB needs an unstripped copy of your program to access symbol and debugging information. Some remote targets (see `qXfer executable filename read`, page 638, and see Section E.7 [Host I/O Packets], page 651) allow GDB to access program files over the same connection used to communicate with GDB. With such a target, if the remote program is unstripped, the only command you need is `target remote`. Otherwise, start up GDB using the name of the local unstripped copy of your program as the first argument, or use the `file` command.

GDB can communicate with the target over a serial line, or over an IP network using TCP or UDP. In each case, GDB uses the same protocol for debugging your program; only the medium carrying the debugging packets varies. The `target remote` command establishes a connection to the target. Its arguments indicate which medium to use:

```
target remote serial-device
```

Use `serial-device` to communicate with the target. For example, to use a serial line connected to the device named `/dev/ttyb`:

```
target remote /dev/ttyb
```

If you’re using a serial line, you may want to give GDB the ‘--baud’ option, or use the `set serial baud` command (see Section 20.4 [Remote Configuration], page 264) before the `target` command.

```
target remote host:port
target remote tcp:host:port
```

Debug using a TCP connection to `port` on `host`. The `host` may be either a host name or a numeric IP address; `port` must be a decimal number. The `host` could be the target machine itself, if it is directly connected to the net, or it might be a terminal server which in turn has a serial line to the target.

For example, to connect to port 2828 on a terminal server named `manyfarms`:

```
target remote manyfarms:2828
```

If your remote target is actually running on the same machine as your debugger session (e.g. a simulator for your target running on the same host), you can omit the hostname. For example, to connect to port 1234 on your local machine:
target remote :1234

Note that the colon is still required here.

target remote udp:host:port
Debug using UDP packets to port on host. For example, to connect to UDP port 2828 on a terminal server named manyfarms:
target remote udp:manyfarms:2828

When using a UDP connection for remote debugging, you should keep in mind that the ‘U’ stands for “Unreliable”. UDP can silently drop packets on busy or unreliable networks, which will cause havoc with your debugging session.

target remote | command
Run command in the background and communicate with it using a pipe. The command is a shell command, to be parsed and expanded by the system’s command shell, /bin/sh; it should expect remote protocol packets on its standard input, and send replies on its standard output. You could use this to run a stand-alone simulator that speaks the remote debugging protocol, to make net connections using programs like ssh, or for other similar tricks.

If command closes its standard output (perhaps by exiting), GDB will try to send it a SIGTERM signal. (If the program has already exited, this will have no effect.)

Once the connection has been established, you can use all the usual commands to examine and change data. The remote program is already running; you can use step and continue, and you do not need to use run.

Whenever GDB is waiting for the remote program, if you type the interrupt character (often Ctrl-c), GDB attempts to stop the program. This may or may not succeed, depending in part on the hardware and the serial drivers the remote system uses. If you type the interrupt character once again, GDB displays this prompt:

Interrupted while waiting for the program.
Give up (and stop debugging it)? (y or n)

If you type y, GDB abandons the remote debugging session. (If you decide you want to try again later, you can use ‘target remote’ again to connect once more.) If you type n, GDB goes back to waiting.

detach
When you have finished debugging the remote program, you can use the detach command to release it from GDB control. Detaching from the target normally resumes its execution, but the results will depend on your particular remote stub. After the detach command, GDB is free to connect to another target.

disconnect
The disconnect command behaves like detach, except that the target is generally not resumed. It will wait for GDB (this instance or another one) to connect and continue debugging. After the disconnect command, GDB is again free to connect to another target.

monitor cmd
This command allows you to send arbitrary commands directly to the remote monitor. Since GDB doesn’t care about the commands it sends like this, this
Chapter 20: Debugging Remote Programs

command is the way to extend GDB—you can add new commands that only the external monitor will understand and implement.

20.2 Sending files to a remote system

Some remote targets offer the ability to transfer files over the same connection used to communicate with GDB. This is convenient for targets accessible through other means, e.g. GNU/Linux systems running gdbserver over a network interface. For other targets, e.g. embedded devices with only a single serial port, this may be the only way to upload or download files.

Not all remote targets support these commands.

remote put hostfile targetfile
Copy file hostfile from the host system (the machine running GDB) to targetfile on the target system.

remote get targetfile hostfile
Copy file targetfile from the target system to hostfile on the host system.

remote delete targetfile
Delete targetfile from the target system.

20.3 Using the gdbserver Program

gdbserver is a control program for Unix-like systems, which allows you to connect your program with a remote GDB via target remote—but without linking in the usual debugging stub.

gdbserver is not a complete replacement for the debugging stubs, because it requires essentially the same operating-system facilities that GDB itself does. In fact, a system that can run gdbserver to connect to a remote GDB could also run GDB locally! gdbserver is sometimes useful nevertheless, because it is a much smaller program than GDB itself. It is also easier to port than all of GDB, so you may be able to get started more quickly on a new system by using gdbserver. Finally, if you develop code for real-time systems, you may find that the tradeoffs involved in real-time operation make it more convenient to do as much development work as possible on another system, for example by cross-compiling. You can use gdbserver to make a similar choice for debugging.

GDB and gdbserver communicate via either a serial line or a TCP connection, using the standard GDB remote serial protocol.

Warning: gdbserver does not have any built-in security. Do not run gdbserver connected to any public network; a GDB connection to gdbserver provides access to the target system with the same privileges as the user running gdbserver.

20.3.1 Running gdbserver

Run gdbserver on the target system. You need a copy of the program you want to debug, including any libraries it requires. gdbserver does not need your program’s symbol table, so you can strip the program if necessary to save space. GDB on the host system does all the symbol handling.
To use the server, you must tell it how to communicate with GDB; the name of your program; and the arguments for your program. The usual syntax is:

```
target> gdbserver comm program [ args ... ]
```

`comm` is either a device name (to use a serial line), or a TCP hostname and portnumber, or `-` or `stdio` to use stdin/stdout of `gdbserver`. For example, to debug Emacs with the argument `foo.txt` and communicate with GDB over the serial port `/dev/com1`:

```
target> gdbserver /dev/com1 emacs foo.txt
```

`gdbserver` waits passively for the host GDB to communicate with it.

To use a TCP connection instead of a serial line:

```
target> gdbserver host:2345 emacs foo.txt
```

The only difference from the previous example is the first argument, specifying that you are communicating with the host GDB via TCP. The `host:2345` argument means that `gdbserver` is to expect a TCP connection from machine `host` to local TCP port 2345. (Currently, the `host` part is ignored.) You can choose any number you want for the port number as long as it does not conflict with any TCP ports already in use on the target system (for example, 23 is reserved for telnet). You must use the same port number with the host GDB `target remote` command.

The `stdio` connection is useful when starting `gdbserver` with ssh:

```
(gdb) target remote | ssh -T hostname gdbserver - hello
```

The `-T` option to ssh is provided because we don’t need a remote pty, and we don’t want escape-character handling. Ssh does this by default when a command is provided, the flag is provided to make it explicit. You could elide it if you want to.

Programs started with stdio-connected `gdbserver` have `'/dev/null'` for `stdin`, and `stdout,stderr` are sent back to gdb for display through a pipe connected to `gdbserver`. Both `stdout` and `stderr` use the same pipe.

### 20.3.1.1 Attaching to a Running Program

On some targets, `gdbserver` can also attach to running programs. This is accomplished via the `--attach` argument. The syntax is:

```
target> gdbserver --attach comm pid
```

`pid` is the process ID of a currently running process. It isn’t necessary to point `gdbserver` at a binary for the running process.

You can debug processes by name instead of process ID if your target has the `pidof` utility:

```
target> gdbserver --attach comm ‘pidof program’
```

In case more than one copy of `program` is running, or `program` has multiple threads, most versions of `pidof` support the `-s` option to only return the first process ID.

---

1 If you choose a port number that conflicts with another service, `gdbserver` prints an error message and exits.
20.3.1.2 Multi-Process Mode for gdbserver

When you connect to gdbserver using target remote, gdbserver debugs the specified program only once. When the program exits, or you detach from it, GDB closes the connection and gdbserver exits.

If you connect using target extended-remote, gdbserver enters multi-process mode. When the debugged program exits, or you detach from it, GDB stays connected to gdbserver even though no program is running. The run and attach commands instruct gdbserver to run or attach to a new program. The run command uses set remote exec-file (see [set remote exec-file], page 266) to select the program to run. Command line arguments are supported, except for wildcard expansion and I/O redirection (see Section 4.3 [Arguments], page 30).

To start gdbserver without supplying an initial command to run or process ID to attach, use the '--multi' command line option. Then you can connect using target extended-remote and start the program you want to debug.

In multi-process mode gdbserver does not automatically exit unless you use the option '--once'. You can terminate it by using monitor exit (see [Monitor Commands for gdbserver], page 262). Note that the conditions under which gdbserver terminates depend on how GDB connects to it (target remote or target extended-remote). The '--multi' option to gdbserver has no influence on that.

20.3.1.3 TCP port allocation lifecycle of gdbserver

This section applies only when gdbserver is run to listen on a TCP port.

gdbserver normally terminates after all of its debugged processes have terminated in target remote mode. On the other hand, for target extended-remote, gdbserver stays running even with no processes left. GDB normally terminates the spawned debugged process on its exit, which normally also terminates gdbserver in the target remote mode. Therefore, when the connection drops unexpectedly, and GDB cannot ask gdbserver to kill its debugged processes, gdbserver stays running even in the target remote mode.

When gdbserver stays running, GDB can connect to it again later. Such reconnecting is useful for features like [disconnected tracing], page 172. For completeness, at most one GDB can be connected at a time.

By default, gdbserver keeps the listening TCP port open, so that subsequent connections are possible. However, if you start gdbserver with the '--once' option, it will stop listening for any further connection attempts after connecting to the first GDB session. This means no further connections to gdbserver will be possible after the first one. It also means gdbserver will terminate after the first connection with remote GDB has closed, even for unexpectedly closed connections and even in the target extended-remote mode. The '--once' option allows reusing the same port number for connecting to multiple instances of gdbserver running on the same host, since each instance closes its port after the first connection.

20.3.1.4 Other Command-Line Arguments for gdbserver

The '--debug' option tells gdbserver to display extra status information about the debugging process. The '--remote-debug' option tells gdbserver to display remote protocol
debug output. These options are intended for gdbserver development and for bug reports to the developers.

The ‘--debug-format=option1[,option2,...]’ option tells gdbserver to include additional information in each output. Possible options are:

- **none**  
  Turn off all extra information in debugging output.

- **all**  
  Turn on all extra information in debugging output.

- **timestamps**  
  Include a timestamp in each line of debugging output.

Options are processed in order. Thus, for example, if ‘none’ appears last then no additional information is added to debugging output.

The ‘--wrapper’ option specifies a wrapper to launch programs for debugging. The option should be followed by the name of the wrapper, then any command-line arguments to pass to the wrapper, then -- indicating the end of the wrapper arguments.

gdbserver runs the specified wrapper program with a combined command line including the wrapper arguments, then the name of the program to debug, then any arguments to the program. The wrapper runs until it executes your program, and then GDB gains control.

You can use any program that eventually calls execve with its arguments as a wrapper. Several standard Unix utilities do this, e.g. env and nohup. Any Unix shell script ending with exec "$@" will also work.

For example, you can use env to pass an environment variable to the debugged program, without setting the variable in gdbserver’s environment:

```
$ gdbserver --wrapper env LD_PRELOAD=libtest.so -- :2222 ./testprog
```

### 20.3.2 Connecting to gdbserver

Run GDB on the host system.

First make sure you have the necessary symbol files. Load symbols for your application using the file command before you connect. Use set sysroot to locate target libraries (unless your GDB was compiled with the correct sysroot using --with-sysroot).

The symbol file and target libraries must exactly match the executable and libraries on the target, with one exception: the files on the host system should not be stripped, even if the files on the target system are. Mismatched or missing files will lead to confusing results during debugging. On GNU/Linux targets, mismatched or missing files may also prevent gdbserver from debugging multi-threaded programs.

Connect to your target (see Section 20.1 [Connecting to a Remote Target], page 257). For TCP connections, you must start up gdbserver prior to using the target remote command. Otherwise you may get an error whose text depends on the host system, but which usually looks something like ‘Connection refused’. Don’t use the load command in GDB when using gdbserver, since the program is already on the target.

### 20.3.3 Monitor Commands for gdbserver

During a GDB session using gdbserver, you can use the monitor command to send special requests to gdbserver. Here are the available commands.
**20.3.4 Tracepoints support in gdbserver**

On some targets, `gdbserver` supports tracepoints, fast tracepoints and static tracepoints.

For fast or static tracepoints to work, a special library called the *in-process agent* (IPA), must be loaded in the inferior process. This library is built and distributed as an integral part of `gdbserver`. In addition, support for static tracepoints requires building the in-process agent library with static tracepoints support. At present, the UST (LTtng Userspace Tracer, [http://lttng.org/ust](http://lttng.org/ust)) tracing engine is supported. This support is automatically available if UST development headers are found in the standard include path when `gdbserver` is built, or if `gdbserver` was explicitly configured using `--with-ust` to point at such headers. You can explicitly disable the support using `--with-ust=no`.

There are several ways to load the in-process agent in your program:
Specifying it as dependency at link time
You can link your program dynamically with the in-process agent library. On most systems, this is accomplished by adding `-linproctrace` to the link command.

Using the system’s preloading mechanisms
You can force loading the in-process agent at startup time by using your system’s support for preloading shared libraries. Many Unixes support the concept of preloading user defined libraries. In most cases, you do that by specifying `LD_PRELOAD=libinproctrace.so` in the environment. See also the description of `gdbserver`’s ‘--wrapper’ command line option.

Using `gdb` to force loading the agent at run time
On some systems, you can force the inferior to load a shared library, by calling a dynamic loader function in the inferior that takes care of dynamically looking up and loading a shared library. On most Unix systems, the function is `dlopen`. You’ll use the `call` command for that. For example:

```
(gdb) call dlopen ("libinproctrace.so", ...) 
```

Note that on most Unix systems, for the `dlopen` function to be available, the program needs to be linked with `-ldl`.

On systems that have a userspace dynamic loader, like most Unix systems, when you connect to `gdbserver` using `target remote`, you’ll find that the program is stopped at the dynamic loader’s entry point, and no shared library has been loaded in the program’s address space yet, including the in-process agent. In that case, before being able to use any of the fast or static tracepoints features, you need to let the loader run and load the shared libraries. The simplest way to do that is to run the program to the main procedure. E.g., if debugging a C or C++ program, start `gdbserver` like so:

```
$ gdbserver :9999 myprogram
```

Start GDB and connect to `gdbserver` like so, and run to main:

```
$ gdb myprogram
(gdb) target remote myhost:9999
0x00007f215893ba60 in ?? () from /lib64/ld-linux-x86-64.so.2
(gdb) b main
(gdb) continue
```

The in-process tracing agent library should now be loaded into the process; you can confirm it with the `info sharedlibrary` command, which will list ‘libinproctrace.so’ as loaded in the process. You are now ready to install fast tracepoints, list static tracepoint markers, probe static tracepoints markers, and start tracing.

20.4 Remote Configuration
This section documents the configuration options available when debugging remote programs. For the options related to the File I/O extensions of the remote protocol, see [system], page 665.

`set remoteaddresssize bits`
Set the maximum size of address in a memory packet to the specified number of bits. GDB will mask off the address bits above that number, when it passes
addresses to the remote target. The default value is the number of bits in the target’s address.

show remoteaddresssize
Show the current value of remote address size in bits.

set serial baud n
Set the baud rate for the remote serial I/O to n baud. The value is used to set the speed of the serial port used for debugging remote targets.

show serial baud
Show the current speed of the remote connection.

set serial parity parity
Set the parity for the remote serial I/O. Supported values of parity are: even, none, and odd. The default is none.

show serial parity
Show the current parity of the serial port.

set remotebreak
If set to on, GDB sends a BREAK signal to the remote when you type Ctrl-c to interrupt the program running on the remote. If set to off, GDB sends the ‘Ctrl-C’ character instead. The default is off, since most remote systems expect to see ‘Ctrl-C’ as the interrupt signal.

show remotebreak
Show whether GDB sends BREAK or ‘Ctrl-C’ to interrupt the remote program.

set remoteflow on
set remoteflow off
Enable or disable hardware flow control (RTS/CTS) on the serial port used to communicate to the remote target.

show remoteflow
Show the current setting of hardware flow control.

set remotelogbase base
Set the base (a.k.a. radix) of logging serial protocol communications to base. Supported values of base are: ascii, octal, and hex. The default is ascii.

show remotelogbase
Show the current setting of the radix for logging remote serial protocol.

set remotelogfile file
Record remote serial communications on the named file. The default is not to record at all.

show remotelogfile.
Show the current setting of the file name on which to record the serial communications.

set remotetimeout num
Set the timeout limit to wait for the remote target to respond to num seconds. The default is 2 seconds.
show remotetimeout
   Show the current number of seconds to wait for the remote target responses.

set remote hardware-watchpoint-limit limit
set remote hardware-breakpoint-limit limit
   Restrict GDB to using limit remote hardware breakpoint or watchpoints. A
   limit of -1, the default, is treated as unlimited.

set remote hardware-watchpoint-length-limit limit
   Restrict GDB to using limit bytes for the maximum length of a remote hardware
   watchpoint. A limit of -1, the default, is treated as unlimited.

show remote hardware-watchpoint-length-limit
   Show the current limit (in bytes) of the maximum length of a remote hardware
   watchpoint.

set remote exec-file filename
show remote exec-file
   Select the file used for run with target extended-remote. This should be set
to a filename valid on the target system. If it is not set, the target will use a
default filename (e.g. the last program run).

set remote interrupt-sequence
   Allow the user to select one of ‘Ctrl-C’, a BREAK or ‘BREAK-g’ as the sequence
to the remote target in order to interrupt the execution. ‘Ctrl-C’ is a default.
   Some system prefers BREAK which is high level of serial line for some certain
time. Linux kernel prefers ‘BREAK-g’, a.k.a Magic SysRq g. It is BREAK signal
followed by character g.

show interrupt-sequence
   Show which of ‘Ctrl-C’, BREAK or BREAK-g is sent by GDB to interrupt the
remote program. BREAK-g is BREAK signal followed by g and also known as
Magic SysRq g.

set remote interrupt-on-connect
   Specify whether interrupt-sequence is sent to remote target when GDB connects
to it. This is mostly needed when you debug Linux kernel. Linux kernel expects
BREAK followed by g which is known as Magic SysRq g in order to connect GDB.

show interrupt-on-connect
   Show whether interrupt-sequence is sent to remote target when GDB connects
to it.

set tcp auto-retry on
   Enable auto-retry for remote TCP connections. This is useful if the remote
debugging agent is launched in parallel with GDB; there is a race condition
because the agent may not become ready to accept the connection before GDB
attempts to connect. When auto-retry is enabled, if the initial attempt to
connect fails, GDB reattempts to establish the connection using the timeout
specified by set tcp connect-timeout.

set tcp auto-retry off
   Do not auto-retry failed TCP connections.
show tcp auto-retry
   Show the current auto-retry setting.

set tcp connect-timeout seconds
set tcp connect-timeout unlimited
   Set the timeout for establishing a TCP connection to the remote target to seconds. The timeout affects both polling to retry failed connections (enabled by set tcp auto-retry on) and waiting for connections that are merely slow to complete, and represents an approximate cumulative value. If seconds is unlimited, there is no timeout and GDB will keep attempting to establish a connection forever, unless interrupted with Ctrl-c. The default is 15 seconds.

show tcp connect-timeout
   Show the current connection timeout setting.

The GDB remote protocol autodetects the packets supported by your debugging stub. If you need to override the autodetection, you can use these commands to enable or disable individual packets. Each packet can be set to ‘on’ (the remote target supports this packet), ‘off’ (the remote target does not support this packet), or ‘auto’ (detect remote target support for this packet). They all default to ‘auto’. For more information about each packet, see Appendix E [Remote Protocol], page 607.

During normal use, you should not have to use any of these commands. If you do, that may be a bug in your remote debugging stub, or a bug in GDB. You may want to report the problem to the GDB developers.

For each packet name, the command to enable or disable the packet is set remote name-packet. The available settings are:

<table>
<thead>
<tr>
<th>Command Name</th>
<th>Remote Packet</th>
<th>Related Features</th>
</tr>
</thead>
<tbody>
<tr>
<td>fetch-register</td>
<td>p</td>
<td>info registers</td>
</tr>
<tr>
<td>set-register</td>
<td>P</td>
<td>set</td>
</tr>
<tr>
<td>binary-download</td>
<td>X</td>
<td>load, set</td>
</tr>
<tr>
<td>read-aux-vector</td>
<td>qXfer:auxv:read</td>
<td>info auxv</td>
</tr>
<tr>
<td>symbol-lookup</td>
<td>qSymbol</td>
<td>Detecting multiple threads</td>
</tr>
<tr>
<td>attach</td>
<td>vAttach</td>
<td>attach</td>
</tr>
<tr>
<td>verbose-resume</td>
<td>vCont</td>
<td>Stepping or resuming multiple threads</td>
</tr>
<tr>
<td>run</td>
<td>vRun</td>
<td>run</td>
</tr>
<tr>
<td>software-breakpoint</td>
<td>Z0</td>
<td>break</td>
</tr>
</tbody>
</table>
hardware-breakpoint  Z1  hbreak
write-watchpoint  Z2  watch
read-watchpoint  Z3  rwatch
access-watchpoint  Z4  awatch
pid-to-exec-file  qXfer:exec-file:read  attach, run
target-features  qXfer:features:read  set architecture
library-info  qXfer:libraries:read  info
memory-map  qXfer:memory-map:read  info mem
read-sdata-object  qXfer:sdata:read  print $_sdata
read-spu-object  qXfer:spu:read  info spu
write-spu-object  qXfer:spu:write  info spu
read-siginfo-object  qXfer:siginfo:read  print $_siginfo
write-siginfo-object  qXfer:siginfo:write  set $_siginfo
threads  qXfer:threads:read  info threads
get-thread-local-storage-address  qGetTLSAddr  Displaying __thread variables
get-thread-information-block-address  qGetTIBAddr  Display MS- Windows Thread Information Block.
search-memory  qSearch:memory  find
supported-packets  qSupported  Remote communications parameters
pass-signals  QPassSignals  handle signal
program-signals  QProgramSignals  handle signal
hostio-close-packet  vFile:close  remote get, remote put
hostio-open-packet  vFile:open  remote get, remote put
hostio-pread-packet  vFile:pread  remote get, remote put
hostio-pwrite-packet  vFile:pwrite  remote get, remote put
hostio-unlink-packet  vFile:unlink  remote delete
hostio-readlink-packet  vFile:readlink  Host I/O
hostio-fstat-packet  vFile:fstat  Host I/O
ttrace-frame-size  QTBuffer:size  set trace-buffer-size
trace-status  qTStatus  tstatus
trace-frame-info  qXfer:traceframe-info:read  Traceframe info
install-in-trace  InstallInTrace  Install tracepoint in tracing
disable-randomization  QDisableRandomization  set disable-randomization
20.5 Implementing a Remote Stub

The stub files provided with GDB implement the target side of the communication protocol, and the GDB side is implemented in the GDB source file `remote.c`. Normally, you can simply allow these subroutines to communicate, and ignore the details. (If you’re implementing your own stub file, you can still ignore the details: start with one of the existing stub files. `sparc-stub.c` is the best organized, and therefore the easiest to read.)

To debug a program running on another machine (the debugging target machine), you must first arrange for all the usual prerequisites for the program to run by itself. For example, for a C program, you need:

1. A startup routine to set up the C runtime environment; these usually have a name like `crt0`. The startup routine may be supplied by your hardware supplier, or you may have to write your own.

2. A C subroutine library to support your program’s subroutine calls, notably managing input and output.

3. A way of getting your program to the other machine—for example, a download program. These are often supplied by the hardware manufacturer, but you may have to write your own from hardware documentation.

The next step is to arrange for your program to use a serial port to communicate with the machine where GDB is running (the host machine). In general terms, the scheme looks like this:
On the host,
GDB already understands how to use this protocol; when everything else is set up, you can simply use the `target remote` command (see Chapter 19 [Specifying a Debugging Target], page 253).

On the target,
you must link with your program a few special-purpose subroutines that implement the GDB remote serial protocol. The file containing these subroutines is called a debugging stub.

On certain remote targets, you can use an auxiliary program `gdbserver` instead of linking a stub into your program. See Section 20.3 [Using the gdbserver Program], page 259, for details.

The debugging stub is specific to the architecture of the remote machine; for example, use `sparc-stub.c` to debug programs on SPARC boards.

These working remote stubs are distributed with GDB:

- `i386-stub.c`  
  For Intel 386 and compatible architectures.

- `m68k-stub.c`  
  For Motorola 680x0 architectures.

- `sh-stub.c`  
  For Renesas SH architectures.

- `sparc-stub.c`  
  For SPARC architectures.

- `sparcl-stub.c`  
  For Fujitsu SPARCLITE architectures.

The `README` file in the GDB distribution may list other recently added stubs.

### 20.5.1 What the Stub Can Do for You

The debugging stub for your architecture supplies these three subroutines:

- `set_debug_traps`
  This routine arranges for `handle_exception` to run when your program stops. You must call this subroutine explicitly in your program’s startup code.

- `handle_exception`
  This is the central workhorse, but your program never calls it explicitly—the setup code arranges for `handle_exception` to run when a trap is triggered. `handle_exception` takes control when your program stops during execution (for example, on a breakpoint), and mediates communications with GDB on the host machine. This is where the communications protocol is implemented; `handle_exception` acts as the GDB representative on the target machine. It begins by sending summary information on the state of your program, then continues to execute, retrieving and transmitting any information GDB needs, until you execute a GDB command that makes your program resume; at that point, `handle_exception` returns control to your own code on the target machine.
breakpoint
Use this auxiliary subroutine to make your program contain a breakpoint. Depending on the particular situation, this may be the only way for GDB to get control. For instance, if your target machine has some sort of interrupt button, you won’t need to call this; pressing the interrupt button transfers control to handle_exception—in effect, to GDB. On some machines, simply receiving characters on the serial port may also trigger a trap; again, in that situation, you don’t need to call breakpoint from your own program—simply running ‘target remote’ from the host GDB session gets control.
Call breakpoint if none of these is true, or if you simply want to make certain your program stops at a predetermined point for the start of your debugging session.

20.5.2 What You Must Do for the Stub
The debugging stubs that come with GDB are set up for a particular chip architecture, but they have no information about the rest of your debugging target machine.

First of all you need to tell the stub how to communicate with the serial port.

int getDebugChar()
Write this subroutine to read a single character from the serial port. It may be identical to getchar for your target system; a different name is used to allow you to distinguish the two if you wish.

void putDebugChar(int)
Write this subroutine to write a single character to the serial port. It may be identical to putchar for your target system; a different name is used to allow you to distinguish the two if you wish.

If you want GDB to be able to stop your program while it is running, you need to use an interrupt-driven serial driver, and arrange for it to stop when it receives a \Control-C (\003, the control-C character). That is the character which GDB uses to tell the remote system to stop.

Getting the debugging target to return the proper status to GDB probably requires changes to the standard stub; one quick and dirty way is to just execute a breakpoint instruction (the “dirty” part is that GDB reports a SIGTRAP instead of a SIGINT).

Other routines you need to supply are:

void exceptionHandler (int exception_number, void *exception_address)
Write this function to install exception_address in the exception handling tables. You need to do this because the stub does not have any way of knowing what the exception handling tables on your target system are like (for example, the processor’s table might be in ROM, containing entries which point to a table in RAM). The exception_number specifies the exception which should be changed; its meaning is architecture-dependent (for example, different numbers might represent divide by zero, misaligned access, etc). When this exception occurs, control should be transferred directly to exception_address, and the processor state (stack, registers, and so on) should be just as it is when a processor exception occurs. So if you want to use a jump instruction to reach exception_address, it should be a simple jump, not a jump to subroutine.
For the 386, *exception_address* should be installed as an interrupt gate so that interrupts are masked while the handler runs. The gate should be at privilege level 0 (the most privileged level). The SPARC and 68k stubs are able to mask interrupts themselves without help from *exceptionHandler*.

```c
void flush_i_cache()
```

On SPARC and SPARC-LITE only, write this subroutine to flush the instruction cache, if any, on your target machine. If there is no instruction cache, this subroutine may be a no-op.

On target machines that have instruction caches, GDB requires this function to make certain that the state of your program is stable.

You must also make sure this library routine is available:

```c
void *memset(void *, int, int)
```

This is the standard library function *memset* that sets an area of memory to a known value. If you have one of the free versions of *libc.a*, *memset* can be found there; otherwise, you must either obtain it from your hardware manufacturer, or write your own.

If you do not use the GNU C compiler, you may need other standard library subroutines as well; this varies from one stub to another, but in general the stubs are likely to use any of the common library subroutines which *gcc* generates as inline code.

### 20.5.3 Putting it All Together

In summary, when your program is ready to debug, you must follow these steps.

1. Make sure you have defined the supporting low-level routines (see Section 20.5.2 [What You Must Do for the Stub], page 272):
   ```c
   getDebugChar, putDebugChar,
   flush_i_cache, memset, exceptionHandler.
   ```

2. Insert these lines in your program’s startup code, before the main procedure is called:
   ```c
   set_debug_traps();
   breakpoint();
   ```

   On some machines, when a breakpoint trap is raised, the hardware automatically makes the PC point to the instruction after the breakpoint. If your machine doesn’t do that, you may need to adjust *handle_exception* to arrange for it to return to the instruction after the breakpoint on this first invocation, so that your program doesn’t keep hitting the initial breakpoint instead of making progress.

3. For the 680x0 stub only, you need to provide a variable called *exceptionHook*. Normally you just use:
   ```c
   void (*exceptionHook)() = 0;
   ```
   but if before calling *set_debug_traps*, you set it to point to a function in your program, that function is called when GDB continues after stopping on a trap (for example, bus error). The function indicated by *exceptionHook* is called with one parameter: an int which is the exception number.

4. Compile and link together: your program, the GDB debugging stub for your target architecture, and the supporting subroutines.
5. Make sure you have a serial connection between your target machine and the GDB host, and identify the serial port on the host.
6. Download your program to your target machine (or get it there by whatever means the manufacturer provides), and start it.
7. Start GDB on the host, and connect to the target (see Section 20.1 [Connecting to a Remote Target], page 257).
21 Configuration-Specific Information

While nearly all gdb commands are available for all native and cross versions of the debugger, there are some exceptions. This chapter describes things that are only available in certain configurations.

There are three major categories of configurations: native configurations, where the host and target are the same, embedded operating system configurations, which are usually the same for several different processor architectures, and bare embedded processors, which are quite different from each other.

21.1 Native

This section describes details specific to particular native configurations.

21.1.1 HP-UX

On HP-UX systems, if you refer to a function or variable name that begins with a dollar sign, gdb searches for a user or system name first, before it searches for a convenience variable.

21.1.2 BSD libkvm Interface

BSD-derived systems (FreeBSD/NetBSD/OpenBSD) have a kernel memory interface that provides a uniform interface for accessing kernel virtual memory images, including live systems and crash dumps. gdb uses this interface to allow you to debug live kernels and kernel crash dumps on many native BSD configurations. This is implemented as a special kvm debugging target. For debugging a live system, load the currently running kernel into gdb and connect to the kvm target:

    (gdb) target kvm

For debugging crash dumps, provide the file name of the crash dump as an argument:

    (gdb) target kvm /var/crash/bsd.0

Once connected to the kvm target, the following commands are available:

    kvm pcb  Set current context from the Process Control Block (PCB) address.
    kvm proc Set current context from proc address. This command isn’t available on modern FreeBSD systems.

21.1.3 SVR4 Process Information

Many versions of SVR4 and compatible systems provide a facility called ‘/proc’ that can be used to examine the image of a running process using file-system subroutines.

If gdb is configured for an operating system with this facility, the command info proc is available to report information about the process running your program, or about any process running on your system. This includes, as of this writing, GNU/Linux and Solaris, but not HP-UX, for example.

This command may also work on core files that were created on a system that has the ‘/proc’ facility.
info proc
info proc process-id
Summarize available information about any running process. If a process ID is specified by process-id, display information about that process; otherwise display information about the program being debugged. The summary includes the debugged process ID, the command line used to invoke it, its current working directory, and its executable file’s absolute file name.

On some systems, process-id can be of the form ‘[pid]/tid’ which specifies a certain thread ID within a process. If the optional pid part is missing, it means a thread from the process being debugged (the leading ‘/’ still needs to be present, or else gdb will interpret the number as a process ID rather than a thread ID).

info proc cmdline
Show the original command line of the process. This command is specific to GNU/Linux.

info proc cwd
Show the current working directory of the process. This command is specific to GNU/Linux.

info proc exe
Show the name of executable of the process. This command is specific to GNU/Linux.

info proc mappings
Report the memory address space ranges accessible in the program, with information on whether the process has read, write, or execute access rights to each range. On GNU/Linux systems, each memory range includes the object file which is mapped to that range, instead of the memory access rights to that range.

info proc stat
info proc status
These subcommands are specific to GNU/Linux systems. They show the process-related information, including the user ID and group ID; how many threads are there in the process; its virtual memory usage; the signals that are pending, blocked, and ignored; its TTY; its consumption of system and user time; its stack size; its ‘nice’ value; etc. For more information, see the ‘proc’ man page (type man 5 proc from your shell prompt).

info proc all
Show all the information about the process described under all of the above info proc subcommands.

set procfs-trace
This command enables and disables tracing of procfs API calls.

show procfs-trace
Show the current state of procfs API call tracing.
set procfs-file file
Tell GDB to write procfs API trace to the named file. GDB appends the trace info to the previous contents of the file. The default is to display the trace on the standard output.

show procfs-file
Show the file to which procfs API trace is written.

proc-trace-entry
proc-trace-exit
proc-untrace-entry
proc-untrace-exit
These commands enable and disable tracing of entries into and exits from the syscall interface.

info pidlist
For QNX Neutrino only, this command displays the list of all the processes and all the threads within each process.

info meminfo
For QNX Neutrino only, this command displays the list of all mapinfos.

21.1.4 Features for Debugging DJGPP Programs
DJGPP is a port of the GNU development tools to MS-DOS and MS-Windows. DJGPP programs are 32-bit protected-mode programs that use the DPMI (DOS Protected-Mode Interface) API to run on top of real-mode DOS systems and their emulations.

GDB supports native debugging of DJGPP programs, and defines a few commands specific to the DJGPP port. This subsection describes those commands.

info dos
This is a prefix of DJGPP-specific commands which print information about the target system and important OS structures.

info dos sysinfo
This command displays assorted information about the underlying platform: the CPU type and features, the OS version and flavor, the DPMI version, and the available conventional and DPMI memory.

info dos gdt
info dos ldt
info dos idt
These 3 commands display entries from, respectively, Global, Local, and Interrupt Descriptor Tables (GDT, LDT, and IDT). The descriptor tables are data structures which store a descriptor for each segment that is currently in use. The segment’s selector is an index into a descriptor table; the table entry for that index holds the descriptor’s base address and limit, and its attributes and access rights.

A typical DJGPP program uses 3 segments: a code segment, a data segment (used for both data and the stack), and a DOS segment (which allows access to DOS/BIOS data structures and absolute addresses in conventional memory). However, the DPMI host will usually define additional segments in order to support the DPMI environment.
These commands allow to display entries from the descriptor tables. Without an argument, all entries from the specified table are displayed. An argument, which should be an integer expression, means display a single entry whose index is given by the argument. For example, here’s a convenient way to display information about the debugged program’s data segment:

(gdb) info dos ldt $ds
0x13f: base=0x11970000 limit=0x0009ffff 32-Bit Data (Read/Write, Exp-up)

This comes in handy when you want to see whether a pointer is outside the data segment’s limit (i.e. garbled).

**info dos pde**

**info dos pte**

These two commands display entries from, respectively, the Page Directory and the Page Tables. Page Directories and Page Tables are data structures which control how virtual memory addresses are mapped into physical addresses. A Page Table includes an entry for every page of memory that is mapped into the program’s address space; there may be several Page Tables, each one holding up to 4096 entries. A Page Directory has up to 4096 entries, one each for every Page Table that is currently in use.

Without an argument, **info dos pde** displays the entire Page Directory, and **info dos pte** displays all the entries in all of the Page Tables. An argument, an integer expression, given to the **info dos pde** command means display only that entry from the Page Directory table. An argument given to the **info dos pte** command means display entries from a single Page Table, the one pointed to by the specified entry in the Page Directory.

These commands are useful when your program uses DMA (Direct Memory Access), which needs physical addresses to program the DMA controller.

These commands are supported only with some DPMI servers.

**info dos address-pte addr**

This command displays the Page Table entry for a specified linear address. The argument *addr* is a linear address which should already have the appropriate segment’s base address added to it, because this command accepts addresses which may belong to any segment. For example, here’s how to display the Page Table entry for the page where a variable *i* is stored:

(gdb) info dos address-pte __djgpp_base_address + (char *)&i
Page Table entry for address 0x11a00d30:
Base=0x02698000 Dirty Acc. Not-Cached Write-Back Usr Read-Write +0xd30

This says that *i* is stored at offset 0xd30 from the page whose physical base address is 0x02698000, and shows all the attributes of that page.

Note that you must cast the addresses of variables to a char *, since otherwise the value of __djgpp_base_address, the base address of all variables and functions in a DJGPP program, will be added using the rules of C pointer arithmetics: if *i* is declared an int, GDB will add 4 times the value of __djgpp_base_address to the address of *i*.

Here’s another example, it displays the Page Table entry for the transfer buffer:

(gdb) info dos address-pte *((unsigned *)&_go32_info_block + 3)
Page Table entry for address 0x29110:  
Base=0x00029000 Dirty Acc. Not-Cached Write-Back Usr Read-Write +0x110  
(The + 3 offset is because the transfer buffer’s address is the 3rd member of the 
_go32_info_block structure.) The output clearly shows that this DPMI server 
maps the addresses in conventional memory 1:1, i.e. the physical (0x00029000 
+ 0x110) and linear (0x29110) addresses are identical.  
This command is supported only with some DPMI servers.  

In addition to native debugging, the DJGPP port supports remote debugging via a serial 
data link. The following commands are specific to remote serial debugging in the DJGPP 
port of GDB.  

**set com1base addr**  
This command sets the base I/O port address of the ‘COM1’ serial port.  

**set com1irq irq**  
This command sets the Interrupt Request (IRQ) line to use for the ‘COM1’ serial 
port.  
There are similar commands ‘set com2base’, ‘set com3irq’, etc. for setting the 
port address and the IRQ lines for the other 3 COM ports.  
The related commands ‘show com1base’, ‘show com1irq’ etc. display the cur-
rent settings of the base address and the IRQ lines used by the COM ports.  

**info serial**  
This command prints the status of the 4 DOS serial ports. For each port, 
it prints whether it’s active or not, its I/O base address and IRQ number, 
whether it uses a 16550-style FIFO, its baudrate, and the counts of various 
errors encountered so far.  

**21.1.5 Features for Debugging MS Windows PE Executables**  

GDB supports native debugging of MS Windows programs, including DLLs with and without 
symbolic debugging information.  

MS-Windows programs that call **SetConsoleMode** to switch off the special meaning of 
the ‘Ctrl-C’ keystroke cannot be interrupted by typing C-c. For this reason, GDB on MS-
Windows supports **C-BREAK** as an alternative interrupt key sequence, which can be used to 
interrupt the debuggee even if it ignores C-c.  

There are various additional Cygwin-specific commands, described in this section. Working 
with DLLs that have no debugging symbols is described in Section 21.1.5.1 [Non-debug 
DLL Symbols], page 281.  

**info w32**  
This is a prefix of MS Windows-specific commands which print information 
about the target system and important OS structures.  

**info w32 selector**  
This command displays information returned by the Win32 API 
GetThreadSelectorEntry function. It takes an optional argument that is 
evaluated to a long value to give the information about this given selector. 
Without argument, this command displays information about the six segment 
registers.
info w32 thread-information-block
This command displays thread specific information stored in the Thread Information Block (readable on the X86 CPU family using $fs selector for 32-bit programs and $gs for 64-bit programs).

set cygwin-exceptions mode
If mode is on, GDB will break on exceptions that happen inside the Cygwin DLL. If mode is off, GDB will delay recognition of exceptions, and may ignore some exceptions which seem to be caused by internal Cygwin DLL “bookkeeping”. This option is meant primarily for debugging the Cygwin DLL itself; the default value is off to avoid annoying GDB users with false SIGSEGV signals.

show cygwin-exceptions
Displays whether GDB will break on exceptions that happen inside the Cygwin DLL itself.

set new-console mode
If mode is on the debuggee will be started in a new console on next start. If mode is off, the debuggee will be started in the same console as the debugger.

show new-console
Displays whether a new console is used when the debuggee is started.

set new-group mode
This boolean value controls whether the debuggee should start a new group or stay in the same group as the debugger. This affects the way the Windows OS handles ‘Ctrl-C’.

show new-group
Displays current value of new-group boolean.

set debugevents
This boolean value adds debug output concerning kernel events related to the debuggee seen by the debugger. This includes events that signal thread and process creation and exit, DLL loading and unloading, console interrupts, and debugging messages produced by the Windows OutputDebugString API call.

set debugexec
This boolean value adds debug output concerning execute events (such as resume thread) seen by the debugger.

set debugexceptions
This boolean value adds debug output concerning exceptions in the debuggee seen by the debugger.

set debugmemory
This boolean value adds debug output concerning debuggee memory reads and writes by the debugger.

set shell
This boolean values specifies whether the debuggee is called via a shell or directly (default value is on).

show shell
Displays if the debuggee will be started with a shell.
21.1.5.1 Support for DLLs without Debugging Symbols

Very often on Windows, some of the DLLs that your program relies on do not include symbolic debugging information (for example, `kernel32.dll`). When GDB doesn’t recognize any debugging symbols in a DLL, it relies on the minimal amount of symbolic information contained in the DLL’s export table. This section describes working with such symbols, known internally to GDB as “minimal symbols”.

Note that before the debugged program has started execution, no DLLs will have been loaded. The easiest way around this problem is simply to start the program — either by setting a breakpoint or letting the program run once to completion.

21.1.5.2 DLL Name Prefixes

In keeping with the naming conventions used by the Microsoft debugging tools, DLL export symbols are made available with a prefix based on the DLL name, for instance `KERNEL32!CreateFileA`. The plain name is also entered into the symbol table, so `CreateFileA` is often sufficient. In some cases there will be name clashes within a program (particularly if the executable itself includes full debugging symbols) necessitating the use of the fully qualified name when referring to the contents of the DLL. Use single-quotes around the name to avoid the exclamation mark (“!”) being interpreted as a language operator.

Note that the internal name of the DLL may be all upper-case, even though the file name of the DLL is lower-case, or vice-versa. Since symbols within GDB are case-sensitive this may cause some confusion. If in doubt, try the `info functions` and `info variables` commands or even `maint print msymbols` (see Chapter 16 [Symbols], page 217). Here’s an example:

```
(gdb) info function CreateFileA
All functions matching regular expression "CreateFileA":

Non-debugging symbols:
0x77e885f4 CreateFileA
0x77e885f4 KERNEL32!CreateFileA
(gdb) info function !
All functions matching regular expression "!":

Non-debugging symbols:
0x6100114c cygwin1!_assert
0x61004034 cygwin1!_dll_crt0@0
0x61004240 cygwin1!dll_crt0(per_process *)
[etc...]
```

21.1.5.3 Working with Minimal Symbols

Symbols extracted from a DLL’s export table do not contain very much type information. All that GDB can do is guess whether a symbol refers to a function or variable depending on the linker section that contains the symbol. Also note that the actual contents of the memory contained in a DLL are not available unless the program is running. This means that you cannot examine the contents of a variable or disassemble a function within a DLL without a running program.

Variables are generally treated as pointers and dereferenced automatically. For this reason, it is often necessary to prefix a variable name with the address-of operator (“&”)
and provide explicit type information in the command. Here’s an example of the type of problem:

```
(gdb) print 'cygwin1!__argv'
$1 = 268572168
(gdb) x 'cygwin1!__argv'
0x10021610: "\230y"
```

And two possible solutions:

```
(gdb) print ((char **)'cygwin1!__argv')[0]
$2 = 0x22fd98 "/cygdrive/c/mydirectory/myprogram"
(gdb) x/2x &'cygwin1!__argv'
0x610c0aa8 <cygwin1!__argv>: 0x10021608 0x00000000
(gdb) x/x 0x10021608
0x10021608: 0x0022fd98
(gdb) x/s 0x0022fd98
0x22fd98: "/cygdrive/c/mydirectory/myprogram"
```

Setting a break point within a DLL is possible even before the program starts execution. However, under these circumstances, GDB can’t examine the initial instructions of the function in order to skip the function’s frame set-up code. You can work around this by using "\&" to set the breakpoint at a raw memory address:

```
(gdb) break *&’python22!PyOS_Readline’
Breakpoint 1 at 0x1e04eff0
```

The author of these extensions is not entirely convinced that setting a break point within a shared DLL like ‘kernel32.dll’ is completely safe.

### 21.1.6 Commands Specific to GNU Hurd Systems

This subsection describes GDB commands specific to the GNU Hurd native debugging.

**set signals**

**set sigs**  This command toggles the state of inferior signal interception by GDB. Mach exceptions, such as breakpoint traps, are not affected by this command. **sigs** is a shorthand alias for **signals**.

**show signals**

**show sigs**  Show the current state of intercepting inferior’s signals.

**set signal-thread**

**set sigthread**  This command tells GDB which thread is the libc signal thread. That thread is run when a signal is delivered to a running process. **set sigthread** is the shorthand alias of **set signal-thread**.

**show signal-thread**

**show sigthread**  These two commands show which thread will run when the inferior is delivered a signal.

**set stopped**  This commands tells GDB that the inferior process is stopped, as with the SIGSTOP signal. The stopped process can be continued by delivering a signal to it.
show stopped
This command shows whether GDB thinks the debuggee is stopped.

set exceptions
Use this command to turn off trapping of exceptions in the inferior. When exception trapping is off, neither breakpoints nor single-stepping will work. To restore the default, set exception trapping on.

show exceptions
Show the current state of trapping exceptions in the inferior.

set task pause
This command toggles task suspension when GDB has control. Setting it to on takes effect immediately, and the task is suspended whenever GDB gets control. Setting it to off will take effect the next time the inferior is continued. If this option is set to off, you can use set thread default pause on or set thread pause on (see below) to pause individual threads.

show task pause
Show the current state of task suspension.

set task detach-suspend-count
This command sets the suspend count the task will be left with when GDB detaches from it.

show task detach-suspend-count
Show the suspend count the task will be left with when detaching.

set task exception-port
set task excp
This command sets the task exception port to which GDB will forward exceptions. The argument should be the value of the send rights of the task. set task excp is a shorthand alias.

set noninvasive
This command switches GDB to a mode that is the least invasive as far as interfering with the inferior is concerned. This is the same as using set task pause, set exceptions, and set signals to values opposite to the defaults.

info send-rights
info receive-rights
info port-rights
info port-sets
info dead-names
info ports
info psets
These commands display information about, respectively, send rights, receive rights, port rights, port sets, and dead names of a task. There are also shorthand aliases: info ports for info port-rights and info psets for info port-sets.
**set thread pause**

This command toggles current thread suspension when GDB has control. Setting it to on takes effect immediately, and the current thread is suspended whenever GDB gets control. Setting it to off will take effect the next time the inferior is continued. Normally, this command has no effect, since when GDB has control, the whole task is suspended. However, if you used `set task pause off` (see above), this command comes in handy to suspend only the current thread.

**show thread pause**

This command shows the state of current thread suspension.

**set thread run**

This command sets whether the current thread is allowed to run.

**show thread run**

Show whether the current thread is allowed to run.

**set thread detach-suspend-count**

This command sets the suspend count GDB will leave on a thread when detaching. This number is relative to the suspend count found by GDB when it notices the thread; use `set thread takeover-suspend-count` to force it to an absolute value.

**show thread detach-suspend-count**

Show the suspend count GDB will leave on the thread when detaching.

**set thread exception-port**

**set thread excp**

Set the thread exception port to which to forward exceptions. This overrides the port set by `set task exception-port` (see above). `set thread excp` is the shorthand alias.

**set thread takeover-suspend-count**

Normally, GDB's thread suspend counts are relative to the value GDB finds when it notices each thread. This command changes the suspend counts to be absolute instead.

**set thread default**

**show thread default**

Each of the above `set thread` commands has a `set thread default` counterpart (e.g., `set thread default pause`, `set thread default exception-port`, etc.). The `thread default` variety of commands sets the default thread properties for all threads; you can then change the properties of individual threads with the non-default commands.

### 21.1.7 Darwin

GDB provides the following commands specific to the Darwin target:

**set debug darwin num**

When set to a non zero value, enables debugging messages specific to the Darwin support. Higher values produce more verbose output.
show debug darwin
Show the current state of Darwin messages.

set debug mach-o num
When set to a non zero value, enables debugging messages while GDB is reading Darwin object files. (Mach-O is the file format used on Darwin for object and executable files.) Higher values produce more verbose output. This is a command to diagnose problems internal to GDB and should not be needed in normal usage.

show debug mach-o
Show the current state of Mach-O file messages.

set mach-exceptions on
set mach-exceptions off
On Darwin, faults are first reported as a Mach exception and are then mapped to a Posix signal. Use this command to turn on trapping of Mach exceptions in the inferior. This might be sometimes useful to better understand the cause of a fault. The default is off.

show mach-exceptions
Show the current state of exceptions trapping.

21.2 Embedded Operating Systems
This section describes configurations involving the debugging of embedded operating systems that are available for several different architectures.

GDB includes the ability to debug programs running on various real-time operating systems.

21.3 Embedded Processors
This section goes into details specific to particular embedded configurations.

Whenever a specific embedded processor has a simulator, GDB allows to send an arbitrary command to the simulator.

sim command
Send an arbitrary command string to the simulator. Consult the documentation for the specific simulator in use for information about acceptable commands.

21.3.1 ARM
GDB provides the following ARM-specific commands:

set arm disassembler
This command selects from a list of disassembly styles. The "std" style is the standard style.

show arm disassembler
Show the current disassembly style.

set arm apcs32
This command toggles ARM operation mode between 32-bit and 26-bit.
show arm apcs32
   Display the current usage of the ARM 32-bit mode.

set arm fpu fputype
   This command sets the ARM floating-point unit (FPU) type. The argument
   fputype can be one of these:
   auto    Determine the FPU type by querying the OS ABI.
   softfpa Software FPU, with mixed-endian doubles on little-endian ARM
              processors.
   fpa     GCC-compiled FPA co-processor.
   softvfp Software FPU with pure-endian doubles.
   vfp     VFP co-processor.

show arm fpu
   Show the current type of the FPU.

set arm abi
   This command forces GDB to use the specified ABI.

show arm abi
   Show the currently used ABI.

set arm fallback-mode (arm|thumb|auto)
   GDB uses the symbol table, when available, to determine whether instructions
   are ARM or Thumb. This command controls GDB’s default behavior when the
   symbol table is not available. The default is ‘auto’, which causes GDB to use
   the current execution mode (from the T bit in the CPSR register).

show arm fallback-mode
   Show the current fallback instruction mode.

set arm force-mode (arm|thumb|auto)
   This command overrides use of the symbol table to determine whether instruc-
   tions are ARM or Thumb. The default is ‘auto’, which causes GDB to use the
   symbol table and then the setting of ‘set arm fallback-mode’.

show arm force-mode
   Show the current forced instruction mode.

set debug arm
   Toggle whether to display ARM-specific debugging messages from the ARM
   target support subsystem.

show debug arm
   Show whether ARM-specific debugging messages are enabled.

target sim [simargs] ...
   The GDB ARM simulator accepts the following optional arguments.
   --swi-support=type
      Tell the simulator which SWI interfaces to support. The argument
      type may be a comma separated list of the following values. The
default value is all.
21.3.2 Renesas M32R/SDI

The following commands are available for M32R/SDI:

sdireset  This command resets the SDI connection.

sdistatus  This command shows the SDI connection status.

debug_chaos  Instructs the remote that M32R/Chaos debugging is to be used.

use_debug_dma  Instructs the remote to use the DEBUG_DMA method of accessing memory.

use_mon_code  Instructs the remote to use the MON_CODE method of accessing memory.

use_ib_break  Instructs the remote to set breakpoints by IB break.

use_dbt_break  Instructs the remote to set breakpoints by DBT.

21.3.3 M68k

The Motorola m68k configuration includes ColdFire support.

21.3.4 MicroBlaze

The MicroBlaze is a soft-core processor supported on various Xilinx FPGAs, such as Spartan or Virtex series. Boards with these processors usually have JTAG ports which connect to a host system running the Xilinx Embedded Development Kit (EDK) or Software Development Kit (SDK). This host system is used to download the configuration bitstream to the target FPGA. The Xilinx Microprocessor Debugger (XMD) program communicates with the target board using the JTAG interface and presents a gdbserver interface to the board. By default xmd uses port 1234. (While it is possible to change this default port, it requires the use of undocumented xmd commands. Contact Xilinx support if you need to do this.)

Use these GDB commands to connect to the MicroBlaze target processor.

target remote :1234  Use this command to connect to the target if you are running GDB on the same system as xmd.

target remote xmd-host:1234  Use this command to connect to the target if it is connected to xmd running on a different system named xmd-host.
load Use this command to download a program to the MicroBlaze target.

set debug microblaze n
Enable MicroBlaze-specific debugging messages if non-zero.

show debug microblaze n
Show MicroBlaze-specific debugging level.

21.3.5 MIPS Embedded

GDB can use the MIPS remote debugging protocol to talk to a MIPS board attached to a serial line. This is available when you configure GDB with ‘--target=mips-elf’.

Use these GDB commands to specify the connection to your target board:

**target mips port**
To run a program on the board, start up gdb with the name of your program as the argument. To connect to the board, use the command ‘target mips port’, where port is the name of the serial port connected to the board. If the program has not already been downloaded to the board, you may use the load command to download it. You can then use all the usual GDB commands.

For example, this sequence connects to the target board through a serial port, and loads and runs a program called prog through the debugger:

```
host$ gdb prog
(gdb) target mips /dev/ttyb
(gdb) load prog
(gdb) run
```

**target mips hostname:portnumber**
On some GDB host configurations, you can specify a TCP connection (for instance, to a serial line managed by a terminal concentrator) instead of a serial port, using the syntax ‘hostname:portnumber’.

**target pmon port**
PMON ROM monitor.

**target ddb port**
NEC’s DDB variant of PMON for Vr4300.

**target lsi port**
LSI variant of PMON.

GDB also supports these special commands for MIPS targets:

**set mipsfpu double**
**set mipsfpu single**
**set mipsfpu none**
**set mipsfpu auto**
**show mipsfpu**

If your target board does not support the MIPS floating point coprocessor, you should use the command ‘**set mipsfpu none**’ (if you need this, you may wish to put the command in your GDB init file). This tells GDB how to find the return value of functions which return floating point values. It also allows GDB to avoid
saving the floating point registers when calling functions on the board. If you are using a floating point coprocessor with only single precision floating point support, as on the R4650 processor, use the command ‘set mipsfpu single’. The default double precision floating point coprocessor may be selected using ‘set mipsfpu double’.

In previous versions the only choices were double precision or no floating point, so ‘set mipsfpu on’ will select double precision and ‘set mipsfpu off’ will select no floating point.

As usual, you can inquire about the mipsfpu variable with ‘show mipsfpu’.

`set timeout seconds`
`set retransmit-timeout seconds`
`show timeout`
`show retransmit-timeout`

You can control the timeout used while waiting for a packet, in the MIPS remote protocol, with the `set timeout seconds` command. The default is 5 seconds. Similarly, you can control the timeout used while waiting for an acknowledgment of a packet with the `set retransmit-timeout seconds` command. The default is 3 seconds. You can inspect both values with `show timeout` and `show retransmit-timeout`. (These commands are only available when GDB is configured for ‘--target=mips-elf’.)

The timeout set by `set timeout` does not apply when GDB is waiting for your program to stop. In that case, GDB waits forever because it has no way of knowing how long the program is going to run before stopping.

`set syn-garbage-limit num`

Limit the maximum number of characters GDB should ignore when it tries to synchronize with the remote target. The default is 10 characters. Setting the limit to -1 means there’s no limit.

`show syn-garbage-limit`

Show the current limit on the number of characters to ignore when trying to synchronize with the remote system.

`set monitor-prompt prompt`

Tell GDB to expect the specified `prompt` string from the remote monitor. The default depends on the target:

```
pmon target 'PMON'
ddb target 'NECO10'
lsi target 'PMON>'
```

`show monitor-prompt`

Show the current strings GDB expects as the prompt from the remote monitor.

`set monitor-warnings`

Enable or disable monitor warnings about hardware breakpoints. This has effect only for the lsi target. When on, GDB will display warning messages whose codes are returned by the lsi PMON monitor for breakpoint commands.
show monitor-warnings
   Show the current setting of printing monitor warnings.

pmon command
   This command allows sending an arbitrary command string to the monitor.
   The monitor must be in debug mode for this to work.

21.3.6 PowerPC Embedded

GDB supports using the DVC (Data Value Compare) register to implement in hardware simple hardware watchpoint conditions of the form:

   (gdb) watch ADDRESS|VARIABLE \ 
       if ADDRESS|VARIABLE == CONSTANT EXPRESSION

   The DVC register will be automatically used when GDB detects such pattern in a condition expression, and the created watchpoint uses one debug register (either the exact-watches option is on and the variable is scalar, or the variable has a length of one byte). This feature is available in native GDB running on a Linux kernel version 2.6.34 or newer.

When running on PowerPC embedded processors, GDB automatically uses ranged hardware watchpoints, unless the exact-watches option is on, in which case watchpoints using only one debug register are created when watching variables of scalar types.

You can create an artificial array to watch an arbitrary memory region using one of the following commands (see Section 10.1 [Expressions], page 115):

   (gdb) watch *((char *) address)@length
   (gdb) watch {char[length]} address

PowerPC embedded processors support masked watchpoints. See the discussion about the mask argument in Section 5.1.2 [Set Watchpoints], page 52.

PowerPC embedded processors support hardware accelerated ranged breakpoints. A ranged breakpoint stops execution of the inferior whenever it executes an instruction at any address within the range it specifies. To set a ranged breakpoint in GDB, use the break-range command.

GDB provides the following PowerPC-specific commands:

break-range start-location, end-location
   Set a breakpoint for an address range given by start-location and end-location, which can specify a function name, a line number, an offset of lines from the current line or from the start location, or an address of an instruction (see Section 9.2 [Specify Location], page 102, for a list of all the possible ways to specify a location.) The breakpoint will stop execution of the inferior whenever it executes an instruction at any address within the specified range, (including start-location and end-location.)

set powerpc soft-float
show powerpc soft-float
   Force GDB to use (or not use) a software floating point calling convention. By default, GDB selects the calling convention based on the selected architecture and the provided executable file.
set powerpc vector-abi
show powerpc vector-abi
Force GDB to use the specified calling convention for vector arguments and return values. The valid options are ‘auto’, ‘generic’, to avoid vector registers even if they are present; ‘altivec’, to use AltiVec registers; and ‘spe’ to use SPE registers. By default, GDB selects the calling convention based on the selected architecture and the provided executable file.

set powerpc exact-watchpoints
show powerpc exact-watchpoints
Allow GDB to use only one debug register when watching a variable of scalar type, thus assuming that the variable is accessed through the address of its first byte.

21.3.7 Atmel AVR
When configured for debugging the Atmel AVR, GDB supports the following AVR-specific commands:

info io_registers
This command displays information about the AVR I/O registers. For each register, GDB prints its number and value.

21.3.8 CRIS
When configured for debugging CRIS, GDB provides the following CRIS-specific commands:

set cris-version ver
Set the current CRIS version to ver, either ‘10’ or ‘32’. The CRIS version affects register names and sizes. This command is useful in case autodetection of the CRIS version fails.

show cris-version
Show the current CRIS version.

set cris-dwarf2-cfi
Set the usage of DWARF-2 CFI for CRIS debugging. The default is ‘on’. Change to ‘off’ when using gcc-cris whose version is below R59.

show cris-dwarf2-cfi
Show the current state of using DWARF-2 CFI.

set cris-mode mode
Set the current CRIS mode to mode. It should only be changed when debugging in guru mode, in which case it should be set to ‘guru’ (the default is ‘normal’).

show cris-mode
Show the current CRIS mode.

21.3.9 Renesas Super-H
For the Renesas Super-H processor, GDB provides these commands:
set sh calling-convention
Set the calling-convention used when calling functions from GDB. Allowed values are ‘gcc’, which is the default setting, and ‘renesas’. With the ‘gcc’ setting, functions are called using the GCC calling convention. If the DWARF-2 information of the called function specifies that the function follows the Renesas calling convention, the function is called using the Renesas calling convention. If the calling convention is set to ‘renesas’, the Renesas calling convention is always used, regardless of the DWARF-2 information. This can be used to override the default of ‘gcc’ if debug information is missing, or the compiler does not emit the DWARF-2 calling convention entry for a function.

show sh calling-convention
Show the current calling convention setting.

21.4 Architectures
This section describes characteristics of architectures that affect all uses of GDB with the architecture, both native and cross.

21.4.1 AArch64
When GDB is debugging the AArch64 architecture, it provides the following special commands:

set debug aarch64
This command determines whether AArch64 architecture-specific debugging messages are to be displayed.

show debug aarch64
Show whether AArch64 debugging messages are displayed.

21.4.2 x86 Architecture-specific Issues

set struct-convention mode
Set the convention used by the inferior to return structs and unions from functions to mode. Possible values of mode are "pcc", "reg", and "default" (the default). "default" or "pcc" means that structs are returned on the stack, while "reg" means that a struct or a union whose size is 1, 2, 4, or 8 bytes will be returned in a register.

show struct-convention
Show the current setting of the convention to return structs from functions.

21.4.2.1 Intel(R) Memory Protection Extensions (MPX).
Memory Protection Extension (MPX) adds the bound registers ‘BND0’ through ‘BND3’. Bound registers store a pair of 64-bit values which are the lower bound and upper bound. Bounds are effective addresses or memory locations. The upper bounds are architecturally represented in 1’s complement form. A bound having lower bound = 0, and upper bound = 0 (1’s complement of all bits set) will allow access to the entire address space.

1 The register named with capital letters represent the architecture registers.
‘BND0’ through ‘BND3’ are represented in GDB as ‘bnd0raw’ through ‘bnd3raw’. Pseudo registers ‘bnd0’ through ‘bnd3’ display the upper bound performing the complement of one operation on the upper bound value, i.e. when upper bound in ‘bnd0raw’ is 0 in the GDB ‘bnd0’ it will be 0xffff.... In this sense it can also be noted that the upper bounds are inclusive.

As an example, assume that the register BND0 holds bounds for a pointer having access allowed for the range between 0x32 and 0x71. The values present on bnd0raw and bnd registers are presented as follows:

```
bnd0raw = {0x32, 0xffffffff8e}
bnd0 = {lbound = 0x32, ubound = 0x71} : size 64
```

This way the raw value can be accessed via bnd0raw...bnd3raw. Any change on bnd0...bnd3 or bnd0raw...bnd3raw is reflect on its counterpart. When the bnd0...bnd3 registers are displayed via Python, the display includes the memory size, in bits, accessible to the pointer.

Bounds can also be stored in bounds tables, which are stored in application memory. These tables store bounds for pointers by specifying the bounds pointer’s value along with its bounds. Evaluating and changing bounds located in bound tables is therefore interesting while investigating bugs on MPX context. GDB provides commands for this purpose:

```
show mpx bound pointer
  Display bounds of the given pointer.

set mpx bound pointer, lbound, ubound
  Set the bounds of a pointer in the bound table. This command takes three parameters: pointer is the pointers whose bounds are to be changed, lbound and ubound are new values for lower and upper bounds respectively.
```

### 21.4.3 Alpha

See the following section.

### 21.4.4 MIPS

Alpha- and MIPS-based computers use an unusual stack frame, which sometimes requires GDB to search backward in the object code to find the beginning of a function.

To improve response time (especially for embedded applications, where GDB may be restricted to a slow serial line for this search) you may want to limit the size of this search, using one of these commands:

```
set heuristic-fence-post limit
  Restrict GDB to examining at most limit bytes in its search for the beginning of a function. A value of 0 (the default) means there is no limit. However, except for 0, the larger the limit the more bytes heuristic-fence-post must search and therefore the longer it takes to run. You should only need to use this command when debugging a stripped executable.

show heuristic-fence-post
  Display the current limit.
```

These commands are available only when GDB is configured for debugging programs on Alpha or MIPS processors.
Several MIPS-specific commands are available when debugging MIPS programs:

**set mips abi arg**
Tell GDB which MIPS ABI is used by the inferior. Possible values of *arg* are:
- ‘auto’ The default ABI associated with the current binary (this is the default).
- ‘o32’
- ‘o64’
- ‘n32’
- ‘n64’
- ‘eabi32’
- ‘eabi64’

**show mips abi**
Show the MIPS ABI used by GDB to debug the inferior.

**set mips compression arg**
Tell GDB which MIPS compressed ISA (Instruction Set Architecture) encoding is used by the inferior. GDB uses this for code disassembly and other internal interpretation purposes. This setting is only referred to when no executable has been associated with the debugging session or the executable does not provide information about the encoding it uses. Otherwise this setting is automatically updated from information provided by the executable.

Possible values of *arg* are ‘mips16’ and ‘micromips’. The default compressed ISA encoding is ‘mips16’, as executables containing MIPS16 code frequently are not identified as such.

This setting is “sticky”; that is, it retains its value across debugging sessions until reset either explicitly with this command or implicitly from an executable.

The compiler and/or assembler typically add symbol table annotations to identify functions compiled for the MIPS16 or microMIPS ISAs. If these function-scope annotations are present, GDB uses them in preference to the global compressed ISA encoding setting.

**show mips compression**
Show the MIPS compressed ISA encoding used by GDB to debug the inferior.

**set mipsfpu**
**show mipsfpu**
See Section 21.3.5 [MIPS Embedded], page 288.

**set mips mask-address arg**
This command determines whether the most-significant 32 bits of 64-bit MIPS addresses are masked off. The argument *arg* can be ‘on’, ‘off’, or ‘auto’. The latter is the default setting, which lets GDB determine the correct value.

**show mips mask-address**
Show whether the upper 32 bits of MIPS addresses are masked off or not.
set remote-mips64-transfers-32bit-reg
This command controls compatibility with 64-bit MIPS targets that transfer data in 32-bit quantities. If you have an old MIPS 64 target that transfers 32 bits for some registers, like SR and FSR, and 64 bits for other registers, set this option to ‘on’.

show remote-mips64-transfers-32bit-reg
Show the current setting of compatibility with older MIPS 64 targets.

set debug mips
This command turns on and off debugging messages for the MIPS-specific target code in GDB.

show debug mips
Show the current setting of MIPS debugging messages.

21.4.5 HPPA
When GDB is debugging the HP PA architecture, it provides the following special commands:

set debug hppa
This command determines whether HPPA architecture-specific debugging messages are to be displayed.

show debug hppa
Show whether HPPA debugging messages are displayed.

maint print unwind address
This command displays the contents of the unwind table entry at the given address.

21.4.6 Cell Broadband Engine SPU architecture
When GDB is debugging the Cell Broadband Engine SPU architecture, it provides the following special commands:

info spu event
Display SPU event facility status. Shows current event mask and pending event status.

info spu signal
Display SPU signal notification facility status. Shows pending signal-control word and signal notification mode of both signal notification channels.

info spu mailbox
Display SPU mailbox facility status. Shows all pending entries, in order of processing, in each of the SPU Write Outbound, SPU Write Outbound Interrupt, and SPU Read Inbound mailboxes.

info spu dma
Display MFC DMA status. Shows all pending commands in the MFC DMA queue. For each entry, opcode, tag, class IDs, effective and local store addresses and transfer size are shown.
info spu proxydma
Display MFC Proxy-DMA status. Shows all pending commands in the MFC Proxy-DMA queue. For each entry, opcode, tag, class IDs, effective and local store addresses and transfer size are shown.

When gdb is debugging a combined PowerPC/SPU application on the Cell Broadband Engine, it provides in addition the following special commands:

set spu stop-on-load arg
Set whether to stop for new SPE threads. When set to on, gdb will give control to the user when a new SPE thread enters its main function. The default is off.

show spu stop-on-load
Show whether to stop for new SPE threads.

set spu auto-flush-cache arg
Set whether to automatically flush the software-managed cache. When set to on, gdb will automatically cause the SPE software-managed cache to be flushed whenever SPE execution stops. This provides a consistent view of PowerPC memory that is accessed via the cache. If an application does not use the software-managed cache, this option has no effect.

show spu auto-flush-cache
Show whether to automatically flush the software-managed cache.

21.4.7 PowerPC
When gdb is debugging the PowerPC architecture, it provides a set of pseudo-registers to enable inspection of 128-bit wide Decimal Floating Point numbers stored in the floating point registers. These values must be stored in two consecutive registers, always starting at an even register like f0 or f2.

The pseudo-registers go from $d10 through $d15, and are formed by joining the even/odd register pairs f0 and f1 for $d10, f2 and f3 for $d11 and so on.

For POWER7 processors, gdb provides a set of pseudo-registers, the 64-bit wide Extended Floating Point Registers (‘f32’ through ‘f63’).

21.4.8 Nios II
When gdb is debugging the Nios II architecture, it provides the following special commands:

set debug nios2
This command turns on and off debugging messages for the Nios II target code in gdb.

show debug nios2
Show the current setting of Nios II debugging messages.
22 Controlling GDB

You can alter the way GDB interacts with you by using the `set` command. For commands controlling how GDB displays data, see Section 10.8 [Print Settings], page 125. Other settings are described here.

22.1 Prompt

GDB indicates its readiness to read a command by printing a string called the `prompt`. This string is normally `(gdb)`. You can change the prompt string with the `set prompt` command. For instance, when debugging GDB with GDB, it is useful to change the prompt in one of the GDB sessions so that you can always tell which one you are talking to.

*Note: set prompt* does not add a space for you after the prompt you set. This allows you to set a prompt which ends in a space or a prompt that does not.

```plaintext
set prompt newprompt
```

Directs GDB to use `newprompt` as its prompt string henceforth.

```plaintext
show prompt
```

Prints a line of the form: ‘Gdb’s prompt is: your-prompt’

Versions of GDB that ship with Python scripting enabled have prompt extensions. The commands for interacting with these extensions are:

```plaintext
set extended-prompt prompt
```

Set an extended prompt that allows for substitutions. See Section 23.2.4.3 [gdb.prompt], page 390, for a list of escape sequences that can be used for substitution. Any escape sequences specified as part of the prompt string are replaced with the corresponding strings each time the prompt is displayed.

For example:

```plaintext
set extended-prompt Current working directory: \w (gdb)
```

Note that when an extended-prompt is set, it takes control of the `prompt_hook` hook. See [prompt_hook], page 326, for further information.

```plaintext
show extended-prompt
```

Prints the extended prompt. Any escape sequences specified as part of the prompt string with `set extended-prompt`, are replaced with the corresponding strings each time the prompt is displayed.

22.2 Command Editing

GDB reads its input commands via the Readline interface. This GNU library provides consistent behavior for programs which provide a command line interface to the user. Advantages are GNU Emacs-style or vi-style inline editing of commands, csh-like history substitution, and a storage and recall of command history across debugging sessions.

You may control the behavior of command line editing in GDB with the command `set`.

```plaintext
set editing
set editing on
```

Enable command line editing (enabled by default).
set editing off
  Disable command line editing.

show editing
  Show whether command line editing is enabled.

  See Chapter 32 [Command Line Editing], page 561, for more details about the Readline interface. Users unfamiliar with GNU Emacs or vi are encouraged to read that chapter.

22.3 Command History

GDB can keep track of the commands you type during your debugging sessions, so that you can be certain of precisely what happened. Use these commands to manage the GDB command history facility.

GDB uses the GNU History library, a part of the Readline package, to provide the history facility. See Chapter 33 [Using History Interactively], page 583, for the detailed description of the History library.

To issue a command to GDB without affecting certain aspects of the state which is seen by users, prefix it with ‘server’ (see Section 28.2 [Server Prefix], page 546). This means that this command will not affect the command history, nor will it affect GDB’s notion of which command to repeat if RET is pressed on a line by itself.

The server prefix does not affect the recording of values into the value history; to print a value without recording it into the value history, use the output command instead of the print command.

Here is the description of GDB commands related to command history.

set history filename filename
  Set the name of the GDB command history file to filename. This is the file where GDB reads an initial command history list, and where it writes the command history from this session when it exits. You can access this list through history expansion or through the history command editing characters listed below. This file defaults to the value of the environment variable GDBHISTFILE, or to ‘./.gdb_history’ (‘./_gdb_history’ on MS-DOS) if this variable is not set.

set history save
set history save on
  Record command history in a file, whose name may be specified with the set history filename command. By default, this option is disabled.

set history save off
  Stop recording command history in a file.

set history size size
set history size unlimited
  Set the number of commands which GDB keeps in its history list. This defaults to the value of the environment variable GDBHISTSIZE, or to 256 if this variable is not set. Non-numeric values of GDBHISTSIZE are ignored. If size is unlimited or if GDBHISTSIZE is either a negative number or the empty string, then the number of commands GDB keeps in the history list is unlimited.
set history remove-duplicates count
set history remove-duplicates unlimited
   Control the removal of duplicate history entries in the command history list.
   If count is non-zero, gdb will look back at the last count history entries and
   remove the first entry that is a duplicate of the current entry being added to the
   command history list. If count is unlimited then this lookbehind is unbounded.
   If count is 0, then removal of duplicate history entries is disabled.
   Only history entries added during the current session are considered for removal.
   This option is set to 0 by default.

History expansion assigns special meaning to the character !. See Section 33.1.1 [Event
Designators], page 583, for more details.

Since ! is also the logical not operator in C, history expansion is off by default. If you
decide to enable history expansion with the set history expansion on command, you may
sometimes need to follow ! (when it is used as logical not, in an expression) with a space
or a tab to prevent it from being expanded. The readline history facilities do not attempt
substitution on the strings != and !(, even when history expansion is enabled.

The commands to control history expansion are:
set history expansion on
set history expansion
   Enable history expansion. History expansion is off by default.
set history expansion off
   Disable history expansion.

show history
show history filename
show history save
show history size
show history expansion
   These commands display the state of the gdb history parameters. show
   history by itself displays all four states.

show commands
   Display the last ten commands in the command history.
show commands n
   Print ten commands centered on command number n.
show commands +
   Print ten commands just after the commands last printed.

22.4 Screen Size

Certain commands to gdb may produce large amounts of information output to the screen.
To help you read all of it, gdb pauses and asks you for input at the end of each page of
output. Type RET when you want to continue the output, or q to discard the remaining
output. Also, the screen width setting determines when to wrap lines of output. Depending
on what is being printed, gdb tries to break the line at a readable place, rather than simply
letting it overflow onto the following line.
Normally GDB knows the size of the screen from the terminal driver software. For example, on Unix GDB uses the termcap data base together with the value of the `TERM` environment variable and the `stty rows` and `stty cols` settings. If this is not correct, you can override it with the `set height` and `set width` commands:

```
set height lpp
set height unlimited
show height
set width cpl
set width unlimited
show width
```

These `set` commands specify a screen height of `lpp` lines and a screen width of `cpl` characters. The associated `show` commands display the current settings.

If you specify a height of either `unlimited` or zero lines, GDB does not pause during output no matter how long the output is. This is useful if output is to a file or to an editor buffer.

Likewise, you can specify `set width unlimited` or `set width 0` to prevent GDB from wrapping its output.

```
set pagination on
set pagination off
```

Turn the output pagination on or off; the default is on. Turning pagination off is the alternative to `set height unlimited`. Note that running GDB with the `--batch` option (see Section 2.1.2 [Mode Options], page 13) also automatically disables pagination.

```
show pagination
```

Show the current pagination mode.

## 22.5 Numbers

You can always enter numbers in octal, decimal, or hexadecimal in GDB by the usual conventions: octal numbers begin with ‘0’, decimal numbers end with ‘.’, and hexadecimal numbers begin with ‘0x’. Numbers that neither begin with ‘0’ or ‘0x’, nor end with a ‘.’ are, by default, entered in base 10; likewise, the default display for numbers—when no particular format is specified—is base 10. You can change the default base for both input and output with the commands described below.

```
set input-radix base
```

Set the default base for numeric input. Supported choices for `base` are decimal 8, 10, or 16. The base must itself be specified either unambiguously or using the current input radix; for example, any of

```
set input-radix 012
set input-radix 10.
set input-radix 0xa
```

sets the input base to decimal. On the other hand, `set input-radix 10` leaves the input radix unchanged, no matter what it was, since ‘10’, being without any leading or trailing signs of its base, is interpreted in the current radix. Thus, if the current radix is 16, ‘10’ is interpreted in hex, i.e. as 16 decimal, which doesn’t change the radix.
**set output-radix base**
Set the default base for numeric display. Supported choices for `base` are decimal 8, 10, or 16. The base must itself be specified either unambiguously or using the current input radix.

**show input-radix**
Display the current default base for numeric input.

**show output-radix**
Display the current default base for numeric display.

**set radix [base]**
**show radix**
These commands set and show the default base for both input and output of numbers. `set radix` sets the radix of input and output to the same base; without an argument, it resets the radix back to its default value of 10.

### 22.6 Configuring the Current ABI

GDB can determine the ABI (Application Binary Interface) of your application automatically. However, sometimes you need to override its conclusions. Use these commands to manage GDB’s view of the current ABI.

One GDB configuration can debug binaries for multiple operating system targets, either via remote debugging or native emulation. GDB will autodetect the OS ABI (Operating System ABI) in use, but you can override its conclusion using the `set osabi` command. One example where this is useful is in debugging of binaries which use an alternate C library (e.g. uCLIBC for GNU/Linux) which does not have the same identifying marks that the standard C library for your platform provides.

When GDB is debugging the AArch64 architecture, it provides a “Newlib” OS ABI. This is useful for handling `setjmp` and `longjmp` when debugging binaries that use the newlib C library. The “Newlib” OS ABI can be selected by `set osabi Newlib`.

**show osabi**
Show the OS ABI currently in use.

**set osabi** With no argument, show the list of registered available OS ABI’s.

**set osabi abi**
Set the current OS ABI to `abi`.

Generally, the way that an argument of type `float` is passed to a function depends on whether the function is prototyped. For a prototyped (i.e. ANSI/ISO style) function, `float` arguments are passed unchanged, according to the architecture’s convention for `float`. For unprototyped (i.e. K&R style) functions, `float` arguments are first promoted to type `double` and then passed.

Unfortunately, some forms of debug information do not reliably indicate whether a function is prototyped. If GDB calls a function that is not marked as prototyped, it consults `set coerce-float-to-double`. 
set coerce-float-to-double
set coerce-float-to-double on
Arguments of type float will be promoted to double when passed to an unprototyped function. This is the default setting.

set coerce-float-to-double off
Arguments of type float will be passed directly to unprototyped functions.

show coerce-float-to-double
Show the current setting of promoting float to double.

GDB needs to know the ABI used for your program’s C++ objects. The correct C++ ABI depends on which C++ compiler was used to build your application. GDB only fully supports programs with a single C++ ABI; if your program contains code using multiple C++ ABI’s or if GDB can not identify your program’s ABI correctly, you can tell GDB which ABI to use. Currently supported ABI’s include “gnu-v2”, for g++ versions before 3.0, “gnu-v3”, for g++ versions 3.0 and later, and “hpaCC” for the HP ANSI C++ compiler. Other C++ compilers may use the “gnu-v2” or “gnu-v3” ABI’s as well. The default setting is “auto”.

show cp-abi
Show the C++ ABI currently in use.

set cp-abi
With no argument, show the list of supported C++ ABI’s.

set cp-abi abi
set cp-abi auto
Set the current C++ ABI to abi, or return to automatic detection.

22.7 Automatically loading associated files

GDB sometimes reads files with commands and settings automatically, without being explicitly told so by the user. We call this feature auto-loading. While auto-loading is useful for automatically adapting GDB to the needs of your project, it can sometimes produce unexpected results or introduce security risks (e.g., if the file comes from untrusted sources).

There are various kinds of files GDB can automatically load. In addition to these files, GDB supports auto-loading code written in various extension languages. See Section 23.4 [Auto-loading extensions], page 442.

Note that loading of these associated files (including the local ‘.gdbinit’ file) requires accordingly configured auto-load safe-path (see Section 22.7.3 [Auto-loading safe path], page 305).

For these reasons, GDB includes commands and options to let you control when to auto-load files and which files should be auto-loaded.

set auto-load off
Globally disable loading of all auto-loaded files. You may want to use this command with the ‘-iex’ option (see [Option -init-eval-command], page 16) such as:

$ gdb -iex "set auto-load off" untrusted-executable corefile

Be aware that system init file (see Section C.6 [System-wide configuration], page 596) and init files from your home directory (see [Home Directory Init
To prevent GDB from auto-loading even those init files, use the `-nx` option (see Section 2.1.2 [Mode Options], page 13), in addition to `set auto-load no`.

**show auto-load**

Show whether auto-loading of each specific `auto-load` file(s) is enabled or disabled.

```
(gdb) show auto-load

gdb-scripts: Auto-loading of canned sequences of commands scripts is on.
libthread-db: Auto-loading of inferior specific libthread_db is on.
local-gdbinit: Auto-loading of .gdbinit script from current directory is on.
python-scripts: Auto-loading of Python scripts is on.
safe-path: List of directories from which it is safe to auto-load files
            is $debugdir:$datadir/auto-load.
scripts-directory: List of directories from which to load auto-loaded scripts
                  is $debugdir:$datadir/auto-load.
```

**info auto-load**

Print whether each specific `auto-load` file(s) have been auto-loaded or not.

```
(gdb) info auto-load

gdb-scripts:
    Loaded Script
    Yes /home/user/gdb/gdb-gdb.gdb
libthread-db: No auto-loaded libthread-db.
local-gdbinit: Local .gdbinit file "/home/user/gdb/.gdbinit" has been loaded.
python-scripts:
    Loaded Script
    Yes /home/user/gdb/gdb-gdb.py
```

These are GDB control commands for the auto-loading:

- See [set auto-load off], page 302. Disable auto-loading globally.
- See [show auto-load], page 303. Show setting of all kinds of files.
- See [info auto-load], page 303. Show state of all kinds of files.
- See [set auto-load gdb-scripts], page 321. Control for GDB command scripts.
- See [show auto-load gdb-scripts], page 321. Show setting of GDB command scripts.
- See [info auto-load gdb-scripts], page 321. Show state of GDB command scripts.
- See [set auto-load python-scripts], page 388. Control for GDB Python scripts.
- See [show auto-load python-scripts], page 388. Show setting of GDB Python scripts.
- See [info auto-load python-scripts], page 388. Show state of GDB Python scripts.
- See [set auto-load guile-scripts], page 440. Control for GDB Guile scripts.
- See [show auto-load guile-scripts], page 440. Show setting of GDB Guile scripts.
- See [info auto-load guile-scripts], page 440. Show state of GDB Guile scripts.
- See [set auto-load scripts-directory], page 442. Control for GDB auto-loaded scripts location.
- See [show auto-load scripts-directory], page 443. Show GDB auto-loaded scripts location.
- See [add-auto-load-scripts-directory], page 443. Add directory for auto-loaded scripts location list.
- See [set auto-load local-gdbinit], page 304. Control for init file in the current directory.
See [show auto-load local-gdbinit], page 304. Show setting of init file in the current directory.

See [info auto-load local-gdbinit], page 304. Show state of init file in the current directory.

See [set auto-load libthread-db], page 304. Control for thread debugging library.

See [show auto-load libthread-db], page 304. Show setting of thread debugging library.

See [info auto-load libthread-db], page 305. Show state of thread debugging library.

See [set auto-load safe-path], page 305. Control directories trusted for automatic loading.

See [show auto-load safe-path], page 305. Show directories trusted for automatic loading.

See [add-auto-load-safe-path], page 305. Add directory trusted for automatic loading.

### 22.7.1 Automatically loading init file in the current directory

By default, GDB reads and executes the canned sequences of commands from init file (if any) in the current working directory, see [Init File in the Current Directory during Startup], page 16.

Note that loading of this local ‘.gdbinit’ file also requires accordingly configured auto-load safe-path (see Section 22.7.3 [Auto-loading safe path], page 305).

**set auto-load local-gdbinit [on|off]**

Enable or disable the auto-loading of canned sequences of commands (see Section 23.1 [Sequences], page 315) found in init file in the current directory.

**show auto-load local-gdbinit**

Show whether auto-loading of canned sequences of commands from init file in the current directory is enabled or disabled.

**info auto-load local-gdbinit**

Print whether canned sequences of commands from init file in the current directory have been auto-loaded.

### 22.7.2 Automatically loading thread debugging library

This feature is currently present only on GNU/Linux native hosts.

GDB reads in some cases thread debugging library from places specific to the inferior (see [set libthread-db-search-path], page 39).

The special ‘libthread-db-search-path’ entry ‘$sdir’ is processed without checking this ‘set auto-load libthread-db’ switch as system libraries have to be trusted in general. In all other cases of ‘libthread-db-search-path’ entries GDB checks first if ‘set auto-load libthread-db’ is enabled before trying to open such thread debugging library.

Note that loading of this debugging library also requires accordingly configured auto-load safe-path (see Section 22.7.3 [Auto-loading safe path], page 305).

**set auto-load libthread-db [on|off]**

Enable or disable the auto-loading of inferior specific thread debugging library.
Chapter 22: Controlling GDB

305

show auto-load libthread-db
Show whether auto-loading of inferior specific thread debugging library is enabled or disabled.

info auto-load libthread-db
Print the list of all loaded inferior specific thread debugging libraries and for each such library print list of inferior pids using it.

22.7.3 Security restriction for auto-loading
As the files of inferior can come from untrusted source (such as submitted by an application user) GDB does not always load any files automatically. GDB provides the ‘set auto-load safe-path’ setting to list directories trusted for loading files not explicitly requested by user. Each directory can also be a shell wildcard pattern.

If the path is not set properly you will see a warning and the file will not get loaded:

```
$ ./gdb -q ./gdb
Reading symbols from /home/user/gdb/gdb...done.
warning: File "/home/user/gdb/gdb-gdb.gdb" auto-loading has been
   declined by your ‘auto-load safe-path’ set
to "$debugdir:$datadir/auto-load".
warning: File "/home/user/gdb/gdb-gdb.py" auto-loading has been
declined by your ‘auto-load safe-path’ set
to "$debugdir:$datadir/auto-load".
```

To instruct GDB to go ahead and use the init files anyway, invoke GDB like this:

```
$ gdb -q -iex "set auto-load safe-path /home/user/gdb" ./gdb
```

The list of trusted directories is controlled by the following commands:

set auto-load safe-path [directories]
Set the list of directories (and their subdirectories) trusted for automatic loading and execution of scripts. You can also enter a specific trusted file. Each directory can also be a shell wildcard pattern; wildcards do not match directory separator - see FNM_PATHNAME for system function fnmatch (see Section “Wildcard Matching” in GNU C Library Reference Manual). If you omit directories, ‘auto-load safe-path’ will be reset to its default value as specified during GDB compilation.

The list of directories uses path separator (‘:’ on GNU and Unix systems, ‘;’ on MS-Windows and MS-DOS) to separate directories, similarly to the PATH environment variable.

show auto-load safe-path
Show the list of directories trusted for automatic loading and execution of scripts.

add-auto-load-safe-path
Add an entry (or list of entries) to the list of directories trusted for automatic loading and execution of scripts. Multiple entries may be delimited by the host platform path separator in use.

This variable defaults to what --with-auto-load-dir has been configured to (see [with-auto-load-dir], page 442). ‘$debugdir’ and ‘$datadir’ substitution applies the same as for
The default `set auto-load safe-path` value can be also overridden by GDB configuration option `--with-auto-load-safe-path`.

Setting this variable to `/` disables this security protection, corresponding GDB configuration option is `--without-auto-load-safe-path`. This variable is supposed to be set to the system directories writable by the system superuser only. Users can add their source directories in init files in their home directories (see [Home Directory Init File], page 16). See also deprecated init file in the current directory (see [Init File in the Current Directory during Startup], page 16).

To force GDB to load the files it declined to load in the previous example, you could use one of the following ways:

```
~/gdbinit': `add-auto-load-safe-path ~/src/gdb'
   Specify this trusted directory (or a file) as additional component of the list. You
   have to specify also any existing directories displayed by `show auto-load
   safe-path' (such as `/usr:/bin` in this example).
```

```
gdb -iex "set auto-load safe-path /usr:/bin:/src/gdb" ... 
   Specify this directory as in the previous case but just for a single GDB session.
```

```
gdb -iex "set auto-load safe-path /" ...  
   Disable auto-loading safety for a single GDB session. This assumes all the files
   you debug during this GDB session will come from trusted sources.
```

```
configure --without-auto-load-safe-path
   During compilation of GDB you may disable any auto-loading safety. This
   assumes all the files you will ever debug with this GDB come from trusted
   sources.
```

On the other hand you can also explicitly forbid automatic files loading which also suppresses any such warning messages:

```
gdb -iex "set auto-load no" ... 
   You can use GDB command-line option for a single GDB session.
```

```
~/gdbinit': `set auto-load no'
   Disable auto-loading globally for the user (see [Home Directory Init File],
   page 16). While it is improbable, you could also use system init file instead
   (see Section C.6 [System-wide configuration], page 596).
```

This setting applies to the file names as entered by user. If no entry matches GDB tries as a last resort to also resolve all the file names into their canonical form (typically resolving symbolic links) and compare the entries again. GDB already canonicalizes most of the filenames on its own before starting the comparison so a canonical form of directories is recommended to be entered.

### 22.7.4 Displaying files tried for auto-load

For better visibility of all the file locations where you can place scripts to be auto-loaded with inferior — or to protect yourself against accidental execution of untrusted scripts — GDB provides a feature for printing all the files attempted to be loaded. Both existing and non-existing files may be printed.
For example the list of directories from which it is safe to auto-load files (see Section 22.7.3 [Auto-loading safe path], page 305) applies also to canonicalized filenames which may not be too obvious while setting it up.

```
(gdb) set debug auto-load on
(gdb) file ~/src/t/true
auto-load: Loading canned sequences of commands script "/tmp/true-gdb.gdb"
    for objfile "/tmp/true".
auto-load: Updating directories of "/usr:/opt".
auto-load: Using directory "/usr".
auto-load: Using directory "/opt".
warning: File "/tmp/true-gdb.gdb" auto-loading has been declined
    by your 'auto-load safe-path' set to "/usr:/opt".
```

```
set debug auto-load [on|off]
Set whether to print the filenames attempted to be auto-loaded.
```

```
show debug auto-load
Show whether printing of the filenames attempted to be auto-loaded is turned on or off.
```

### 22.8 Optional Warnings and Messages

By default, GDB is silent about its inner workings. If you are running on a slow machine, you may want to use the `set verbose` command. This makes GDB tell you when it does a lengthy internal operation, so you will not think it has crashed.

Currently, the messages controlled by `set verbose` are those which announce that the symbol table for a source file is being read; see `symbol-file` in Section 18.1 [Commands to Specify Files], page 237.

```
set verbose on
Enables GDB output of certain informational messages.
```

```
set verbose off
Disables GDB output of certain informational messages.
```

```
show verbose
Displays whether `set verbose` is on or off.
```

By default, if GDB encounters bugs in the symbol table of an object file, it is silent; but if you are debugging a compiler, you may find this information useful (see Section 18.6 [Errors Reading Symbol Files], page 251).

```
set complaints limit
Permits GDB to output limit complaints about each type of unusual symbols
before becoming silent about the problem. Set limit to zero to suppress all complaints; set it to a large number to prevent complaints from being suppressed.
```

```
show complaints
Displays how many symbol complaints GDB is permitted to produce.
```

By default, GDB is cautious, and asks what sometimes seems to be a lot of stupid questions to confirm certain commands. For example, if you try to run a program which is already running:
(gdb) run
The program being debugged has been started already.
Start it from the beginning? (y or n)

If you are willing to unflinchingly face the consequences of your own commands, you can disable this “feature”:

```plaintext
set confirm off
```

Disables confirmation requests. Note that running gdb with the ‘--batch’ option (see Section 2.1.2 [Mode Options], page 13) also automatically disables confirmation requests.

```plaintext
set confirm on
```

Enables confirmation requests (the default).

```plaintext
show confirm
```

Displays state of confirmation requests.

If you need to debug user-defined commands or sourced files you may find it useful to enable command tracing. In this mode each command will be printed as it is executed, prefixed with one or more ‘+’ symbols, the quantity denoting the call depth of each command.

```plaintext
set trace-commands on
```

Enable command tracing.

```plaintext
set trace-commands off
```

Disable command tracing.

```plaintext
show trace-commands
```

Display the current state of command tracing.

### 22.9 Optional Messages about Internal Happenings

GDB has commands that enable optional debugging messages from various GDB subsystems; normally these commands are of interest to GDB maintainers, or when reporting a bug. This section documents those commands.

```plaintext
set exec-done-display
```

Turns on or off the notification of asynchronous commands’ completion. When on, GDB will print a message when an asynchronous command finishes its execution. The default is off.

```plaintext
show exec-done-display
```

Displays the current setting of asynchronous command completion notification.

```plaintext
set debug aarch64
```

Turns on or off display of debugging messages related to ARM AArch64. The default is off.

```plaintext
show debug aarch64
```

Displays the current state of displaying debugging messages related to ARM AArch64.

```plaintext
set debug arch
```

Turns on or off display of gdbarch debugging info. The default is off
show debug arch
Displays the current state of displaying gdbarch debugging info.

set debug aix-solib
Control display of debugging messages from the AIX shared library support module. The default is off.

show debug aix-thread
Show the current state of displaying AIX shared library debugging messages.

set debug aix-thread
Display debugging messages about inner workings of the AIX thread module.

show debug aix-thread
Show the current state of AIX thread debugging info display.

set debug check-physname
Check the results of the “physname” computation. When reading DWARF debugging information for C++, GDB attempts to compute each entity’s name. GDB can do this computation in two different ways, depending on exactly what information is present. When enabled, this setting causes GDB to compute the names both ways and display any discrepancies.

show debug check-physname
Show the current state of “physname” checking.

set debug coff-pe-read
Control display of debugging messages related to reading of COFF/PE exported symbols. The default is off.

show debug coff-pe-read
Displays the current state of displaying debugging messages related to reading of COFF/PE exported symbols.

set debug dwarf-die
Dump DWARF DIEs after they are read in. The value is the number of nesting levels to print. A value of zero turns off the display.

show debug dwarf-die
Show the current state of DWARF DIE debugging.

set debug dwarf-line
Turns on or off display of debugging messages related to reading DWARF line tables. The default is 0 (off). A value of 1 provides basic information. A value greater than 1 provides more verbose information.

show debug dwarf-line
Show the current state of DWARF line table debugging.

set debug dwarf-read
Turns on or off display of debugging messages related to reading DWARF debug info. The default is 0 (off). A value of 1 provides basic information. A value greater than 1 provides more verbose information.
show debug dwarf-read
  Show the current state of DWARF reader debugging.

set debug displaced
  Turns on or off display of GDB debugging info for the displaced stepping support. The default is off.

show debug displaced
  Displays the current state of displaying GDB debugging info related to displaced stepping.

set debug event
  Turns on or off display of GDB event debugging info. The default is off.

show debug event
  Displays the current state of displaying GDB event debugging info.

set debug expression
  Turns on or off display of debugging info about GDB expression parsing. The default is off.

show debug expression
  Displays the current state of displaying debugging info about GDB expression parsing.

set debug frame
  Turns on or off display of GDB frame debugging info. The default is off.

show debug frame
  Displays the current state of displaying GDB frame debugging info.

set debug gnu-nat
  Turns on or off debugging messages from the GNU/Hurd debug support.

show debug gnu-nat
  Show the current state of GNU/Hurd debugging messages.

set debug infrun
  Turns on or off display of GDB debugging info for running the inferior. The default is off. ‘infrun.c’ contains GDB’s runtime state machine used for implementing operations such as single-stepping the inferior.

show debug infrun
  Displays the current state of GDB inferior debugging.

set debug jit
  Turns on or off debugging messages from JIT debug support.

show debug jit
  Displays the current state of GDB JIT debugging.

set debug lin-lwp
  Turns on or off debugging messages from the Linux LWP debug support.

show debug lin-lwp
  Show the current state of Linux LWP debugging messages.
set debug linux-namespaces
  Turns on or off debugging messages from the Linux namespaces debug support.

show debug linux-namespaces
  Show the current state of Linux namespaces debugging messages.

set debug mach-o
  Control display of debugging messages related to Mach-O symbols processing.
  The default is off.

show debug mach-o
  Displays the current state of displaying debugging messages related to reading
  of COFF/PE exported symbols.

set debug notification
  Turns on or off debugging messages about remote async notification. The de-
  fault is off.

show debug notification
  Displays the current state of remote async notification debugging messages.

set debug observer
  Turns on or off display of GDB observer debugging. This includes info such as
  the notification of observable events.

show debug observer
  Displays the current state of observer debugging.

set debug overload
  Turns on or off display of GDB C++ overload debugging info. This includes info
  such as ranking of functions, etc. The default is off.

show debug overload
  Displays the current state of displaying GDB C++ overload debugging info.

set debug parser
  Turns on or off the display of expression parser debugging output. Internally,
  this sets the yydebug variable in the expression parser. See Section “Tracing
  Your Parser” in Bison, for details. The default is off.

show debug parser
  Show the current state of expression parser debugging.

set debug remote
  Turns on or off display of reports on all packets sent back and forth across the
  serial line to the remote machine. The info is printed on the GDB standard
  output stream. The default is off.

show debug remote
  Displays the state of display of remote packets.

set debug serial
  Turns on or off display of GDB serial debugging info. The default is off.

show debug serial
  Displays the current state of displaying GDB serial debugging info.
set debug solib-frv
  Turns on or off debugging messages for FR-V shared-library code.

show debug solib-frv
  Display the current state of FR-V shared-library code debugging messages.

set debug symbol-lookup
  Turns on or off display of debugging messages related to symbol lookup. The
default is 0 (off). A value of 1 provides basic information. A value greater than
1 provides more verbose information.

show debug symbol-lookup
  Show the current state of symbol lookup debugging messages.

set debug symfile
  Turns on or off display of debugging messages related to symbol file functions.
The default is off. See Section 18.1 [Files], page 237.

show debug symfile
  Show the current state of symbol file debugging messages.

set debug symtab-create
  Turns on or off display of debugging messages related to symbol table creation.
The default is 0 (off). A value of 1 provides basic information. A value greater
than 1 provides more verbose information.

show debug symtab-create
  Show the current state of symbol table creation debugging.

set debug target
  Turns on or off display of GDB target debugging info. This info includes what
is going on at the target level of GDB, as it happens. The default is 0. Set it
to 1 to track events, and to 2 to also track the value of large memory transfers.

show debug target
  Displays the current state of displaying GDB target debugging info.

set debug timestamp
  Turns on or off display of timestamps with GDB debugging info. When enabled,
seconds and microseconds are displayed before each debugging message.

show debug timestamp
  Displays the current state of displaying timestamps with GDB debugging info.

set debug varobj
  Turns on or off display of GDB variable object debugging info. The default is
off.

show debug varobj
  Displays the current state of displaying GDB variable object debugging info.

set debug xml
  Turns on or off debugging messages for built-in XML parsers.

show debug xml
  Displays the current state of XML debugging messages.
22.10 Other Miscellaneous Settings

set interactive-mode
If on, forces GDB to assume that GDB was started in a terminal. In practice, this means that GDB should wait for the user to answer queries generated by commands entered at the command prompt. If off, forces GDB to operate in the opposite mode, and it uses the default answers to all queries. If auto (the default), GDB tries to determine whether its standard input is a terminal, and works in interactive-mode if it is, non-interactively otherwise.
In the vast majority of cases, the debugger should be able to guess correctly which mode should be used. But this setting can be useful in certain specific cases, such as running a MinGW GDB inside a cygwin window.

show interactive-mode
Displays whether the debugger is operating in interactive mode or not.
23 Extending GDB

GDB provides several mechanisms for extension. GDB also provides the ability to automatically load extensions when it reads a file for debugging. This allows the user to automatically customize GDB for the program being debugged.

To facilitate the use of extension languages, GDB is capable of evaluating the contents of a file. When doing so, GDB can recognize which extension language is being used by looking at the filename extension. Files with an unrecognized filename extension are always treated as a GDB Command Files. See Section 23.1.3 [Command files], page 318.

You can control how GDB evaluates these files with the following setting:

\texttt{set script-extension off}

All scripts are always evaluated as GDB Command Files.

\texttt{set script-extension soft}

The debugger determines the scripting language based on filename extension. If this scripting language is supported, GDB evaluates the script using that language. Otherwise, it evaluates the file as a GDB Command File.

\texttt{set script-extension strict}

The debugger determines the scripting language based on filename extension, and evaluates the script using that language. If the language is not supported, then the evaluation fails.

\texttt{show script-extension}

Display the current value of the \texttt{script-extension} option.

23.1 Canned Sequences of Commands

Aside from breakpoint commands (see Section 5.1.7 [Breakpoint Command Lists], page 62), GDB provides two ways to store sequences of commands for execution as a unit: user-defined commands and command files.

23.1.1 User-defined Commands

A user-defined command is a sequence of GDB commands to which you assign a new name as a command. This is done with the \texttt{define} command. User commands may accept up to 10 arguments separated by whitespace. Arguments are accessed within the user command via $\texttt{arg0}...$\texttt{arg9}. A trivial example:

\begin{verbatim}
define adder
    print $arg0 + $arg1 + $arg2
end
\end{verbatim}

To execute the command use:

\begin{verbatim}
adder 1 2 3
\end{verbatim}

This defines the command \texttt{adder}, which prints the sum of its three arguments. Note the arguments are text substitutions, so they may reference variables, use complex expressions, or even perform inferior functions calls.

In addition, $\texttt{argc}$ may be used to find out how many arguments have been passed. This expands to a number in the range 0...10.
define adder
  if $argc == 2
    print $arg0 + $arg1
  end
  if $argc == 3
    print $arg0 + $arg1 + $arg2
  end
end

define commandname
  Define a command named commandname. If there is already a command by that name, you are asked to confirm that you want to redefine it. The argument commandname may be a bare command name consisting of letters, numbers, dashes, and underscores. It may also start with any predefined prefix command. For example, ‘define target my-target’ creates a user-defined ‘target my-target’ command.

  The definition of the command is made up of other GDB command lines, which are given following the define command. The end of these commands is marked by a line containing end.

document commandname
  Document the user-defined command commandname, so that it can be accessed by help. The command commandname must already be defined. This command reads lines of documentation just as define reads the lines of the command definition, ending with end. After the document command is finished, help on command commandname displays the documentation you have written.

  You may use the document command again to change the documentation of a command. Redefining the command with define does not change the documentation.

dont-repeat
  Used inside a user-defined command, this tells GDB that this command should not be repeated when the user hits RET (see Section 3.1 [Command Syntax], page 19).

help user-defined
  List all user-defined commands and all python commands defined in class COMMAND_USER. The first line of the documentation or docstring is included (if any).

show user

show user commandname
  Display the GDB commands used to define commandname (but not its documentation). If no commandname is given, display the definitions for all user-defined commands. This does not work for user-defined python commands.

show max-user-call-depth

set max-user-call-depth
  The value of max-user-call-depth controls how many recursion levels are allowed in user-defined commands before GDB suspects an infinite recursion and aborts the command. This does not apply to user-defined python commands.
In addition to the above commands, user-defined commands frequently use control flow commands, described in Section 23.1.3 [Command Files], page 318.

When user-defined commands are executed, the commands of the definition are not printed. An error in any command stops execution of the user-defined command.

If used interactively, commands that would ask for confirmation proceed without asking when used inside a user-defined command. Many \texttt{gdb} commands that normally print messages to say what they are doing omit the messages when used in a user-defined command.

### 23.1.2 User-defined Command Hooks

You may define \textit{hooks}, which are a special kind of user-defined command. Whenever you run the command ‘\texttt{foo}’, if the user-defined command ‘\texttt{hook-foo}’ exists, it is executed (with no arguments) before that command.

A hook may also be defined which is run after the command you executed. Whenever you run the command ‘\texttt{foo}’, if the user-defined command ‘\texttt{hookpost-foo}’ exists, it is executed (with no arguments) after that command. Post-execution hooks may exist simultaneously with pre-execution hooks, for the same command.

It is valid for a hook to call the command which it hooks. If this occurs, the hook is not re-executed, thereby avoiding infinite recursion.

In addition, a pseudo-command, ‘\texttt{stop}’ exists. Defining (‘\texttt{hook-stop}’) makes the associated commands execute every time execution stops in your program: before breakpoint commands are run, displays are printed, or the stack frame is printed.

For example, to ignore \texttt{SIGALRM} signals while single-stepping, but treat them normally during normal execution, you could define:

```bash
define hook-stop
  handle SIGALRM nopass
end

define hook-run
  handle SIGALRM pass
end

define hook-continue
  handle SIGALRM pass
end
```

As a further example, to hook at the beginning and end of the \texttt{echo} command, and to add extra text to the beginning and end of the message, you could define:

```bash
define hook-echo
  echo <<<---
end

define hookpost-echo
  echo --->>>
end
```

(gdb) \texttt{echo Hello World}
<<<---Hello World--->>>
(gdb)

You can define a hook for any single-word command in \texttt{gdb}, but not for command aliases; you should define a hook for the basic command name, e.g. \texttt{backtrace} rather than
bt. You can hook a multi-word command by adding hook- or hookpost- to the last word of the command, e.g. `define target hook-remote` to add a hook to `target remote`.

If an error occurs during the execution of your hook, execution of GDB commands stops and GDB issues a prompt (before the command that you actually typed had a chance to run).

If you try to define a hook which does not match any known command, you get a warning from the define command.

### 23.1.3 Command Files

A command file for GDB is a text file made of lines that are GDB commands. Comments (lines starting with `#`) may also be included. An empty line in a command file does nothing; it does not mean to repeat the last command, as it would from the terminal.

You can request the execution of a command file with the source command. Note that the source command is also used to evaluate scripts that are not Command Files. The exact behavior can be configured using the script-extension setting. See Chapter 23 [Extending GDB], page 315.

```bash
source [-s] [-v] filename
```

Execute the command file `filename`.

The lines in a command file are generally executed sequentially, unless the order of execution is changed by one of the flow-control commands described below. The commands are not printed as they are executed. An error in any command terminates execution of the command file and control is returned to the console.

GDB first searches for `filename` in the current directory. If the file is not found there, and `filename` does not specify a directory, then GDB also looks for the file on the source search path (specified with the `directory` command); except that `$cdir` is not searched because the compilation directory is not relevant to scripts.

If `-s` is specified, then GDB searches for `filename` on the search path even if `filename` specifies a directory. The search is done by appending `filename` to each element of the search path. So, for example, if `filename` is `mylib/myscript` and the search path contains `/home/user` then GDB will look for the script `/home/user/mylib/myscript`. The search is also done if `filename` is an absolute path. For example, if `filename` is `/tmp/myscript` and the search path contains `/home/user` then GDB will look for the script `/home/user/tmp/myscript`.

For DOS-like systems, if `filename` contains a drive specification, it is stripped before concatenation. For example, if `filename` is `d:\myscript` and the search path contains `c:\tmp` then GDB will look for the script `c:\tmp/myscript`.

If `-v`, for verbose mode, is given then GDB displays each command as it is executed. The option must be given before `filename`, and is interpreted as part of the filename anywhere else.

Commands that would ask for confirmation if used interactively proceed without asking when used in a command file. Many GDB commands that normally print messages to say what they are doing omit the messages when called from command files.

GDB also accepts command input from standard input. In this mode, normal output goes to standard output and error output goes to standard error. Errors in a command file supplied on standard input do not terminate execution of the command file—execution continues with the next command.
gdb < cmds > log 2>&1

(The syntax above will vary depending on the shell used.) This example will execute commands from the file ‘cmds’. All output and errors would be directed to ‘log’.

Since commands stored on command files tend to be more general than commands typed interactively, they frequently need to deal with complicated situations, such as different or unexpected values of variables and symbols, changes in how the program being debugged is built, etc. GDB provides a set of flow-control commands to deal with these complexities. Using these commands, you can write complex scripts that loop over data structures, execute commands conditionally, etc.

if
else

This command allows to include in your script conditionally executed commands. The if command takes a single argument, which is an expression to evaluate. It is followed by a series of commands that are executed only if the expression is true (its value is nonzero). There can then optionally be an else line, followed by a series of commands that are only executed if the expression was false. The end of the list is marked by a line containing end.

while

This command allows to write loops. Its syntax is similar to if: the command takes a single argument, which is an expression to evaluate, and must be followed by the commands to execute, one per line, terminated by an end. These commands are called the body of the loop. The commands in the body of while are executed repeatedly as long as the expression evaluates to true.

loop_break

This command exits the while loop in whose body it is included. Execution of the script continues after that while end line.

loop_continue

This command skips the execution of the rest of the body of commands in the while loop in whose body it is included. Execution branches to the beginning of the while loop, where it evaluates the controlling expression.

end

Terminate the block of commands that are the body of if, else, or while flow-control commands.

23.1.4 Commands for Controlled Output

During the execution of a command file or a user-defined command, normal GDB output is suppressed; the only output that appears is what is explicitly printed by the commands in the definition. This section describes three commands useful for generating exactly the output you want.

echo text

Print text. Nonprinting characters can be included in text using C escape sequences, such as ‘\n’ to print a newline. No newline is printed unless you specify one. In addition to the standard C escape sequences, a backslash followed by a space stands for a space. This is useful for displaying a string with spaces at the beginning or the end, since leading and trailing spaces are otherwise trimmed from all arguments. To print ‘ and foo = ’, use the command ‘echo \ and foo = \ ’.
A backslash at the end of text can be used, as in C, to continue the command onto subsequent lines. For example,

```bash
echo This is some text
  which is continued
  onto several lines.
```

produces the same output as

```bash
echo This is some text
echo which is continued
echo onto several lines.
```

**output expression**

Print the value of expression and nothing but that value: no newlines, no `$nn` = `. The value is not entered in the value history either. See Section 10.1 [Expressions], page 115, for more information on expressions.

**output/fmt expression**

Print the value of expression in format fmt. You can use the same formats as for print. See Section 10.5 [Output Formats], page 120, for more information.

**printf template, expressions...**

Print the values of one or more expressions under the control of the string template. To print several values, make expressions be a comma-separated list of individual expressions, which may be either numbers or pointers. Their values are printed as specified by template, exactly as a C program would do by executing the code below:

```c
printf (template, expressions...);
```

As in C printf, ordinary characters in template are printed verbatim, while conversion specification introduced by the `%` character cause subsequent expressions to be evaluated, their values converted and formatted according to type and style information encoded in the conversion specifications, and then printed.

For example, you can print two values in hex like this:

```bash
printf "foo, bar-foo = 0x%x, 0x%x\n", foo, bar-foo
```

**printf** supports all the standard C conversion specifications, including the flags and modifiers between the `%` character and the conversion letter, with the following exceptions:

- The argument-ordering modifiers, such as `2$`, are not supported.
- The modifier `*` is not supported for specifying precision or width.
- The ‘+’ flag (for separation of digits into groups according to LC_NUMERIC) is not supported.
- The type modifiers ‘hh’, ‘j’, ‘t’, and ‘z’ are not supported.
- The conversion letter ‘n’ (as in ‘%n’) is not supported.
- The conversion letters ‘a’ and ‘A’ are not supported.

Note that the ‘11’ type modifier is supported only if the underlying C implementation used to build GDB supports the `long long int` type, and the ‘L’ type modifier is supported only if `long double` type is available.
As in C, \printf supports simple backslash-escape sequences, such as \n, \t, \\
, \", \a, and \f, that consist of backslash followed by a single character. Octal and hexadecimal escape sequences are not supported.

Additionally, \printf supports conversion specifications for DFP (Decimal Floating Point) types using the following length modifiers together with a floating point specifier. letters:

- ‘H’ for printing Decimal32 types.
- ‘D’ for printing Decimal64 types.
- ‘DD’ for printing Decimal128 types.

If the underlying C implementation used to build \gdb has support for the three length modifiers for DFP types, other modifiers such as width and precision will also be available for \gdb to use.

In case there is no such C support, no additional modifiers will be available and the value will be printed in the standard way.

Here’s an example of printing DFP types using the above conversion letters:

\printf "D32: %Hf - D64: %Df - D128: %DFf\n",1.2345df,1.2E10dd,1.2E1dl

eval template, expressions...
Convert the values of one or more expressions under the control of the string \template to a command line, and call it.

### 23.1.5 Controlling auto-loading native \gdb scripts

When a new object file is read (for example, due to the file command, or because the inferior has loaded a shared library), \gdb will look for the command file ‘objfile-gdb.gdb’. See Section 23.4 [Auto-loading extensions], page 442.

Auto-loading can be enabled or disabled, and the list of auto-loaded scripts can be printed.

\texttt{set auto-load gdb-scripts [on|off]}
Enable or disable the auto-loading of canned sequences of commands scripts.

\texttt{show auto-load gdb-scripts}
Show whether auto-loading of canned sequences of commands scripts is enabled or disabled.

\texttt{info auto-load gdb-scripts [regexp]}
Print the list of all canned sequences of commands scripts that \gdb auto-loaded.

If \regexp is supplied only canned sequences of commands scripts with matching names are printed.

### 23.2 Extending \gdb using Python

You can extend \gdb using the Python programming language. This feature is available only if \gdb was configured using ‘--with-python’.

Python scripts used by \gdb should be installed in ‘data-directory/python’, where data-directory is the data directory as determined at \gdb startup (see Section 18.7 [Data Files], page 252). This directory, known as the python directory, is automatically added
to the Python Search Path in order to allow the Python interpreter to locate all scripts installed at this location.

Additionally, GDB commands and convenience functions which are written in Python and are located in the ‘data-directory/python/gdb/command’ or ‘data-directory/python/gdb/function’ directories are automatically imported when GDB starts.

### 23.2.1 Python Commands

GDB provides two commands for accessing the Python interpreter, and one related setting:

**python-interactive [command]**

**pi [command]**

Without an argument, the `python-interactive` command can be used to start an interactive Python prompt. To return to GDB, type the `EOF` character (e.g., `Ctrl-D` on an empty prompt).

Alternatively, a single-line Python command can be given as an argument and evaluated. If the command is an expression, the result will be printed; otherwise, nothing will be printed. For example:

```
(gdb) python-interactive 2 + 3
5
```

**python [command]**

**py [command]**

The `python` command can be used to evaluate Python code.

If given an argument, the `python` command will evaluate the argument as a Python command. For example:

```
(gdb) python print 23
23
```

If you do not provide an argument to `python`, it will act as a multi-line command, like `define`. In this case, the Python script is made up of subsequent command lines, given after the `python` command. This command list is terminated using a line containing `end`. For example:

```
(gdb) python
Type python script
End with a line saying just "end".
>print 23
>end
23
```

**set python print-stack**

By default, GDB will print only the message component of a Python exception when an error occurs in a Python script. This can be controlled using `set python print-stack`: if full, then full Python stack printing is enabled; if none, then Python stack and message printing is disabled; if `message`, the default, only the message component of the error is printed.

It is also possible to execute a Python script from the GDB interpreter:
source `script-name`

The script name must end with `\.py` and GDB must be configured to recognize
the script language based on filename extension using the `script-extension`
setting. See Chapter 23 [Extending GDB], page 315.

`python execfile ("script-name")`

This method is based on the `execfile` Python built-in function, and thus is
always available.

### 23.2.2 Python API

You can get quick online help for GDB’s Python API by issuing the command
`python help (gdb)`. Functions and methods which have two or more optional arguments allow them to be
specified using keyword syntax. This allows passing some optional arguments while skipping
others. Example: `gdb.some_function (‘foo’, bar = 1, baz = 2)

#### 23.2.2.1 Basic Python

At startup, GDB overrides Python’s `sys.stdout` and `sys.stderr` to print using GDB’s
output-paging streams. A Python program which outputs to one of these streams may
have its output interrupted by the user (see Section 22.4 [Screen Size], page 299). In this
situation, a Python `KeyboardInterrupt` exception is thrown.

Some care must be taken when writing Python code to run in GDB. Two things worth
noting in particular:

- GDB install handlers for `SIGCHLD` and `SIGINT`. Python code must not override these,
or even change the options using `sigaction`. If your program changes the handling of
these signals, GDB will most likely stop working correctly. Note that it is unfortunately
common for GUI toolkits to install a `SIGCHLD` handler.

- GDB takes care to mark its internal file descriptors as close-on-exec. However, this
cannot be done in a thread-safe way on all platforms. Your Python programs should
be aware of this and should both create new file descriptors with the close-on-exec flag
set and arrange to close unneeded file descriptors before starting a child process.

GDB introduces a new Python module, named `gdb`. All methods and classes added by
GDB are placed in this module. GDB automatically `imports` the `gdb` module for use in all
scripts evaluated by the `python` command.

```
gdb.PYTHONDIR  
A string containing the python directory (see Section 23.2 [Python], page 321).

```

```
gdb.execute (command [, from_tty [, to_string]])  
Evaluate command, a string, as a GDB CLI command. If a GDB exception happens
while command runs, it is translated as described in Section 23.2.2.2 [Exception
Handling], page 326.

The from_tty flag specifies whether GDB ought to consider this command as having
originated from the user invoking it interactively. It must be a boolean value. If
omitted, it defaults to `False`

By default, any output produced by command is sent to GDB’s standard output (and
to the log output if logging is turned on). If the to_string parameter is `True`, then
output will be collected by `gdb.execute` and returned as a string. The default is `False`, in which case the return value is `None`. If `to_string` is `True`, the GDB virtual terminal will be temporarily set to unlimited width and height, and its pagination will be disabled; see Section 22.4 [Screen Size], page 299.

```python
[Function]
gdb.breakpoints ()

Return a sequence holding all of GDB’s breakpoints. See Section 23.2.2.29 [Breakpoints In Python], page 382, for more information.
```

```python
[Function]
gdb.parameter (parameter)

Return the value of a GDB parameter given by its name, a string; the parameter name string may contain spaces if the parameter has a multi-part name. For example, ‘print object’ is a valid parameter name.

If the named parameter does not exist, this function throws a `gdb.error` (see Section 23.2.2.2 [Exception Handling], page 326). Otherwise, the parameter’s value is converted to a Python value of the appropriate type, and returned.
```

```python
[Function]
gdb.history (number)

Return a value from GDB’s value history (see Section 10.10 [Value History], page 136). The `number` argument indicates which history element to return. If `number` is negative, then GDB will take its absolute value and count backward from the last element (i.e., the most recent element) to find the value to return. If `number` is zero, then GDB will return the most recent element. If the element specified by `number` doesn’t exist in the value history, a `gdb.error` exception will be raised.

If no exception is raised, the return value is always an instance of `gdb.Value` (see Section 23.2.2.3 [Values From Inferior], page 327).
```

```python
[Function]
gdb.parse_and_eval (expression)

Parse `expression`, which must be a string, as an expression in the current language, evaluate it, and return the result as a `gdb.Value`.

This function can be useful when implementing a new command (see Section 23.2.2.19 [Commands In Python], page 362), as it provides a way to parse the command’s argument as an expression. It is also useful simply to compute values, for example, it is the only way to get the value of a convenience variable (see Section 10.11 [Convenience Vars], page 137) as a `gdb.Value`.
```

```python
[Function]
gdb.find_pc_line (pc)

Return the `gdb.Symtab_and_line` object corresponding to the `pc` value. See Section 23.2.2.27 [Symbol Tables In Python], page 380. If an invalid value of `pc` is passed as an argument, then the `symtab` and `line` attributes of the returned `gdb.Symtab_and_line` object will be `None` and 0 respectively.
```

```python
[Function]
gdb.post_event (event)

Put `event`, a callable object taking no arguments, into GDB’s internal event queue. This callable will be invoked at some later point, during GDB’s event processing. Events posted using `post_event` will be run in the order in which they were posted; however, there is no way to know when they will be processed relative to other events inside GDB.
```
GDB is not thread-safe. If your Python program uses multiple threads, you must be careful to only call GDB-specific functions in the GDB thread. `post_event` ensures this. For example:

```python
(gdb) python
import threading

class Writer:
    def __init__(self, message):
        self.message = message;
    def __call__(self):
        gdb.write(self.message)

class MyThread1 (threading.Thread):
    def run (self):
        gdb.post_event(Writer("Hello "))

class MyThread2 (threading.Thread):
    def run (self):
        gdb.post_event(Writer("World\n"))

MyThread1().start()
MyThread2().start()
end
(gdb) Hello World
```

`gdb.write` ([Function]

Print a string to GDB’s paginated output stream. The optional `stream` determines the stream to print to. The default stream is GDB’s standard output stream. Possible stream values are:

- `gdb.STDOUT`  
  GDB’s standard output stream.

- `gdb.STDERR`  
  GDB’s standard error stream.

- `gdb.STDLOG`  
  GDB’s log stream (see Section 2.4 [Logging Output], page 18).

Writing to `sys.stdout` or `sys.stderr` will automatically call this function and will automatically direct the output to the relevant stream.

`gdb.flush` ([Function]

Flush the buffer of a GDB paginated stream so that the contents are displayed immediately. GDB will flush the contents of a stream automatically when it encounters a newline in the buffer. The optional `stream` determines the stream to flush. The default stream is GDB’s standard output stream. Possible stream values are:

- `gdb.STDOUT`  
  GDB’s standard output stream.

- `gdb.STDERR`  
  GDB’s standard error stream.

- `gdb.STDLOG`  
  GDB’s log stream (see Section 2.4 [Logging Output], page 18).
Flushing \texttt{sys.stdout} or \texttt{sys.stderr} will automatically call this function for the relevant stream.

\texttt{gdb.target_charset} \hspace{1cm} \textbf{[Function]}
Return the name of the current target character set (see Section 10.20 [Character Sets], page 149). This differs from \texttt{gdb.parameter('target-charset')} in that ‘auto’ is never returned.

\texttt{gdb.target_wide_charset} \hspace{1cm} \textbf{[Function]}
Return the name of the current target wide character set (see Section 10.20 [Character Sets], page 149). This differs from \texttt{gdb.parameter('target-wide-charset')} in that ‘auto’ is never returned.

\texttt{gdb.solib_name} \hspace{1cm} \textbf{[Function]}
Return the name of the shared library holding the given \texttt{address} as a string, or \texttt{None}.

\texttt{gdb.decode_line} \hspace{1cm} \textbf{[Function]}
Return locations of the line specified by \texttt{expression}, or of the current line if no argument was given. This function returns a Python tuple containing two elements. The first element contains a string holding any unparsed section of \texttt{expression} (or \texttt{None} if the expression has been fully parsed). The second element contains either \texttt{None} or another tuple that contains all the locations that match the expression represented as \texttt{gdb.Symtab_and_line} objects (see Section 23.2.2.27 [Symbol Tables In Python], page 380). If \texttt{expression} is provided, it is decoded the way that GDB’s inbuilt \texttt{break} or \texttt{edit} commands do (see Section 9.2 [Specify Location], page 102).

\texttt{gdb.prompt_hook} \hspace{1cm} \textbf{[Function]}
If \texttt{promptHook} is callable, GDB will call the method assigned to this operation before a prompt is displayed by GDB.

The parameter \texttt{current_prompt} contains the current GDB prompt. This method must return a Python string, or \texttt{None}. If a string is returned, the GDB prompt will be set to that string. If \texttt{None} is returned, GDB will continue to use the current prompt.

Some prompts cannot be substituted in GDB. Secondary prompts such as those used by readline for command input, and annotation related prompts are prohibited from being changed.

\textbf{23.2.2.2 Exception Handling}

When executing the \texttt{python} command, Python exceptions uncaught within the Python code are translated to calls to GDB error-reporting mechanism. If the command that called \texttt{python} does not handle the error, GDB will terminate it and print an error message containing the Python exception name, the associated value, and the Python call stack backtrace at the point where the exception was raised. Example:

```
(gdb) python print foo
Traceback (most recent call last):
  File "<string>", line 1, in <module>
NameError: name 'foo' is not defined
```

GDB errors that happen in GDB commands invoked by Python code are converted to Python exceptions. The type of the Python exception depends on the error.
Chapter 23: Extending GDB

327

gdb.error
This is the base class for most exceptions generated by GDB. It is derived from RuntimeException, for compatibility with earlier versions of GDB.

If an error occurring in GDB does not fit into some more specific category, then the generated exception will have this type.

gdb.MemoryError
This is a subclass of gdb.error which is thrown when an operation tried to access invalid memory in the inferior.

KeyboardInterrupt
User interrupt (via C-c or by typing q at a pagination prompt) is translated to a Python KeyboardInterrupt exception.

In all cases, your exception handler will see the GDB error message as its value and the Python call stack backtrace at the Python statement closest to where the GDB error occurred as the traceback.

When implementing GDB commands in Python via gdb.Command, it is useful to be able to throw an exception that doesn’t cause a traceback to be printed. For example, the user may have invoked the command incorrectly. Use the gdb.GdbError exception to handle this case. Example:

(gdb) python
>class HelloWorld (gdb.Command):
>   """Greet the whole world."""
>   def __init__ (self):
>     super (HelloWorld, self).__init__ ("hello-world", gdb.COMMAND_USER)
>     def invoke (self, args, from_tty):
>       argv = gdb.string_to_argv (args)
>       if len (argv) != 0:
>         raise gdb.GdbError ("hello-world takes no arguments")
>       print "Hello, World!"
>   HelloWorld ()
>end
(gdb) hello-world 42
hello-world takes no arguments

23.2.2.3 Values From Inferior

GDB provides values it obtains from the inferior program in an object of type gdb.Value. GDB uses this object for its internal bookkeeping of the inferior’s values, and for fetching values when necessary.

Inferior values that are simple scalars can be used directly in Python expressions that are valid for the value’s data type. Here’s an example for an integer or floating-point value some_val:

   bar = some_val + 2

As result of this, bar will also be a gdb.Value object whose values are of the same type as those of some_val. Valid Python operations can also be performed on gdb.Value objects representing a struct or class object. For such cases, the overloaded operator (if present), is used to perform the operation. For example, if val1 and val2 are gdb.Value objects representing instances of a class which overloads the + operator, then one can use the + operator in their Python script as follows:
val3 = val1 + val2

The result of the operation `val3` is also a `gdb.Value` object corresponding to the value returned by the overloaded `+` operator. In general, overloaded operators are invoked for the following operations: `+` (binary addition), `-` (binary subtraction), `*` (multiplication), `/`, `%`, `<<`, `>>`, `|`, `&`, `^`.

Inferior values that are structures or instances of some class can be accessed using the Python dictionary syntax. For example, if `some_val` is a `gdb.Value` instance holding a structure, you can access its `foo` element with:

```python
bar = some_val['foo']
```

Again, `bar` will also be a `gdb.Value` object. Structure elements can also be accessed by using `gdb.Field` objects as subscripts (see Section 23.2.2.4 [Types In Python], page 332, for more information on `gdb.Field` objects). For example, if `foo_field` is a `gdb.Field` object corresponding to element `foo` of the above structure, then `bar` can also be accessed as follows:

```python
bar = some_val[foo_field]
```

A `gdb.Value` that represents a function can be executed via inferior function call. Any arguments provided to the call must match the function’s prototype, and must be provided in the order specified by that prototype.

For example, `some_val` is a `gdb.Value` instance representing a function that takes two integers as arguments. To execute this function, call it like so:

```python
result = some_val(10, 20)
```

Any values returned from a function call will be stored as a `gdb.Value`.

The following attributes are provided:

- **Value.address**
  
  If this object is addressable, this read-only attribute holds a `gdb.Value` object representing the address. Otherwise, this attribute holds `None`.

- **Value.is_optimized_out**
  
  This read-only boolean attribute is true if the compiler optimized out this value, thus it is not available for fetching from the inferior.

- **Value.type**
  
  The type of this `gdb.Value`. The value of this attribute is a `gdb.Type` object (see Section 23.2.2.4 [Types In Python], page 332).

- **Value.dynamic_type**
  
  The dynamic type of this `gdb.Value`. This uses C++ run-time type information (RTTI) to determine the dynamic type of the value. If this value is of class type, it will return the class in which the value is embedded, if any. If this value is of pointer or reference to a class type, it will compute the dynamic type of the referenced object, and return a pointer or reference to that type, respectively. In all other cases, it will return the value’s static type.

  Note that this feature will only work when debugging a C++ program that includes RTTI for the object in question. Otherwise, it will just return the static type of the value as in `ptype foo` (see Chapter 16 [Symbols], page 217).
Value.is_lazy

The value of this read-only boolean attribute is True if this gdb.Value has not yet been fetched from the inferior. GDB does not fetch values until necessary, for efficiency. For example:

```
myval = gdb.parse_and_eval ('somevar')
```

The value of somevar is not fetched at this time. It will be fetched when the value is needed, or when the fetch_lazy method is invoked.

The following methods are provided:

Value.__init__ (val)

Many Python values can be converted directly to a gdb.Value via this object initializer. Specifically:

Python boolean

A Python boolean is converted to the boolean type from the current language.

Python integer

A Python integer is converted to the C long type for the current architecture.

Python long

A Python long is converted to the C long long type for the current architecture.

Python float

A Python float is converted to the C double type for the current architecture.

Python string

A Python string is converted to a target string in the current target language using the current target encoding. If a character cannot be represented in the current target encoding, then an exception is thrown.

gdb.Value

If val is a gdb.Value, then a copy of the value is made.

gdb.LazyString

If val is a gdb.LazyString (see Section 23.2.2.31 [Lazy Strings In Python], page 386), then the lazy string’s value method is called, and its result is used.

Value.cast (type)

Return a new instance of gdb.Value that is the result of casting this instance to the type described by type, which must be a gdb.Type object. If the cast cannot be performed for some reason, this method throws an exception.

Value.dereference ()

For pointer data types, this method returns a new gdb.Value object whose contents is the object pointed to by the pointer. For example, if foo is a C pointer to an int, declared in your C program as
int *foo;
then you can use the corresponding `gdb.Value` to access what `foo` points to like this:

```c
bar = foo.dereference()
```

The result `bar` will be a `gdb.Value` object holding the value pointed to by `foo`. A similar function `Value.referenced_value` exists which also returns `gdb.Value` objects corresponding to the values pointed to by pointer values (and additionally, values referenced by reference values). However, the behavior of `Value.dereference` differs from `Value.referenced_value` by the fact that the behavior of `Value.dereference` is identical to applying the C unary operator `*` on a given value. For example, consider a reference to a pointer `ptrref`, declared in your C++ program as:

```c
typedef int *intptr;
...
int val = 10;
intptr ptr = &val;
intptr &ptrref = ptr;
```

Though `ptrref` is a reference value, one can apply the method `Value.dereference` to the `gdb.Value` object corresponding to it and obtain a `gdb.Value` which is identical to that corresponding to `val`. However, if you apply the method `Value.referenced_value`, the result would be a `gdb.Value` object identical to that corresponding to `ptr`.

```c
py_ptrref = gdb.parse_and_eval("ptrref")
py_val = py_ptrref.dereference()  # Returns the referenced value
py_ptr = py_ptrref.referenced_value()  # Results in error
```

The `gdb.Value` object `py_val` is identical to that corresponding to `val`, and `py_ptr` is identical to that corresponding to `ptr`. In general, `Value.dereference` can be applied whenever the C unary operator `*` can be applied to the corresponding C value. For those cases where applying both `Value.dereference` and `Value.referenced_value` is allowed, the results obtained need not be identical (as we have seen in the above example). The results are however identical when applied on `gdb.Value` objects corresponding to pointers (`gdb.Value` objects with type code `TYPE_CODE_PTR`) in a C/C++ program.

**Value.referenced_value** ()
[Function]

For pointer or reference data types, this method returns a new `gdb.Value` object corresponding to the value referenced by the pointer/reference value. For pointer data types, `Value.dereference` and `Value.referenced_value` produce identical results. The difference between these methods is that `Value.dereference` cannot get the values referenced by reference values. For example, consider a reference to an `int`, declared in your C++ program as:

```c
int val = 10;
int &ref = val;
```

then applying `Value.dereference` to the `gdb.Value` object corresponding to `ref` will result in an error, while applying `Value.referenced_value` will result in a `gdb.Value` object identical to that corresponding to `val`.

```c
py_ref = gdb.parse_and_eval("ref")
err_ref = py_ref.dereference()  # Results in error
py_val = py_ref.referenced_value()  # Returns the referenced value
```

The `gdb.Value` object `py_val` is identical to that corresponding to `val`. 
Value.reference_value ()

Return a gdb.Value object which is a reference to the value encapsulated by this instance.

Value.const_value ()

Return a gdb.Value object which is a const version of the value encapsulated by this instance.

Value.dynamic_cast (type)

Like Value.cast, but works as if the C++ dynamic_cast operator were used. Consult a C++ reference for details.

Value.reinterpret_cast (type)

Like Value.cast, but works as if the C++ reinterpret_cast operator were used. Consult a C++ reference for details.

Value.string ([encoding[, errors[, length]]])

If this gdb.Value represents a string, then this method converts the contents to a Python string. Otherwise, this method will throw an exception.

Values are interpreted as strings according to the rules of the current language. If the optional length argument is given, the string will be converted to that length, and will include any embedded zeroes that the string may contain. Otherwise, for languages where the string is zero-terminated, the entire string will be converted.

For example, in C-like languages, a value is a string if it is a pointer to or an array of characters or ints of type wchar_t, char16_t, or char32_t.

If the optional encoding argument is given, it must be a string naming the encoding of the string in the gdb.Value, such as "ascii", "iso-8859-6" or "utf-8". It accepts the same encodings as the corresponding argument to Python’s string.decode method, and the Python codec machinery will be used to convert the string. If encoding is not given, or if encoding is the empty string, then either the target-charset (see Section 10.20 [Character Sets], page 149) will be used, or a language-specific encoding will be used, if the current language is able to supply one.

The optional errors argument is the same as the corresponding argument to Python’s string.decode method.

If the optional length argument is given, the string will be fetched and converted to the given length.

Value.lazy_string ([encoding [, length]])

If this gdb.Value represents a string, then this method converts the contents to a gdb.LazyString (see Section 23.2.2.31 [Lazy Strings In Python], page 386). Otherwise, this method will throw an exception.

If the optional encoding argument is given, it must be a string naming the encoding of the gdb.LazyString. Some examples are: 'ascii', 'iso-8859-6' or 'utf-8'. If the encoding argument is an encoding that GDB does recognize, GDB will raise an error.

When a lazy string is printed, the GDB encoding machinery is used to convert the string during printing. If the optional encoding argument is not provided, or is an empty string, GDB will automatically select the encoding most suitable for the string.
type. For further information on encoding in GDB please see Section 10.20 [Character Sets], page 149.

If the optional \texttt{length} argument is given, the string will be fetched and encoded to
the length of characters specified. If the \texttt{length} argument is not provided, the string
will be fetched and encoded until a null of appropriate width is found.

\texttt{Value.fetch\_lazy ()} [Function]

If the \texttt{gdb.Value} object is currently a lazy value (\texttt{gdb.Value.is\_lazy} is \texttt{True}), then
the value is fetched from the inferior. Any errors that occur in the process will produce
a Python exception.

If the \texttt{gdb.Value} object is not a lazy value, this method has no effect.

This method does not return a value.

\subsection{Types In Python}

GDB represents types from the inferior using the class \texttt{gdb.Type}.

The following type-related functions are available in the \texttt{gdb} module:

\texttt{gdb.lookup\_type \textit{name} \texttt{[}, \textit{block}\texttt{]} \texttt{)} [Function]

This function looks up a type by its \textit{name}, which must be a string.

If \textit{block} is given, then \textit{name} is looked up in that scope. Otherwise, it is searched for
globally.

Ordinarily, this function will return an instance of \texttt{gdb.Type}. If the named type
cannot be found, it will throw an exception.

If the type is a structure or class type, or an enum type, the fields of that type can be
accessed using the Python \texttt{dictionary syntax}. For example, if \texttt{some\_type} is a \texttt{gdb.Type}
instance holding a structure type, you can access its \texttt{foo} field with:

\begin{verbatim}
bar = some\_type[’foo’]
\end{verbatim}

\texttt{bar} will be a \texttt{gdb.Field} object; see below under the description of the \texttt{Type.fields}
method for a description of the \texttt{gdb.Field} class.

An instance of \texttt{Type} has the following attributes:

\texttt{Type.code} [Variable]

The type code for this type. The type code will be one of the \texttt{TYPE\_CODE\_} constants
defined below.

\texttt{Type.name} [Variable]

The name of this type. If this type has no name, then \texttt{None} is returned.

\texttt{Type.sizeof} [Variable]

The size of this type, in target \texttt{char} units. Usually, a target’s \texttt{char} type will be an
8-bit byte. However, on some unusual platforms, this type may have a different size.

\texttt{Type.tag} [Variable]

The tag name for this type. The tag name is the name after \texttt{struct}, \texttt{union}, or \texttt{enum}
in C and C++; not all languages have this concept. If this type has no tag name, then
\texttt{None} is returned.
The following methods are provided:

**Type.fields ()**

For structure and union types, this method returns the fields. Range types have two fields, the minimum and maximum values. Enum types have one field per enum constant. Function and method types have one field per parameter. The base types of C++ classes are also represented as fields. If the type has no fields, or does not fit into one of these categories, an empty sequence will be returned.

Each field is a *gdb.Field* object, with some pre-defined attributes:

- **bitpos**: This attribute is not available for *enum* or *static* (as in C++ or Java) fields. The value is the position, counting in bits, from the start of the containing type.
- **enumval**: This attribute is only available for *enum* fields, and its value is the enumeration member’s integer representation.
- **name**: The name of the field, or *None* for anonymous fields.
- **artificial**: This is *True* if the field is artificial, usually meaning that it was provided by the compiler and not the user. This attribute is always provided, and is *False* if the field is not artificial.
- **is_base_class**: This is *True* if the field represents a base class of a C++ structure. This attribute is always provided, and is *False* if the field is not a base class of the type that is the argument of *fields*, or if that type was not a C++ class.
- **bitsize**: If the field is packed, or is a bitfield, then this will have a non-zero value, which is the size of the field in bits. Otherwise, this will be zero; in this case the field’s size is given by its type.
- **type**: The type of the field. This is usually an instance of *Type*, but it can be *None* in some situations.
- **parent_type**: The type which contains this field. This is an instance of *gdb.Type*.

**Type.array (n1 [, n2])**

Return a new *gdb.Type* object which represents an array of this type. If one argument is given, it is the inclusive upper bound of the array; in this case the lower bound is zero. If two arguments are given, the first argument is the lower bound of the array, and the second argument is the upper bound of the array. An array’s length must not be negative, but the bounds can be.

**Type.vector (n1 [, n2])**

Return a new *gdb.Type* object which represents a vector of this type. If one argument is given, it is the inclusive upper bound of the vector; in this case the lower bound is zero. If two arguments are given, the first argument is the lower bound of the vector, and the second argument is the upper bound of the vector. A vector’s length must not be negative, but the bounds can be.
The difference between an array and a vector is that arrays behave like in C: when used in expressions they decay to a pointer to the first element whereas vectors are treated as first class values.

**Type.const ()**
Return a new `gdb.Type` object which represents a `const`-qualified variant of this type.

**Type.volatile ()**
Return a new `gdb.Type` object which represents a `volatile`-qualified variant of this type.

**Type.unqualified ()**
Return a new `gdb.Type` object which represents an unqualified variant of this type. That is, the result is neither `const` nor `volatile`.

**Type.range ()**
Return a Python `Tuple` object that contains two elements: the low bound of the argument type and the high bound of that type. If the type does not have a range, GDB will raise a `gdb.error` exception (see Section 23.2.2.2 [Exception Handling], page 326).

**Type.reference ()**
Return a new `gdb.Type` object which represents a reference to this type.

**Type.pointer ()**
Return a new `gdb.Type` object which represents a pointer to this type.

**Type.strip_typedefs ()**
Return a new `gdb.Type` that represents the real type, after removing all layers of typedefs.

**Type.target ()**
Return a new `gdb.Type` object which represents the target type of this type.
For a pointer type, the target type is the type of the pointed-to object. For an array type (meaning C-like arrays), the target type is the type of the elements of the array. For a function or method type, the target type is the type of the return value. For a complex type, the target type is the type of the elements. For a typedef, the target type is the aliased type.
If the type does not have a target, this method will throw an exception.

**Type.template_argument (n [, block])**
If this `gdb.Type` is an instantiation of a template, this will return a new `gdb.Value` or `gdb.Type` which represents the value of the n-th template argument (indexed starting at 0).

If this `gdb.Type` is not a template type, or if the type has fewer than n template arguments, this will throw an exception. Ordinarily, only C++ code will have template types.

If `block` is given, then `name` is looked up in that scope. Otherwise, it is searched for globally.
Type.optimize_out ()  
[Function]  
Return `gdb.Value` instance of this type whose value is optimized out. This allows a 
frame decorator to indicate that the value of an argument or a local variable is not 
known.

Each type has a code, which indicates what category this type falls into. The available 
type categories are represented by constants defined in the `gdb` module:

`gdb.TYPE_CODE_PTR`  
The type is a pointer.

`gdb.TYPE_CODE_ARRAY`  
The type is an array.

`gdb.TYPE_CODE_STRUCT`  
The type is a structure.

`gdb.TYPE_CODE_UNION`  
The type is a union.

`gdb.TYPE_CODE_ENUM`  
The type is an enum.

`gdb.TYPE_CODE_FLAGS`  
A bit flags type, used for things such as status registers.

`gdb.TYPE_CODE_FUNC`  
The type is a function.

`gdb.TYPE_CODE_INT`  
The type is an integer type.

`gdb.TYPE_CODE_FLT`  
A floating point type.

`gdb.TYPE_CODE_VOID`  
The special type `void`.

`gdb.TYPE_CODE_SET`  
A Pascal set type.

`gdb.TYPE_CODE_RANGE`  
A range type, that is, an integer type with bounds.

`gdb.TYPE_CODE_STRING`  
A string type. Note that this is only used for certain languages with language-
defined string types; C strings are not represented this way.

`gdb.TYPE_CODE_BITSTRING`  
A string of bits. It is deprecated.

`gdb.TYPE_CODE_ERROR`  
An unknown or erroneous type.

`gdb.TYPE_CODE_METHOD`  
A method type, as found in C++ or Java.
gdb.TYPED_CODE_METHODPTR
   A pointer-to-member-function.

gdb.TYPED_CODE_MEMBERPTR
   A pointer-to-member.

gdb.TYPED_CODE_REF
   A reference type.

gdb.TYPED_CODE_CHAR
   A character type.

gdb.TYPED_CODE_BOOL
   A boolean type.

gdb.TYPED_CODE_COMPLEX
   A complex float type.

gdb.TYPED_CODE_TYPEDEF
   A typedef to some other type.

gdb.TYPED_CODE_NAMESPACE
   A C++ namespace.

gdb.TYPED_CODE_DECFLOAT
   A decimal floating point type.

gdb.TYPED_CODE_INTERNAL_FUNCTION
   A function internal to gdb. This is the type used to represent convenience functions.

Further support for types is provided in the gdb.types Python module (see Section 23.2.4.2 [gdb.types], page 389).

23.2.2.5 Pretty Printing API

An example output is provided (see Section 10.9 [Pretty Printing], page 133).

A pretty-printer is just an object that holds a value and implements a specific interface, defined here.

PRETTY_PRINTER.CHILDREN (self) [Function]
   GDB will call this method on a pretty-printer to compute the children of the pretty-printer’s value.

   This method must return an object conforming to the Python iterator protocol. Each item returned by the iterator must be a tuple holding two elements. The first element is the “name” of the child; the second element is the child’s value. The value can be any Python object which is convertible to a gdb value.

   This method is optional. If it does not exist, GDB will act as though the value has no children.

PRETTY_PRINTER.DISPLAY_HINT (self) [Function]
   The CLI may call this method and use its result to change the formatting of a value.

   The result will also be supplied to an MI consumer as a ‘displayhint’ attribute of the variable being printed.
This method is optional. If it does exist, this method must return a string.

Some display hints are predefined by GDB:

- `'array'` Indicate that the object being printed is “array-like”. The CLI uses this to respect parameters such as `set print elements` and `set print array`.

- `'map'` Indicate that the object being printed is “map-like”, and that the children of this value can be assumed to alternate between keys and values.

- `'string'` Indicate that the object being printed is “string-like”. If the printer’s `to_string` method returns a Python string of some kind, then GDB will call its internal language-specific string-printing function to format the string. For the CLI this means adding quotation marks, possibly escaping some characters, respecting `set print elements`, and the like.

```python
def pretty_printer.to_string(self):
    GDB will call this method to display the string representation of the value passed to the object’s constructor.

    When printing from the CLI, if the `to_string` method exists, then GDB will prepend its result to the values returned by `children`. Exactly how this formatting is done is dependent on the display hint, and may change as more hints are added. Also, depending on the print settings (see Section 10.8 [Print Settings], page 125), the CLI may print just the result of `to_string` in a stack trace, omitting the result of `children`.

    If this method returns a string, it is printed verbatim.

    Otherwise, if this method returns an instance of `gdb.Value`, then GDB prints this value. This may result in a call to another pretty-printer.

    If instead the method returns a Python value which is convertible to a `gdb.Value`, then GDB performs the conversion and prints the resulting value. Again, this may result in a call to another pretty-printer. Python scalars (integers, floats, and booleans) and strings are convertible to `gdb.Value`; other types are not.

    Finally, if this method returns `None` then no further operations are performed in this method and nothing is printed.

    If the result is not one of these types, an exception is raised.
```

GDB provides a function which can be used to look up the default pretty-printer for a `gdb.Value`:

```python
def gdb.default_visualizer(value):
    This function takes a `gdb.Value` object as an argument. If a pretty-printer for this value exists, then it is returned. If no such printer exists, then this returns `None`.
```

### 23.2.2.6 Selecting Pretty-Printers

The Python list `gdb.pretty_printers` contains an array of functions or callable objects that have been registered via addition as a pretty-printer. Printers in this list are called global printers, they’re available when debugging all inferiors. Each `gdb.Progspace` contains a `pretty_printers` attribute. Each `gdb.Objfile` also contains a `pretty_printers` attribute.
Each function on these lists is passed a single `gdb.Value` argument and should return a pretty-printer object conforming to the interface definition above (see Section 23.2.2.5 [Pretty Printing API], page 336). If a function cannot create a pretty-printer for the value, it should return `None`.

GDB first checks the `pretty_printers` attribute of each `gdb.Objfile` in the current program space and iteratively calls each enabled lookup routine in the list for that `gdb.Objfile` until it receives a pretty-printer object. If no pretty-printer is found in the objfile lists, GDB then searches the pretty-printer list of the current program space, calling each enabled function until an object is returned. After these lists have been exhausted, it tries the global `gdb.pretty_printers` list, again calling each enabled function until an object is returned.

The order in which the objfiles are searched is not specified. For a given list, functions are always invoked from the head of the list, and iterated over sequentially until the end of the list, or a printer object is returned.

For various reasons a pretty-printer may not work. For example, the underlying data structure may have changed and the pretty-printer is out of date.

The consequences of a broken pretty-printer are severe enough that GDB provides support for enabling and disabling individual printers. For example, if `print frame-arguments` is on, a backtrace can become highly illegible if any argument is printed with a broken printer.

Pretty-printers are enabled and disabled by attaching an `enabled` attribute to the registered function or callable object. If this attribute is present and its value is `False`, the printer is disabled, otherwise the printer is enabled.

### 23.2.2.7 Writing a Pretty-Printer

A pretty-printer consists of two parts: a lookup function to detect if the type is supported, and the printer itself.

Here is an example showing how a `std::string` printer might be written. See Section 23.2.2.5 [Pretty Printing API], page 336, for details on the API this class must provide.

```python
class StdStringPrinter(object):
    "Print a std::string"
    def __init__(self, val):
        self.val = val
    def to_string(self):
        return self.val['_M_dataplus']['_M_p']
    def display_hint(self):
        return 'string'
```

And here is an example showing how a lookup function for the printer example above might be written.

```python
def str_lookup_function(val):
    lookup_tag = val.type.tag
    if lookup_tag == None:
        return None
    regex = re.compile("std::basic_string<char,.*>\$")
    if regex.match(lookup_tag):
        return StdStringPrinter(val)
```
The example lookup function extracts the value’s type, and attempts to match it to a type that it can pretty-print. If it is a type the printer can pretty-print, it will return a printer object. If not, it returns \texttt{None}.

We recommend that you put your core pretty-printers into a Python package. If your pretty-printers are for use with a library, we further recommend embedding a version number into the package name. This practice will enable \texttt{gdb} to load multiple versions of your pretty-printers at the same time, because they will have different names.

You should write auto-loaded code (see Section 23.2.3 [Python Auto-loading], page 387) such that it can be evaluated multiple times without changing its meaning. An ideal auto-load file will consist solely of \texttt{imports} of your printer modules, followed by a call to a register pretty-printers with the current objfile.

Taken as a whole, this approach will scale nicely to multiple inferiors, each potentially using a different library version. Embedding a version number in the Python package name will ensure that \texttt{gdb} is able to load both sets of printers simultaneously. Then, because the search for pretty-printers is done by objfile, and because your auto-loaded code took care to register your library’s printers with a specific objfile, \texttt{gdb} will find the correct printers for the specific version of the library used by each inferior.

To continue the \texttt{std::string} example (see Section 23.2.2.5 [Pretty Printing API], page 336), this code might appear in \texttt{gdb.libstdcxx.v6}:

```python
def register_printers(objfile):
    objfile.pretty_printers.append(str_lookup_function)
```

And then the corresponding contents of the auto-load file would be:

```python
import gdb.libstdcxx.v6

libstdcxx.v6.register_printers(gdb.current_objfile())
```

The previous example illustrates a basic pretty-printer. There are a few things that can be improved on. The printer doesn’t have a name, making it hard to identify in a list of installed printers. The lookup function has a name, but lookup functions can have arbitrary, even identical, names.

Second, the printer only handles one type, whereas a library typically has several types. One could install a lookup function for each desired type in the library, but one could also have a single lookup function recognize several types. The latter is the conventional way this is handled. If a pretty-printer can handle multiple data types, then its \textit{subprinters} are the printers for the individual data types.

The \texttt{gdb.printing} module provides a formal way of solving these problems (see Section 23.2.4.1 [gdb.printing], page 388). Here is another example that handles multiple types.

These are the types we are going to pretty-print:

```python
struct foo { int a, b; }
struct bar { struct foo x, y; }
```

Here are the printers:

```python
class fooPrinter:
    """Print a foo object."
    ""

    def __init__(self, val):
        self.val = val
```
def to_string(self):
    return ("a=<" + str(self.val['a']) + ">
b=<" + str(self.val['b']) + ">")

class barPrinter:
    """Print a bar object."""
    def __init__(self, val):
        self.val = val
    def to_string(self):
        return ("x=<" + str(self.val['x']) + ">
"y=<" + str(self.val['y']) + ">")

This example doesn't need a lookup function, that is handled by the \texttt{gdb.printing} module. Instead a function is provided to build up the object that handles the lookup.

import gdb.printing

def build_pretty_printer():
    pp = gdb.printing.RegexpCollectionPrettyPrinter(
        "my_library")
    pp.add_printer('foo', '^foo$', fooPrinter)
    pp.add_printer('bar', '^bar$', barPrinter)
    return pp

And here is the autoload support:

import gdb.printing
import my_library
gdb.printing.register_pretty_printer(  
gdb.current_objfile(),
    my_library.build_pretty_printer())

Finally, when this printer is loaded into \texttt{gdb}, here is the corresponding output of \texttt{info pretty-printer}:

\begin{verbatim}
(gdb) info pretty-printer
my_library.so:
  my_library
  foo
  bar
\end{verbatim}

\section{Debugging with GDB}

\subsection{23.2.2.8 Type Printing API}

\texttt{GDB} provides a way for Python code to customize type display. This is mainly useful for substituting canonical \texttt{typedef} names for types.

A \textit{type printer} is just a Python object conforming to a certain protocol. A simple base class implementing the protocol is provided; see Section 23.2.4.2 \cite{gdb.types}, page 389. A type printer must supply at least:

\begin{description}
  \item[enabled] [Instance Variable of type\_printer]
    A boolean which is True if the printer is enabled, and False otherwise. This is manipulated by the \texttt{enable type-printer} and \texttt{disable type-printer} commands.
  \item[name] [Instance Variable of type\_printer]
    The name of the type printer. This must be a string. This is used by the \texttt{enable type-printer} and \texttt{disable type-printer} commands.
\end{description}


**Chapter 23: Extending GDB**

341

**instantiate** *(self)*  
[Method on *type_printer*]

This is called by GDB at the start of type-printing. It is only called if the type printer is enabled. This method must return a new object that supplies a *recognize* method, as described below.

When displaying a type, say via the `ptype` command, GDB will compute a list of type recognizers. This is done by iterating first over the per-objfile type printers (see Section 23.2.2.23 [Objfiles In Python], page 370), followed by the per-progspace type printers (see Section 23.2.2.22 [Progspaces In Python], page 369), and finally the global type printers.

GDB will call the `instantiate` method of each enabled type printer. If this method returns `None`, then the result is ignored; otherwise, it is appended to the list of recognizers.

Then, when GDB is going to display a type name, it iterates over the list of recognizers. For each one, it calls the recognition function, stopping if the function returns a non-`None` value. The recognition function is defined as:

**recognize** *(self, type)*  
[Method on *type_recognizer*]

If *type* is not recognized, return `None`. Otherwise, return a string which is to be printed as the name of *type*. The *type* argument will be an instance of `gdb.Type` (see Section 23.2.2.4 [Types In Python], page 332).

GDB uses this two-pass approach so that type printers can efficiently cache information without holding on to it too long. For example, it can be convenient to look up type information in a type printer and hold it for a recognizer’s lifetime; if a single pass were done then type printers would have to make use of the event system in order to avoid holding information that could become stale as the inferior changed.

### 23.2.2.9 Filtering Frames.

Frame filters are Python objects that manipulate the visibility of a frame or frames when a backtrace (see Section 8.2 [Backtrace], page 94) is printed by GDB.

Only commands that print a backtrace, or, in the case of GDB/MI commands (see Chapter 27 [GDB/MI], page 457), those that return a collection of frames are affected. The commands that work with frame filters are:

- `backtrace` (see [The backtrace command], page 94), `-stack-list-frames` (see [The -stack-list-frames command], page 499), `-stack-list-variables` (see [The -stack-list-variables command], page 501), `-stack-list-arguments` see [The -stack-list-arguments command], page 498) and `-stack-list-locals` (see [The -stack-list-locals command], page 501).

A frame filter works by taking an iterator as an argument, applying actions to the contents of that iterator, and returning another iterator (or, possibly, the same iterator it was provided in the case where the filter does not perform any operations). Typically, frame filters utilize tools such as the Python’s `itertools` module to work with and create new iterators from the source iterator. Regardless of how a filter chooses to apply actions, it must not alter the underlying GDB frame or frames, or attempt to alter the call-stack within GDB. This preserves data integrity within GDB. Frame filters are executed on a priority basis and care should be taken that some frame filters may have been executed before, and that some frame filters will be executed after.
An important consideration when designing frame filters, and well worth reflecting upon, is that frame filters should avoid unwinding the call stack if possible. Some stacks can run very deep, into the tens of thousands in some cases. To search every frame when a frame filter executes may be too expensive at that step. The frame filter cannot know how many frames it has to iterate over, and it may have to iterate through them all. This ends up duplicating effort as GDB performs this iteration when it prints the frames. If the filter can defer unwinding frames until frame decorators are executed, after the last filter has executed, it should. See Section 23.2.2.10 [Frame Decorator API], page 343, for more information on decorators. Also, there are examples for both frame decorators and filters in later chapters. See Section 23.2.2.11 [Writing a Frame Filter], page 346, for more information.

The Python dictionary `gdb.frame_filters` contains key/object pairings that comprise a frame filter. Frame filters in this dictionary are called global frame filters, and they are available when debugging all inferiors. These frame filters must register with the dictionary directly. In addition to the global dictionary, there are other dictionaries that are loaded with different inferiors via auto-loading (see Section 23.2.3 [Python Auto-loading], page 387). The two other areas where frame filter dictionaries can be found are: `gdb.Progspace` which contains a `frame_filters` dictionary attribute, and each `gdb.Objfile` object which also contains a `frame_filters` dictionary attribute.

When a command is executed from GDB that is compatible with frame filters, GDB combines the global, `gdb.Progspace` and all `gdb.Objfile` dictionaries currently loaded. All of the `gdb.Objfile` dictionaries are combined, as several frames, and thus several object files, might be in use. GDB then prunes any frame filter whose `enabled` attribute is `False`. This pruned list is then sorted according to the `priority` attribute in each filter.

Once the dictionaries are combined, pruned and sorted, GDB creates an iterator which wraps each frame in the call stack in a `FrameDecorator` object, and calls each filter in order. The output from the previous filter will always be the input to the next filter, and so on.

Frame filters have a mandatory interface which each frame filter must implement, defined here:

```
FrameFilter.filter (iterator) [Function]
```

GDB will call this method on a frame filter when it has reached the order in the priority list for that filter.

For example, if there are four frame filters:

<table>
<thead>
<tr>
<th>Name</th>
<th>Priority</th>
</tr>
</thead>
<tbody>
<tr>
<td>Filter1</td>
<td>5</td>
</tr>
<tr>
<td>Filter2</td>
<td>10</td>
</tr>
<tr>
<td>Filter3</td>
<td>100</td>
</tr>
<tr>
<td>Filter4</td>
<td>1</td>
</tr>
</tbody>
</table>

The order that the frame filters will be called is:

```
Filter3 -> Filter2 -> Filter1 -> Filter4
```

Note that the output from `Filter3` is passed to the input of `Filter2`, and so on.

This `filter` method is passed a Python iterator. This iterator contains a sequence of frame decorators that wrap each `gdb.Frame`, or a frame decorator that wraps another frame decorator. The first filter that is executed in the sequence of frame filters will receive an iterator entirely comprised of default `FrameDecorator` objects. However,
after each frame filter is executed, the previous frame filter may have wrapped some or all of the frame decorators with their own frame decorator. As frame decorators must also conform to a mandatory interface, these decorators can be assumed to act in a uniform manner (see Section 23.2.2.10 [Frame Decorator API], page 343).

This method must return an object conforming to the Python iterator protocol. Each item in the iterator must be an object conforming to the frame decorator interface. If a frame filter does not wish to perform any operations on this iterator, it should return that iterator untouched.

This method is not optional. If it does not exist, GDB will raise and print an error.

FrameFilter.name
The name attribute must be Python string which contains the name of the filter displayed by GDB (see Section 8.3 [Frame Filter Management], page 97). This attribute may contain any combination of letters or numbers. Care should be taken to ensure that it is unique. This attribute is mandatory.

FrameFilter.enabled
The enabled attribute must be Python boolean. This attribute indicates to GDB whether the frame filter is enabled, and should be considered when frame filters are executed. If enabled is True, then the frame filter will be executed when any of the backtrace commands detailed earlier in this chapter are executed. If enabled is False, then the frame filter will not be executed. This attribute is mandatory.

FrameFilter.priority
The priority attribute must be Python integer. This attribute controls the order of execution in relation to other frame filters. There are no imposed limits on the range of priority other than it must be a valid integer. The higher the priority attribute, the sooner the frame filter will be executed in relation to other frame filters. Although priority can be negative, it is recommended practice to assume zero is the lowest priority that a frame filter can be assigned. Frame filters that have the same priority are executed in unsorted order in that priority slot. This attribute is mandatory.

23.2.2.10 Decorating Frames.
Frame decorators are sister objects to frame filters (see Section 23.2.2.9 [Frame Filter API], page 341). Frame decorators are applied by a frame filter and can only be used in conjunction with frame filters.

The purpose of a frame decorator is to customize the printed content of each gdb.Frame in commands where frame filters are executed. This concept is called decorating a frame. Frame decorators decorate a gdb.Frame with Python code contained within each API call. This separates the actual data contained in a gdb.Frame from the decorated data produced by a frame decorator. This abstraction is necessary to maintain integrity of the data contained in each gdb.Frame.

Frame decorators have a mandatory interface, defined below.

GDB already contains a frame decorator called FrameDecorator. This contains substantial amounts of boilerplate code to decorate the content of a gdb.Frame. It is recommended
that other frame decorators inherit and extend this object, and only to override the methods needed.

**FrameDecorator.elided** *(self)*

The **elided** method groups frames together in a hierarchical system. An example would be an interpreter, where multiple low-level frames make up a single call in the interpreted language. In this example, the frame filter would elide the low-level frames and present a single high-level frame, representing the call in the interpreted language, to the user.

The **elided** function must return an iterable and this iterable must contain the frames that are being elided wrapped in a suitable frame decorator. If no frames are being elided this function may return an empty iterable, or **None**. Elided frames are indented from normal frames in a CLI backtrace, or in the case of GDB/MI, are placed in the **children** field of the eliding frame.

It is the frame filter’s task to also filter out the elided frames from the source iterator. This will avoid printing the frame twice.

**FrameDecorator.function** *(self)*

This method returns the name of the function in the frame that is to be printed.

This method must return a Python string describing the function, or **None**. If this function returns **None**, gdb will not print any data for this field.

**FrameDecorator.address** *(self)*

This method returns the address of the frame that is to be printed.

This method must return a Python numeric integer type of sufficient size to describe the address of the frame, or **None**. If this function returns a **None**, gdb will not print any data for this field.

**FrameDecorator.filename** *(self)*

This method returns the filename and path associated with this frame.

This method must return a Python string containing the filename and the path to the object file backing the frame, or **None**. If this function returns a **None**, gdb will not print any data for this field.

**FrameDecorator.line** *(self)*:

This method returns the line number associated with the current position within the function addressed by this frame.

This method must return a Python integer type, or **None**. If this function returns a **None**, gdb will not print any data for this field.

**FrameDecorator.frame_args** *(self)*

This method must return an iterable, or **None**. Returning an empty iterable, or **None** means frame arguments will not be printed for this frame. This iterable must contain objects that implement two methods, described here.

This object must implement a **argument** method which takes a single **self** parameter and must return a **gdb.Symbol** (see Section 23.2.2.26 [Symbols In Python], page 377),
or a Python string. The object must also implement a `value` method which takes a single `self` parameter and must return a `gdb.Value` (see Section 23.2.2.3 [Values From Inferior], page 327), a Python value, or None. If the `value` method returns `None`, and the `argument` method returns a `gdb.Symbol`, GDB will look-up and print the value of the `gdb.Symbol` automatically.

A brief example:

```python
class SymValueWrapper():
    def __init__(self, symbol, value):
        self.sym = symbol
        self.val = value
    def value(self):
        return self.val
    def symbol(self):
        return self.sym
class SomeFrameDecorator():
    ...
    ...
    def frame_args(self):
        args = []
        try:
            block = self.inferior_frame.block()
        except:
            return None
        # Iterate over all symbols in a block. Only add
        # symbols that are arguments.
        for sym in block:
            if not sym.is_argument:
                continue
            args.append(SymValueWrapper(sym, None))
        # Add example synthetic argument.
        args.append(SymValueWrapper('foo', 42))
        return args

FrameDecorator.frame_locals (self)  [Function]
This method must return an iterable or `None`. Returning an empty iterable, or `None` means frame local arguments will not be printed for this frame.

The object interface, the description of the various strategies for reading frame locals, and the example are largely similar to those described in the `frame_args` function, (see [The frame filter frame_args function], page 344). Below is a modified example:

```python
class SomeFrameDecorator():
    ...
    ...
    def frame_locals(self):
        vars = []
        try:
            block = self.inferior_frame.block()
        except:
            return None
# Iterate over all symbols in a block. Add all
# symbols, except arguments.
for sym in block:
    if sym.is_argument:
        continue
    vars.append(SymValueWrapper(sym, None))

# Add an example of a synthetic local variable.
vars.append(SymValueWrapper(’bar’, 99))

return vars

FrameDecorator.inferior_frame (self):

This method must return the underlying gdb.Frame that this frame decorator is
decorating. GDB requires the underlying frame for internal frame information to
determine how to print certain values when printing a frame.

23.2.2.11 Writing a Frame Filter

There are three basic elements that a frame filter must implement: it must correctly implement the documented interface (see Section 23.2.2.9 [Frame Filter API], page 341), it must register itself with GDB, and finally, it must decide if it is to work on the data provided by GDB. In all cases, whether it works on the iterator or not, each frame filter must return an iterator. A bare-bones frame filter follows the pattern in the following example.

```python
import gdb

class FrameFilter():
    def __init__(self):
        # Frame filter attribute creation.
        #
        # ’name’ is the name of the filter that GDB will display.
        #
        # ’priority’ is the priority of the filter relative to other
        # filters.
        #
        # ’enabled’ is a boolean that indicates whether this filter is
        # enabled and should be executed.

        self.name = "Foo"
        self.priority = 100
        self.enabled = True

        # Register this frame filter with the global frame_filters
        # dictionary.
        gdb.frame_filters[self.name] = self

    def filter(self, frame_iter):
        # Just return the iterator.
        return frame_iter
```

The frame filter in the example above implements the three requirements for all frame filters. It implements the API, self registers, and makes a decision on the iterator (in this case, it just returns the iterator untouched).
The first step is attribute creation and assignment, and as shown in the comments the filter assigns the following attributes: name, priority and whether the filter should be enabled with the enabled attribute.

The second step is registering the frame filter with the dictionary or dictionaries that the frame filter has interest in. As shown in the comments, this filter just registers itself with the global dictionary gdb.frame_filters. As noted earlier, gdb.frame_filters is a dictionary that is initialized in the gdb module when GDB starts. What dictionary a filter registers with is an important consideration. Generally, if a filter is specific to a set of code, it should be registered either in the objfile or progspace dictionaries as they are specific to the program currently loaded in GDB. The global dictionary is always present in GDB and is never unloaded. Any filters registered with the global dictionary will exist until GDB exits. To avoid filters that may conflict, it is generally better to register frame filters against the dictionaries that more closely align with the usage of the filter currently in question. See Section 23.2.3 [Python Auto-loading], page 387, for further information on auto-loading Python scripts.

GDB takes a hands-off approach to frame filter registration, therefore it is the frame filter’s responsibility to ensure registration has occurred, and that any exceptions are handled appropriately. In particular, you may wish to handle exceptions relating to Python dictionary key uniqueness. It is mandatory that the dictionary key is the same as frame filter’s name attribute. When a user manages frame filters (see Section 8.3 [Frame Filter Management], page 97), the names GDB will display are those contained in the name attribute.

The final step of this example is the implementation of the filter method. As shown in the example comments, we define the filter method and note that the method must take an iterator, and also must return an iterator. In this bare-bones example, the frame filter is not very useful as it just returns the iterator untouched. However this is a valid operation for frame filters that have the enabled attribute set, but decide not to operate on any frames.

In the next example, the frame filter operates on all frames and utilizes a frame decorator to perform some work on the frames. See Section 23.2.2.10 [Frame Decorator API], page 343, for further information on the frame decorator interface.

This example works on inlined frames. It highlights frames which are inlined by tagging them with an “[inlined]” tag. By applying a frame decorator to all frames with the Python itertools imap method, the example defers actions to the frame decorator. Frame decorators are only processed when GDB prints the backtrace.

This introduces a new decision making topic: whether to perform decision making operations at the filtering step, or at the printing step. In this example’s approach, it does not perform any filtering decisions at the filtering step beyond mapping a frame decorator to each frame. This allows the actual decision making to be performed when each frame is printed. This is an important consideration, and well worth reflecting upon when designing a frame filter. An issue that frame filters should avoid is unwinding the stack if possible. Some stacks can run very deep, into the tens of thousands in some cases. To search every frame to determine if it is inlined ahead of time may be too expensive at the filtering step. The frame filter cannot know how many frames it has to iterate over, and it would have to iterate through them all. This ends up duplicating effort as GDB performs this iteration when it prints the frames.
In this example decision making can be deferred to the printing step. As each frame is printed, the frame decorator can examine each frame in turn when GDB iterates. From a performance viewpoint, this is the most appropriate decision to make as it avoids duplicating the effort that the printing step would undertake anyway. Also, if there are many frame filters unwinding the stack during filtering, it can substantially delay the printing of the backtrace which will result in large memory usage, and a poor user experience.

```python
class InlineFilter():
    def __init__(self):
        self.name = "InlinedFrameFilter"
        self.priority = 100
        self.enabled = True
        gdb.frame_filters[self.name] = self

    def filter(self, frame_iter):
        frame_iter = itertools.imap(InlinedFrameDecorator,
                                     frame_iter)
        return frame_iter
```

This frame filter is somewhat similar to the earlier example, except that the `filter` method applies a frame decorator object called `InlinedFrameDecorator` to each element in the iterator. The `imap` Python method is light-weight. It does not proactively iterate over the iterator, but rather creates a new iterator which wraps the existing one.

Below is the frame decorator for this example.

```python
class InlinedFrameDecorator(FrameDecorator):
    def __init__(self, fobj):
        super(InlinedFrameDecorator, self).__init__(fobj)

    def function(self):
        frame = fobj.inferior_frame()
        name = str(frame.name())

        if frame.type() == gdb.INLINE_FRAME:
            name = name + " [inlined]"

        return name
```

This frame decorator only defines and overrides the `function` method. It lets the supplied `FrameDecorator`, which is shipped with GDB, perform the other work associated with printing this frame.

The combination of these two objects create this output from a backtrace:

```
#0 0x004004e0 in bar () at inline.c:11
#1 0x00400566 in max [inlined] (b=6, a=12) at inline.c:21
#2 0x00400566 in main () at inline.c:31
```

So in the case of this example, a frame decorator is applied to all frames, regardless of whether they may be inlined or not. As GDB iterates over the iterator produced by the frame filters, GDB executes each frame decorator which then makes a decision on what to print in the `function` callback. Using a strategy like this is a way to defer decisions on the frame content to printing time.
Eliding Frames

It might be that the above example is not desirable for representing inlined frames, and a hierarchical approach may be preferred. If we want to hierarchically represent frames, the elided frame decorator interface might be preferable.

This example approaches the issue with the elided method. This example is quite long, but very simplistic. It is out-of-scope for this section to write a complete example that comprehensively covers all approaches of finding and printing inlined frames. However, this example illustrates the approach an author might use.

This example comprises of three sections.

```python
class InlineFrameFilter():
    def __init__(self):
        self.name = "InlinedFrameFilter"
        self.priority = 100
        self.enabled = True
        gdb.frame_filters[self.name] = self

    def filter(self, frame_iter):
        return ElidingInlineIterator(frame_iter)
```

This frame filter is very similar to the other examples. The only difference is this frame filter is wrapping the iterator provided to it (`frame_iter`) with a custom iterator called `ElidingInlineIterator`. This again defers actions to when GDB prints the backtrace, as the iterator is not traversed until printing.

The iterator for this example is as follows. It is in this section of the example where decisions are made on the content of the backtrace.

```python
class ElidingInlineIterator:
    def __init__(self, ii):
        self.input_iterator = ii

    def __iter__(self):
        return self

    def next(self):
        frame = next(self.input_iterator)
        if frame.inferior_frame().type() != gdb.INLINE_FRAME:
            return frame
        try:
            eliding_frame = next(self.input_iterator)
        except StopIteration:
            return frame
        return ElidingFrameDecorator(eliding_frame, [frame])
```

This iterator implements the Python iterator protocol. When the `next` function is called (when GDB prints each frame), the iterator checks if this frame decorator, `frame`, is wrapping an inlined frame. If it is not, it returns the existing frame decorator untouched. If it is wrapping an inlined frame, it assumes that the inlined frame was contained within the next oldest frame, `eliding_frame`, which it fetches. It then creates and returns a frame decorator, `ElidingFrameDecorator`, which contains both the elided frame, and the eliding frame.
class ElidingInlineDecorator(FrameDecorator):
    def __init__(self, frame, elided_frames):
        super(ElidingInlineDecorator, self).__init__(frame)
        self.frame = frame
        self.elided_frames = elided_frames

    def elided(self):
        return iter(self.elided_frames)

This frame decorator overrides one function and returns the inlined frame in the `elided` method. As before it lets `FrameDecorator` do the rest of the work involved in printing this frame. This produces the following output.

```plaintext
#0 0x004004e0 in bar () at inline.c:11
#2 0x00400529 in main () at inline.c:25
#1 0x00400529 in max (b=6, a=12) at inline.c:15
```

In that output, `max` which has been inlined into `main` is printed hierarchically. Another approach would be to combine the `function` method, and the `elided` method to both print a marker in the inlined frame, and also show the hierarchical relationship.

### 23.2.2.12 Unwinding Frames in Python

In GDB terminology “unwinding” is the process of finding the previous frame (that is, caller’s) from the current one. An unwinder has three methods. The first one checks if it can handle given frame (“sniff” it). For the frames it can sniff an unwinder provides two additional methods: it can return frame’s ID, and it can fetch registers from the previous frame. A running GDB maintains a list of the unwinders and calls each unwinder’s sniffer in turn until it finds the one that recognizes the current frame. There is an API to register an unwinder.

The unwinders that come with GDB handle standard frames. However, mixed language applications (for example, an application running Java Virtual Machine) sometimes use frame layouts that cannot be handled by the GDB unwinders. You can write Python code that can handle such custom frames.

You implement a frame unwinder in Python as a class with which has two attributes, `name` and `enabled`, with obvious meanings, and a single method `__call__`, which examines a given frame and returns an object (an instance of `gdb.UnwindInfo` class) describing it. If an unwinder does not recognize a frame, it should return `None`. The code in GDB that enables writing unwinders in Python uses this object to return frame’s ID and previous frame registers when GDB core asks for them.

### Unwinder Input

An object passed to an unwinder (a `gdb.PendingFrame` instance) provides a method to read frame’s registers:

```python
PendingFrame.read_register (reg) [Function]
```

This method returns the contents of the register `regn` in the frame as a `gdb.Value` object. `reg` can be either a register number or a register name; the values are platform-specific. They are usually found in the corresponding ‘`platform-tdep.h`’ file in the GDB source tree.
It also provides a factory method to create a `gdb.UnwindInfo` instance to be returned to GDB:

```python
PendingFrame.create_unwind_info (frame_id)  # Function
Returns a new `gdb.UnwindInfo` instance identified by given `frame_id`. The argument is used to build GDB’s frame ID using one of functions provided by GDB. `frame_id`’s attributes determine which function will be used, as follows:

- `sp, pc, special`
  `frame_id_build_special (frame_id.sp, frame_id.pc, frame_id.special)`
- `sp, pc`
  `frame_id_build (frame_id.sp, frame_id.pc)`
  This is the most common case.
- `sp`
  `frame_id_build_wild (frame_id.sp)`

The attribute values should be `gdb.Value`

### Unwinder Output: UnwindInfo

Use `PendingFrame.create_unwind_info` method described above to create a `gdb.UnwindInfo` instance. Use the following method to specify caller registers that have been saved in this frame:

```python
gdb.UnwindInfo.add_saved_register (reg, value)  # Function
reg identifies the register. It can be a number or a name, just as for the `PendingFrame.read_register` method above. value is a register value (a `gdb.Value` object).
```

### Unwinder Skeleton Code

GDB comes with the module containing the base `Unwinder` class. Derive your unwinder class from it and structure the code as follows:

```python
from gdb.unwinders import Unwinder

class FrameId(object):
    def __init__(self, sp, pc):
        self.sp = sp
        self.pc = pc

class MyUnwinder(Unwinder):
    def __init__(self):
        super(MyUnwinder, self).__init__(<expects unwinder name argument>)

    def __call__(pending_frame):
        if not <we recocognize frame>:
            return None

        # Create UnwindInfo. Usually the frame is identified by the stack
        # pointer and the program counter.
        sp = pending_frame.read_register(<SP number>)
        pc = pending_frame.read_register(<PC number>)
        unwind_info = pending_frame.create_unwind_info(FrameId(sp, pc))
```
Debugging with gdb

# Find the values of the registers in the caller's frame and
# save them in the result:
unwind_info.add_saved_register(<register>, <value>)
....

# Return the result:
return unwind_info

Registering a Unwinder

An object file, a program space, and the GDB proper can have unwinders registered with it.

The gdb.unwinders module provides the function to register a unwinder:

gdb.unwinder.register_unwinder (locus, unwinder, replace=False)  

locus is specifies an object file or a program space to which unwinder is added. 
Passing None or gdb adds unwinder to the GDB’s global unwinder list. The newly 
added unwinder will be called before any other unwinder from the same locus. Two 
unwinders in the same locus cannot have the same name. An attempt to add a 
unwinder with already existing name raises an exception unless replace is True, in 
which case the old unwinder is deleted.

Unwinder Precedence

GDB first calls the unwinders from all the object files in no particular order, then the 
unwinders from the current program space, and finally the unwinders from GDB.

23.2.2.13 Xmethods In Python

Xmethods are additional methods or replacements for existing methods of a C++ class. 
This feature is useful for those cases where a method defined in C++ source code could be 
illined or optimized out by the compiler, making it unavailable to GDB. For such cases, 
one can define an xmethod to serve as a replacement for the method defined in the C++ 
source code. GDB will then invoke the xmethod, instead of the C++ method, to evaluate 
expressions. One can also use xmethods when debugging with core files. Moreover, when 
debugging live programs, invoking an xmethod need not involve running the inferior (which 
can potentially perturb its state). Hence, even if the C++ method is available, it is better 
to use its replacement xmethod if one is defined.

The xmethods feature in Python is available via the concepts of an xmethod matcher 
and an xmethod worker. To implement an xmethod, one has to implement a matcher and 
a corresponding worker for it (more than one worker can be implemented, each catering to 
a different overloaded instance of the method). Internally, GDB invokes the match method 
of a matcher to match the class type and method name. On a match, the match method 
returns a list of matching worker objects. Each worker object typically corresponds to 
an overloaded instance of the xmethod. They implement a get_arg_types method which 
returns a sequence of types corresponding to the arguments the xmethod requires. GDB uses 
this sequence of types to perform overload resolution and picks a winning xmethod worker. 
A winner is also selected from among the methods GDB finds in the C++ source code. Next, 
the winning xmethod worker and the winning C++ method are compared to select an overall 
winner. In case of a tie between a xmethod worker and a C++ method, the xmethod worker 
is selected as the winner. That is, if a winning xmethod worker is found to be equivalent
to the winning C++ method, then the xmethod worker is treated as a replacement for the C++ method. GDB uses the overall winner to invoke the method. If the winning xmethod worker is the overall winner, then the corresponding xmethod is invoked via the \_\_call\_\_ method of the worker object.

If one wants to implement an xmethod as a replacement for an existing C++ method, then they have to implement an equivalent xmethod which has exactly the same name and takes arguments of exactly the same type as the C++ method. If the user wants to invoke the C++ method even though a replacement xmethod is available for that method, then they can disable the xmethod.

See Section 23.2.2.14 [Xmethod API], page 353, for API to implement xmethods in Python. See Section 23.2.2.15 [Writing an Xmethod], page 354, for implementing xmethods in Python.

23.2.2.14 Xmethod API

The GDB Python API provides classes, interfaces and functions to implement, register and manipulate xmethods. See Section 23.2.2.13 [Xmethods In Python], page 352.

An xmethod matcher should be an instance of a class derived from XMethodMatcher defined in the module gdb.xmethod, or an object with similar interface and attributes. An instance of XMethodMatcher has the following attributes:

- **name** ([Variable])
  
  The name of the matcher.

- **enabled** ([Variable])
  
  A boolean value indicating whether the matcher is enabled or disabled.

- **methods** ([Variable])
  
  A list of named methods managed by the matcher. Each object in the list is an instance of the class XMethod defined in the module gdb.xmethod, or any object with the following attributes:

  - **name**
    
    Name of the xmethod which should be unique for each xmethod managed by the matcher.

  - **enabled**
    
    A boolean value indicating whether the xmethod is enabled or disabled.

The class XMethod is a convenience class with same attributes as above along with the following constructor:

\[\text{XMethod}.\_\_init\_\_ (self, name)\] ([Function])

Constructs an enabled xmethod with name name.

The XMethodMatcher class has the following methods:

\[\text{XMethodMatcher}.\_\_init\_\_ (self, name)\] ([Function])

Constructs an enabled xmethod matcher with name name. The methods attribute is initialized to None.
XMethodMatcher.match (self, class_type, method_name)  [Function]
Derived classes should override this method. It should return a xmethod worker object
(or a sequence of xmethod worker objects) matching the class_type and method_name.
class_type is a gdb.Type object, and method_name is a string value. If the matcher
manages named methods as listed in its methods attribute, then only those worker
objects whose corresponding entries in the methods list are enabled should be re-
turned.

An xmethod worker should be an instance of a class derived from XMethodWorker defined
in the module gdb.xmethod, or support the following interface:

XMethodWorker.get_arg_types (self)  [Function]
This method returns a sequence of gdb.Type objects corresponding to the arguments
that the xmethod takes. It can return an empty sequence or None if the xmethod
does not take any arguments. If the xmethod takes a single argument, then a single
gdb.Type object corresponding to it can be returned.

XMethodWorker.get_result_type (self, *args)  [Function]
This method returns a gdb.Type object representing the type of the result of invoking
this xmethod. The args argument is the same tuple of arguments that would be passed
to the __call__ method of this worker.

XMethodWorker.__call__ (self, *args)  [Function]
This is the method which does the work of the xmethod. The args arguments is the
tuple of arguments to the xmethod. Each element in this tuple is a gdb.Value object.
The first element is always the this pointer value.

For GDB to lookup xmethods, the xmethod matchers should be registered using the
following function defined in the module gdb.xmethod:

register_xmethod_matcher (locus, matcher, replace=False)  [Function]
The matcher is registered with locus, replacing an existing matcher with the same
name as matcher if replace is True. locus can be a gdb.Objfile object (see
Section 23.2.2.23 [Objfiles In Python], page 370), or a gdb.Progspace object (see
Section 23.2.2.22 [Progspaces In Python], page 369), or None. If it is None, then
matcher is registered globally.

23.2.2.15 Writing an Xmethod
Implementing xmethods in Python will require implementing xmethod matchers and
xmethod workers (see Section 23.2.2.13 [Xmethods In Python], page 352). Consider the
following C++ class:

class MyClass
{
 public:
 MyClass (int a) : a_(a) { }

 int geta (void) { return a_; }
 int operator+ (int b);

 private:

int a_;
};

int MyClass::operator+ (int b)
{
    return a_ + b;
}

Let us define two xmethods for the class MyClass, one replacing the method geta, and another adding an overloaded flavor of operator+ which takes a MyClass argument (the C++ code above already has an overloaded operator+ which takes an int argument). The xmethod matcher can be defined as follows:

class MyClass_geta(gdb.xmethod.XMethod):
    def __init__(self):
        gdb.xmethod.XMethod.__init__(self, 'geta')

    def get_worker(self, method_name):
        if method_name == 'geta':
            return MyClassWorker_geta()

class MyClass_sum(gdb.xmethod.XMethod):
    def __init__(self):
        gdb.xmethod.XMethod.__init__(self, 'sum')

    def get_worker(self, method_name):
        if method_name == 'operator+':
            return MyClassWorker_plus()

class MyClassMatcher(gdb.xmethod.XMethodMatcher):
    def __init__(self):
        gdb.xmethod.XMethodMatcher.__init__(self, MyClassMatcher')
        # List of methods 'managed' by this matcher
        self.methods = [MyClass_geta(), MyClass_sum()]

    def match(self, class_type, method_name):
        if class_type.tag != 'MyClass':
            return None
        workers = []
        for method in self.methods:
            if method.enabled:
                worker = method.get_worker(method_name)
                if worker:
                    workers.append(worker)

        return workers

Notice that the match method of MyClassMatcher returns a worker object of type MyClassWorker_geta for the geta method, and a worker object of type MyClassWorker_plus for the operator+ method. This is done indirectly via helper classes derived from gdb.xmethod.XMethod. One does not need to use the methods attribute in a matcher as it is optional. However, if a matcher manages more than one xmethod, it is a good practice to list the xmethods in the methods attribute of the matcher. This will then facilitate enabling and disabling individual xmethods via the enable/disable commands.
Notice also that a worker object is returned only if the corresponding entry in the *methods* attribute of the matcher is enabled.

The implementation of the worker classes returned by the matcher setup above is as follows:

```python
class MyClassWorker_geta(gdb.xmethod.XMethodWorker):
    def get_arg_types(self):
        return None
    def get_result_type(self, obj):
        return gdb.lookup_type('int')
    def __call__(self, obj):
        return obj['a_']

class MyClassWorker_plus(gdb.xmethod.XMethodWorker):
    def get_arg_types(self):
        return gdb.lookup_type('MyClass')
    def get_result_type(self, obj):
        return gdb.lookup_type('int')
    def __call__(self, obj, other):
        return obj['a_'] + other['a_']
```

For GDB to actually lookup a xmethod, it has to be registered with it. The matcher defined above is registered with GDB globally as follows:

```python
gdb.xmethod.register_xmethod_matcher(None, MyClassMatcher())
```

If an object `obj` of type `MyClass` is initialized in C++ code as follows:

```
MyClass obj(5);
```

then, after loading the Python script defining the xmethod matchers and workers into `GDBN`, invoking the method `geta` or using the operator `+` on `obj` will invoke the xmethods defined above:

```bash
(gdb) p obj.geta()
$1 = 5
(gdb) p obj + obj
$2 = 10
```

Consider another example with a C++ template class:

```cpp
template <class T>
class MyTemplate
{
public:
    MyTemplate () : dsize_(10), data_ (new T [10]) { }
    ~MyTemplate () { delete [] data_; }

    int footprint (void)
    {
        return sizeof (T) * dsize_ + sizeof (MyTemplate<T>);
    }

private:
    int dsize_;
    T *data_;
Let us implement an xmethod for the above class which serves as a replacement for the \texttt{footprint} method. The full code listing of the xmethod workers and xmethod matchers is as follows:

```python
class MyTemplateWorker_footprint(gdb.xmethod.XMethodWorker):
    def __init__(self, class_type):
        self.class_type = class_type

    def get_arg_types(self):
        return None

    def get_result_type(self):
        return gdb.lookup_type('int')

    def __call__(self, obj):
        return (self.class_type.sizeof +
                obj['dsize_'] *
                self.class_type.template_argument(0).sizeof)

class MyTemplateMatcher_footprint(gdb.xmethod.XMethodMatcher):
    def __init__(self):
        gdb.xmethod.XMethodMatcher.__init__(self, 'MyTemplateMatcher')

    def match(self, class_type, method_name):
        if (re.match('MyTemplate<[^\t\n]*[^_a-zA-Z][_a-zA-Z0-9]*>',
                     class_type.tag) and
            method_name == 'footprint'):
            return MyTemplateWorker_footprint(class_type)
```

Notice that, in this example, we have not used the \texttt{methods} attribute of the matcher as the matcher manages only one xmethod. The user can enable/disable this xmethod by enabling/disabling the matcher itself.

### 23.2.2.16 Inferiors In Python

Programs which are being run under GDB are called inferiors (see Section 4.9 \textit{Inferiors and Programs}, page 33). Python scripts can access information about and manipulate inferiors controlled by GDB via objects of the \texttt{gdb.Inferior} class.

The following inferior-related functions are available in the \texttt{gdb} module:

- \texttt{gdb.inferiors} \hspace{1cm} [Function]
  - Return a tuple containing all inferior objects.

- \texttt{gdb.selected_inferior} \hspace{1cm} [Function]
  - Return an object representing the current inferior.

A \texttt{gdb.Inferior} object has the following attributes:

- \texttt{Inferior.num} \hspace{1cm} [Variable]
  - ID of inferior, as assigned by GDB.

- \texttt{Inferior.pid} \hspace{1cm} [Variable]
  - Process ID of the inferior, as assigned by the underlying operating system.
Inferior.was_attached

Boolean signaling whether the inferior was created using ‘attach’, or started by GDB itself.

A gdb.Inferior object has the following methods:

Inferior.is_valid ()

Returns True if the gdb.Inferior object is valid, False if not. A gdb.Inferior object will become invalid if the inferior no longer exists within GDB. All other gdb.Inferior methods will throw an exception if it is invalid at the time the method is called.

Inferior.threads ()

This method returns a tuple holding all the threads which are valid when it is called. If there are no valid threads, the method will return an empty tuple.

Inferior.read_memory (address, length)

Read length addressable memory units from the inferior, starting at address. Returns a buffer object, which behaves much like an array or a string. It can be modified and given to the Inferior.write_memory function. In Python 3, the return value is a memoryview object.

Inferior.write_memory (address, buffer [, length])

Write the contents of buffer to the inferior, starting at address. The buffer parameter must be a Python object which supports the buffer protocol, i.e., a string, an array or the object returned from Inferior.read_memory. If given, length determines the number of addressable memory units from buffer to be written.

Inferior.search_memory (address, length, pattern)

Search a region of the inferior memory starting at address with the given length using the search pattern supplied in pattern. The pattern parameter must be a Python object which supports the buffer protocol, i.e., a string, an array or the object returned from gdb.read_memory. Returns a Python Long containing the address where the pattern was found, or None if the pattern could not be found.

23.2.2.17 Events In Python

GDB provides a general event facility so that Python code can be notified of various state changes, particularly changes that occur in the inferior.

An event is just an object that describes some state change. The type of the object and its attributes will vary depending on the details of the change. All the existing events are described below.

In order to be notified of an event, you must register an event handler with an event registry. An event registry is an object in the gdb.events module which dispatches particular events. A registry provides methods to register and unregister event handlers:

EventRegistry.connect (object)

Add the given callable object to the registry. This object will be called when an event corresponding to this registry occurs.
EventRegistry.disconnect (object)  [Function]
Remove the given object from the registry. Once removed, the object will no longer receive notifications of events.

Here is an example:

```python
def exit_handler(event):
    print "event type: exit"
    print "exit code: %d" % (event.exit_code)

gdb.events.exited.connect(exit_handler)
```

In the above example we connect our handler exit_handler to the registry events.exited. Once connected, exit_handler gets called when the inferior exits. The argument event in this example is of type gdb.ExitedEvent. As you can see in the example the ExitedEvent object has an attribute which indicates the exit code of the inferior.

The following is a listing of the event registries that are available and details of the events they emit:

**events.cont**
Emits gdb.ThreadEvent.

Some events can be thread specific when GDB is running in non-stop mode. When represented in Python, these events all extend gdb.ThreadEvent. Note, this event is not emitted directly; instead, events which are emitted by this or other modules might extend this event. Examples of these events are gdb.BreakpointEvent and gdb.ContinueEvent.

**ThreadEvent.inferior_thread**  [Variable]
In non-stop mode this attribute will be set to the specific thread which was involved in the emitted event. Otherwise, it will be set to None.

Emits gdb.ContinueEvent which extends gdb.ThreadEvent.
This event indicates that the inferior has been continued after a stop. For inherited attribute refer to gdb.ThreadEvent above.

**events.exited**
Emits events.ExitedEvent which indicates that the inferior has exited.

**ExitedEvent.exit_code**  [Variable]
An integer representing the exit code, if available, which the inferior has returned. (The exit code could be unavailable if, for example, GDB detaches from the inferior.) If the exit code is unavailable, the attribute does not exist.

**ExitedEvent.inferior**  [Variable]
A reference to the inferior which triggered the exited event.

**events.stop**
Emits gdb.StopEvent which extends gdb.ThreadEvent.
Indicates that the inferior has stopped. All events emitted by this registry extend StopEvent. As a child of `gdb.ThreadEvent`, `gdb.StopEvent` will indicate the stopped thread when GDB is running in non-stop mode. Refer to `gdb.ThreadEvent` above for more details.

Emits `gdb.SignalEvent` which extends `gdb.StopEvent`.

This event indicates that the inferior or one of its threads has received as signal. `gdb.SignalEvent` has the following attributes:

- `SignalEvent.stop_signal` [Variable]
  A string representing the signal received by the inferior. A list of possible signal values can be obtained by running the command `info signals` in the GDB command prompt.

Also emits `gdb.BreakpointEvent` which extends `gdb.StopEvent`.

`gdb.BreakpointEvent` event indicates that one or more breakpoints have been hit, and has the following attributes:

- `BreakpointEvent.breakpoints` [Variable]
  A sequence containing references to all the breakpoints (type `gdb.Breakpoint`) that were hit. See Section 23.2.2.29 [Breakpoints In Python], page 382, for details of the `gdb.Breakpoint` object.

- `BreakpointEvent.breakpoint` [Variable]
  A reference to the first breakpoint that was hit. This function is maintained for backward compatibility and is now deprecated in favor of the `gdb.BreakpointEvent.breakpoints` attribute.

`events.new_objfile` Emits `gdb.NewObjFileEvent` which indicates that a new object file has been loaded by GDB. `gdb.NewObjFileEvent` has one attribute:

- `NewObjFileEvent.new_objfile` [Variable]
  A reference to the object file (`gdb.Objfile`) which has been loaded. See Section 23.2.2.23 [Objfiles In Python], page 370, for details of the `gdb.Objfile` object.

`events.clear_objfiles` Emits `gdb.ClearObjFilesEvent` which indicates that the list of object files for a program space has been reset. `gdb.ClearObjFilesEvent` has one attribute:

- `ClearObjFilesEvent.progspace` [Variable]
  A reference to the program space (`gdb.Progspace`) whose objfile list has been cleared. See Section 23.2.2.22 [Progspaces In Python], page 369.

`events.inferior_call_pre` Emits `gdb.InferiorCallPreEvent` which indicates that a function in the inferior is about to be called.

- `InferiorCallPreEvent.ptid` [Variable]
  The thread in which the call will be run.
InferiorCallPreEvent.address
   The location of the function to be called.

events.inferior_call_post
   Emits gdb.InferiorCallPostEvent which indicates that a function in the inferior has returned.

InferiorCallPostEvent.ptid
   The thread in which the call was run.

InferiorCallPostEvent.address
   The location of the function that was called.

events.memory_changed
   Emits gdb.MemoryChangedEvent which indicates that the memory of the inferior has been modified by the GDB user, for instance via a command like set *addr = value. The event has the following attributes:

MemoryChangedEvent.address
   The start address of the changed region.

MemoryChangedEvent.length
   Length in bytes of the changed region.

events.register_changed
   Emits gdb.RegisterChangedEvent which indicates that a register in the inferior has been modified by the GDB user.

RegisterChangedEvent.frame
   A gdb.Frame object representing the frame in which the register was modified.

RegisterChangedEvent.regnum
   Denotes which register was modified.

23.2.2.18 Threads In Python

Python scripts can access information about, and manipulate inferior threads controlled by GDB, via objects of the gdb.InferiorThread class.

The following thread-related functions are available in the gdb module:

gdb.selected_thread ()
   This function returns the thread object for the selected thread. If there is no selected thread, this will return None.

A gdb.InferiorThread object has the following attributes:

InferiorThread.name
   The name of the thread. If the user specified a name using thread name, then this returns that name. Otherwise, if an OS-supplied name is available, then it is returned. Otherwise, this returns None.

This attribute can be assigned to. The new value must be a string object, which sets the new name, or None, which removes any user-specified thread name.
InferiorThread.num  [Variable]
ID of the thread, as assigned by GDB.

InferiorThread.ptid  [Variable]
ID of the thread, as assigned by the operating system. This attribute is a tuple containing three integers. The first is the Process ID (PID); the second is the Lightweight Process ID (LWPID), and the third is the Thread ID (TID). Either the LWPID or TID may be 0, which indicates that the operating system does not use that identifier.

A gdb.InferiorThread object has the following methods:

InferiorThread.is_valid ()  [Function]
Returns True if the gdb.InferiorThread object is valid, False if not. A gdb.InferiorThread object will become invalid if the thread exits, or the inferior that the thread belongs is deleted. All other gdb.InferiorThread methods will throw an exception if it is invalid at the time the method is called.

InferiorThread.switch ()  [Function]
This changes GDB’s currently selected thread to the one represented by this object.

InferiorThread.is_stopped ()  [Function]
Return a Boolean indicating whether the thread is stopped.

InferiorThread.is_running ()  [Function]
Return a Boolean indicating whether the thread is running.

InferiorThread.is_exited ()  [Function]
Return a Boolean indicating whether the thread is exited.

23.2.2.19 Commands In Python
You can implement new GDB CLI commands in Python. A CLI command is implemented using an instance of the gdb.Command class, most commonly using a subclass.

Command.__init__ (name, command_class [, completer_class [, prefix]])  [Function]
The object initializer for Command registers the new command with GDB. This initializer is normally invoked from the subclass’ own __init__ method.

name is the name of the command. If name consists of multiple words, then the initial words are looked for as prefix commands. In this case, if one of the prefix commands does not exist, an exception is raised.

There is no support for multi-line commands.

command_class should be one of the ‘COMMAND_’ constants defined below. This argument tells GDB how to categorize the new command in the help system.

completer_class is an optional argument. If given, it should be one of the ‘COMPLETE_’ constants defined below. This argument tells GDB how to perform completion for this command. If not given, GDB will attempt to complete using the object’s complete method (see below); if no such method is found, an error will occur when completion is attempted.
prefix is an optional argument. If True, then the new command is a prefix command; sub-commands of this command may be registered.

The help text for the new command is taken from the Python documentation string for the command’s class, if there is one. If no documentation string is provided, the default value “This command is not documented.” is used.

Command.dont_repeat () [Function]
By default, a GDB command is repeated when the user enters a blank line at the command prompt. A command can suppress this behavior by invoking the dont_repeat method. This is similar to the user command dont-repeat, see Section 23.1.1 [Define], page 315.

Command.invoke (argument, from_tty) [Function]
This method is called by GDB when this command is invoked.

argument is a string. It is the argument to the command, after leading and trailing whitespace has been stripped.

from_tty is a boolean argument. When true, this means that the command was entered by the user at the terminal; when false it means that the command came from elsewhere.

If this method throws an exception, it is turned into a GDB error call. Otherwise, the return value is ignored.

To break argument up into an argy-like string use gdb.string_to_argv. This function behaves identically to GDB’s internal argument lexer buildargv. It is recommended to use this for consistency. Arguments are separated by spaces and may be quoted. Example:

    print gdb.string_to_argv ("1 2 " \ "3 '4 "5' "6 '7")
[1, 2 '3', '4 '5', '6 '7']

Command.complete (text, word) [Function]
This method is called by GDB when the user attempts completion on this command. All forms of completion are handled by this method, that is, the TAB and M-? key bindings (see Section 3.2 [Completion], page 19), and the complete command (see Section 3.3 [Help], page 22).

The arguments text and word are both strings; text holds the complete command line up to the cursor’s location, while word holds the last word of the command line; this is computed using a word-breaking heuristic.

The complete method can return several values:

- If the return value is a sequence, the contents of the sequence are used as the completions. It is up to complete to ensure that the contents actually do complete the word. A zero-length sequence is allowed, it means that there were no completions available. Only string elements of the sequence are used; other elements in the sequence are ignored.
- If the return value is one of the ‘COMPLETE_’ constants defined below, then the corresponding GDB-internal completion function is invoked, and its result is used.
- All other results are treated as though there were no available completions.
When a new command is registered, it must be declared as a member of some general class of commands. This is used to classify top-level commands in the on-line help system; note that prefix commands are not listed under their own category but rather that of their top-level command. The available classifications are represented by constants defined in the gdb module:

`gdb.COMMAND_NONE`
- The command does not belong to any particular class. A command in this category will not be displayed in any of the help categories.

`gdb.COMMAND_RUNNING`
- The command is related to running the inferior. For example, `start`, `step`, and `continue` are in this category. Type `help running` at the GDB prompt to see a list of commands in this category.

`gdb.COMMAND_DATA`
- The command is related to data or variables. For example, `call`, `find`, and `print` are in this category. Type `help data` at the GDB prompt to see a list of commands in this category.

`gdb.COMMAND_STACK`
- The command has to do with manipulation of the stack. For example, `backtrace`, `frame`, and `return` are in this category. Type `help stack` at the GDB prompt to see a list of commands in this category.

`gdb.COMMAND_FILES`
- This class is used for file-related commands. For example, `file`, `list` and `section` are in this category. Type `help files` at the GDB prompt to see a list of commands in this category.

`gdb.COMMAND_SUPPORT`
- This should be used for “support facilities”, generally meaning things that are useful to the user when interacting with GDB, but not related to the state of the inferior. For example, `help`, `make`, and `shell` are in this category. Type `help support` at the GDB prompt to see a list of commands in this category.

`gdb.COMMAND_STATUS`
- The command is an ‘info’-related command, that is, related to the state of GDB itself. For example, `info`, `macro`, and `show` are in this category. Type `help status` at the GDB prompt to see a list of commands in this category.

`gdb.COMMAND_BREAKPOINTS`
- The command has to do with breakpoints. For example, `break`, `clear`, and `delete` are in this category. Type `help breakpoints` at the GDB prompt to see a list of commands in this category.

`gdb.COMMAND_TRACEPOINTS`
- The command has to do with tracepoints. For example, `trace`, `actions`, and `tfind` are in this category. Type `help tracepoints` at the GDB prompt to see a list of commands in this category.
The command is a general purpose command for the user, and typically does not fit in one of the other categories. Type `help user-defined` at the GDB prompt to see a list of commands in this category, as well as the list of gdb macros (see Section 23.1 [Sequences], page 315).

The command is only used in unusual circumstances, or is not of general interest to users. For example, `checkpoint`, `fork`, and `stop` are in this category. Type `help obscure` at the GDB prompt to see a list of commands in this category.

The command is only useful to GDB maintainers. The `maintenance` and `flushregs` commands are in this category. Type `help internals` at the GDB prompt to see a list of commands in this category.

A new command can use a predefined completion function, either by specifying it via an argument at initialization, or by returning it from the `complete` method. These predefined completion constants are all defined in the `gdb` module:

- `gdb.COMPLETE_NONE`: This constant means that no completion should be done.
- `gdb.COMPLETE_FILENAME`: This constant means that filename completion should be performed.
- `gdb.COMPLETE_LOCATION`: This constant means that location completion should be done. See Section 9.2 [Specify Location], page 102.
- `gdb.COMPLETE_COMMAND`: This constant means that completion should examine GDB command names.
- `gdb.COMPLETE_SYMBOL`: This constant means that completion should be done using symbol names as the source.
- `gdb.COMPLETE_EXPRESSION`: This constant means that completion should be done on expressions. Often this means completing on symbol names, but some language parsers also have support for completing on field names.

The following code snippet shows how a trivial CLI command can be implemented in Python:

```python
class HelloWorld (gdb.Command):
    """Greet the whole world.""

    def __init__ (self):
        super (HelloWorld, self).__init__ ("hello-world", gdb.COMMAND_USER)

    def invoke (self, arg, from_tty):
        print "Hello, World!"

HelloWorld ()
```
The last line instantiates the class, and is necessary to trigger the registration of the command with GDB. Depending on how the Python code is read into GDB, you may need to import the `gdb` module explicitly.

### 23.2.2.20 Parameters In Python

You can implement new GDB parameters using Python. A new parameter is implemented as an instance of the `gdb.Parameter` class.

Parameters are exposed to the user via the `set` and `show` commands. See Section 3.3 [Help], page 22.

There are many parameters that already exist and can be set in GDB. Two examples are: `set follow fork` and `set charset`. Setting these parameters influences certain behavior in GDB. Similarly, you can define parameters that can be used to influence behavior in custom Python scripts and commands.

```python
Parameter.__init__(name, command-class, parameter-class [, enum-sequence])
```

The object initializer for `Parameter` registers the new parameter with GDB. This initializer is normally invoked from the subclass’ own `__init__` method.

`name` is the name of the new parameter. If `name` consists of multiple words, then the initial words are looked for as prefix parameters. An example of this can be illustrated with the `set print set` of parameters. If `name` is `print foo`, then `print` will be searched as the prefix parameter. In this case the parameter can subsequently be accessed in GDB as `set print foo`.

If `name` consists of multiple words, and no prefix parameter group can be found, an exception is raised.

`command-class` should be one of the `COMMAND_` constants (see Section 23.2.2.19 [Commands In Python], page 362). This argument tells GDB how to categorize the new parameter in the help system.

`parameter-class` should be one of the `PARAM_` constants defined below. This argument tells GDB the type of the new parameter; this information is used for input validation and completion.

If `parameter-class` is `PARAM_ENUM`, then `enum-sequence` must be a sequence of strings. These strings represent the possible values for the parameter.

If `parameter-class` is not `PARAM_ENUM`, then the presence of a fourth argument will cause an exception to be thrown.

The help text for the new parameter is taken from the Python documentation string for the parameter’s class, if there is one. If there is no documentation string, a default value is used.

```python
Parameter.set_doc
```

If this attribute exists, and is a string, then its value is used as the help text for this parameter’s `set` command. The value is examined when `Parameter.__init__` is invoked; subsequent changes have no effect.
Chapter 23: Extending GDB

Parameter.show_doc

If this attribute exists, and is a string, then its value is used as the help text for this parameter’s show command. The value is examined when Parameter.__init__ is invoked; subsequent changes have no effect.

Parameter.value

The value attribute holds the underlying value of the parameter. It can be read and assigned to just as any other attribute. GDB does validation when assignments are made.

There are two methods that should be implemented in any Parameter class. These are:

Parameter.get_set_string (self)

GDB will call this method when a parameter’s value has been changed via the set API (for example, set foo off). The value attribute has already been populated with the new value and may be used in output. This method must return a string.

Parameter.get_show_string (self, svalue)

GDB will call this method when a parameter’s show API has been invoked (for example, show foo). The argument svalue receives the string representation of the current value. This method must return a string.

When a new parameter is defined, its type must be specified. The available types are represented by constants defined in the gdb module:

gdb.PARAM_BOOLEAN

The value is a plain boolean. The Python boolean values, True and False are the only valid values.

gdb.PARAM_AUTO_BOOLEAN

The value has three possible states: true, false, and ‘auto’. In Python, true and false are represented using boolean constants, and ‘auto’ is represented using None.

gdb.PARAM_UINTEGER

The value is an unsigned integer. The value of 0 should be interpreted to mean “unlimited”.

gdb.PARAM_INTEGER

The value is a signed integer. The value of 0 should be interpreted to mean “unlimited”.

gdb.PARAM_STRING

The value is a string. When the user modifies the string, any escape sequences, such as ‘\t’, ‘\f’, and octal escapes, are translated into corresponding characters and encoded into the current host charset.

gdb.PARAM_STRING_NOESCAPE

The value is a string. When the user modifies the string, escapes are passed through untranslated.

gdb.PARAM_OPTIONAL_FILENAME

The value is a either a filename (a string), or None.
gdb.PARAM_FILENAME
The value is a filename. This is just like PARAM_STRING_NOESCAPE, but uses file
names for completion.

gdb.PARAM_ZINTEGER
The value is an integer. This is like PARAM_INTEGER, except 0 is interpreted as
itself.

gdb.PARAM_ENUM
The value is a string, which must be one of a collection string constants provided
when the parameter is created.

23.2.2.21 Writing new convenience functions
You can implement new convenience functions (see Section 10.11 [Convenience Vars],
page 137) in Python. A convenience function is an instance of a subclass of the class
gdb.Function.

Function.__init__(name)  [Function]
The initializer for Function registers the new function with GDB. The argument
name is the name of the function, a string. The function will be visible to the user
as a convenience variable of type internal function, whose name is the same as the
given name.
The documentation for the new function is taken from the documentation string for
the new class.

Function.invoke(*args)  [Function]
When a convenience function is evaluated, its arguments are converted to instances of
gdb.Value, and then the function’s invoke method is called. Note that GDB does not
predetermine the arity of convenience functions. Instead, all available arguments are
passed to invoke, following the standard Python calling convention. In particular, a
convenience function can have default values for parameters without ill effect.
The return value of this method is used as its value in the enclosing expression. If an
ordinary Python value is returned, it is converted to a gdb.Value following the usual
rules.

The following code snippet shows how a trivial convenience function can be implemented
in Python:

class Greet (gdb.Function):
    """Return string to greet someone.
    Takes a name as argument.""
    def __init__ (self):
        super (Greet, self).__init__ ("greet")
    def invoke (self, name):
        return "Hello, %s!" % name.string ()

Greet ()

The last line instantiates the class, and is necessary to trigger the registration of the
function with GDB. Depending on how the Python code is read into GDB, you may need to
import the gdb module explicitly.
Now you can use the function in an expression:

```
(gdb) print $greet("Bob")
$1 = "Hello, Bob!"
```

### 23.2.2.22 Program Spaces In Python

A program space, or `progspace`, represents a symbolic view of an address space. It consists of all of the `objfiles` of the program. See Section 23.2.2.23 [Objfiles In Python], page 370. See Section 4.9 [Inferiors and Programs], page 33, for more details about program spaces.

The following `progspace`-related functions are available in the `gdb` module:

**Function**

`gdb.current_progspace()`

This function returns the program space of the currently selected inferior. See Section 4.9 [Inferiors and Programs], page 33.

**Function**

`gdb.progspace()`

Return a sequence of all the progspaces currently known to `gdb`.

Each progspace is represented by an instance of the `gdb.Progspace` class.

**Variable**

`Progspace.filename`

The file name of the progspace as a string.

**Variable**

`Progspace.pretty_printers`

The `pretty_printers` attribute is a list of functions. It is used to look up pretty-printers. A `Value` is passed to each function in order; if the function returns `None`, then the search continues. Otherwise, the return value should be an object which is used to format the value. See Section 23.2.2.5 [Pretty Printing API], page 336, for more information.

**Variable**

`Progspace.type_printers`

The `type_printers` attribute is a list of type printer objects. See Section 23.2.2.8 [Type Printing API], page 340, for more information.

**Variable**

`Progspace.frame_filters`

The `frame_filters` attribute is a dictionary of frame filter objects. See Section 23.2.2.9 [Frame Filter API], page 341, for more information.

One may add arbitrary attributes to `gdb.Progspace` objects in the usual Python way. This is useful if, for example, one needs to do some extra record keeping associated with the program space.

In this contrived example, we want to perform some processing when an objfile with a certain symbol is loaded, but we only want to do this once because it is expensive. To achieve this we record the results with the program space because we can’t predict when the desired objfile will be loaded.

```
(gdb) python
def clear_objfiles_handler(event):
    event.progspace.expensive_computation = None
def expensive(symbol):
    """A mock routine to perform an "expensive" computation on symbol."
    """    print "Computing the answer to the ultimate question ..."
return 42

def new_objfile_handler(event):
    objfile = event.new_objfile
    progspace = objfile.progspace
    if not hasattr(progspace, 'expensive_computation') or \
        progspace.expensive_computation is None:
        # We use 'main' for the symbol to keep the example simple.
        # Note: There's no current way to constrain the lookup
        # to one objfile.
        symbol = gdb.lookup_global_symbol('main')
        if symbol is not None:
            progspace.expensive_computation = expensive(symbol)

gdb.events.clear_objfiles.connect(clear_objfiles_handler)
gdb.events.new_objfile.connect(new_objfile_handler)
end

(gdb) file /tmp/hello
Reading symbols from /tmp/hello...done.
Computing the answer to the ultimate question ...
(gdb) python print gdb.current_progspace().expensive_computation
42
(gdb) run
Starting program: /tmp/hello
Hello.
[Inferior 1 (process 4242) exited normally]

23.2.2.23 Objfiles In Python

GDB loads symbols for an inferior from various symbol-containing files (see Section 18.1 [Files], page 237). These include the primary executable file, any shared libraries used by the inferior, and any separate debug info files (see Section 18.3 [Separate Debug Files], page 246). GDB calls these symbol-containing files *objfiles*.

The following objfile-related functions are available in the *gdb* module:

- **gdb.current_objfile ()**  
  When auto-loading a Python script (see Section 23.2.3 [Python Auto-loading], page 387), GDB sets the “current objfile” to the corresponding objfile. This function returns the current objfile. If there is no current objfile, this function returns *None*.

- **gdb.objfiles ()**  
  Return a sequence of all the objfiles current known to GDB. See Section 23.2.2.23 [Objfiles In Python], page 370.

- **gdb.lookup_objfile (name [, by_build_id])**  
  Look up *name*, a file name or build ID, in the list of objfiles for the current program space (see Section 23.2.2.22 [Progspaces In Python], page 369). If the objfile is not found throw the Python *ValueError* exception.

  If *name* is a relative file name, then it will match any source file name with the same trailing components. For example, if *name* is `gcc/expr.c`, then it will match source file name of `/build/trunk/gcc/expr.c`, but not `/build/trunk/libcpp/expr.c` or `/build/trunk/gcc/x-expr.c`.

  If *by_build_id* is provided and is *True* then *name* is the build ID of the objfile. Otherwise, *name* is a file name. This is supported only on some operating systems, notably
those which use the ELF format for binary files and the GNU Binutils. For more details about this feature, see the description of the ‘--build-id’ command-line option in Section “Command Line Options” in The GNU Linker.

Each objfile is represented by an instance of the `gdb.Objfile` class.

**Objfile.filename**  
[Variable]  
The file name of the objfile as a string, with symbolic links resolved.  
The value is `None` if the objfile is no longer valid. See the `gdb.Objfile.is_valid` method, described below.

**Objfile.username**  
[Variable]  
The file name of the objfile as specified by the user as a string.  
The value is `None` if the objfile is no longer valid. See the `gdb.Objfile.is_valid` method, described below.

**Objfile.owner**  
[Variable]  
For separate debug info objfiles this is the corresponding `gdb.Objfile` object that debug info is being provided for. Otherwise this is `None`. Separate debug info objfiles are added with the `gdb.Objfile.add_separate_debug_file` method, described below.

**Objfile.build_id**  
[Variable]  
The build ID of the objfile as a string. If the objfile does not have a build ID then the value is `None`.  
This is supported only on some operating systems, notably those which use the ELF format for binary files and the GNU Binutils. For more details about this feature, see the description of the ‘--build-id’ command-line option in Section “Command Line Options” in The GNU Linker.

**Objfile.progspace**  
[Variable]  
The containing program space of the objfile as a `gdb.Progspace` object. See Section 23.2.2.22 [Progspace In Python], page 369.

**Objfile.pretty_printers**  
[Variable]  
The `pretty_printers` attribute is a list of functions. It is used to look up pretty-printers. A `Value` is passed to each function in order; if the function returns `None`, then the search continues. Otherwise, the return value should be an object which is used to format the value. See Section 23.2.2.5 [Pretty Printing API], page 336, for more information.

**Objfile.type_printers**  
[Variable]  
The `type_printers` attribute is a list of type printer objects. See Section 23.2.2.8 [Type Printing API], page 340, for more information.

**Objfile.frame_filters**  
[Variable]  
The `frame_filters` attribute is a dictionary of frame filter objects. See Section 23.2.2.9 [Frame Filter API], page 341, for more information.
One may add arbitrary attributes to `gdb.Objfile` objects in the usual Python way. This is useful if, for example, one needs to do some extra record keeping associated with the objfile.

In this contrived example we record the time when GDB loaded the objfile.

```python
(gdb) python
import datetime
def new_objfile_handler(event):
    # Set the time_loaded attribute of the new objfile.
    event.new_objfile.time_loaded = datetime.datetime.today()
gdb.events.new_objfile.connect(new_objfile_handler)
end
(gdb) file ./hello
Reading symbols from ./hello...done.
(gdb) python print gdb.objfiles()[0].time_loaded
2014-10-09 11:41:36.770345
```

A `gdb.Objfile` object has the following methods:

- `Objfile.is_valid()`  
  Returns True if the `gdb.Objfile` object is valid, False if not. A `gdb.Objfile` object can become invalid if the object file it refers to is not loaded in GDB any longer. All other `gdb.Objfile` methods will throw an exception if it is invalid at the time the method is called.

- `Objfile.add_separate_debug_file(file)`  
  Add file to the list of files that GDB will search for debug information for the objfile. This is useful when the debug info has been removed from the program and stored in a separate file. GDB has built-in support for finding separate debug info files (see Section 18.3 [Separate Debug Files], page 246), but if the file doesn’t live in one of the standard places that GDB searches then this function can be used to add a debug info file from a different place.

### 23.2.2.24 Accessing inferior stack frames from Python.

When the debugged program stops, GDB is able to analyze its call stack (see Section 8.1 [Stack frames], page 93). The `gdb.Frame` class represents a frame in the stack. A `gdb.Frame` object is only valid while its corresponding frame exists in the inferior’s stack. If you try to use an invalid frame object, GDB will throw a `gdb.error` exception (see Section 23.2.2.2 [Exception Handling], page 326).

Two `gdb.Frame` objects can be compared for equality with the `==` operator, like:

```python
(gdb) python print gdb.newest_frame() == gdb.selected_frame ()
True
```

The following frame-related functions are available in the `gdb` module:

- `gdb.selected_frame()`  
  Return the selected frame object. (see Section 8.4 [Selecting a Frame], page 99).

- `gdb.newest_frame()`  
  Return the newest frame object for the selected thread.
gdb.frame_stop_reason_string (reason) [Function]
Return a string explaining the reason why GDB stopped unwinding frames, as expressed by the given reason code (an integer, see the unwind_stop_reason method further down in this section).

A gdb.Frame object has the following methods:

Frame.is_valid () [Function]
Returns true if the gdb.Frame object is valid, false if not. A frame object can become invalid if the frame it refers to doesn’t exist anymore in the inferior. All gdb.Frame methods will throw an exception if it is invalid at the time the method is called.

Frame.name () [Function]
Returns the function name of the frame, or None if it can’t be obtained.

Frame.architecture () [Function]
Returns the gdb.Architecture object corresponding to the frame’s architecture. See Section 23.2.2.32 [Architectures In Python], page 387.

Frame.type () [Function]
Returns the type of the frame. The value can be one of:

gdb.NORMAL_FRAME
An ordinary stack frame.

gdb.DUMMY_FRAME
A fake stack frame that was created by GDB when performing an inferior function call.

gdb.INLINE_FRAME
A frame representing an inlined function. The function was inlined into a gdb.NORMAL_FRAME that is older than this one.

gdb.TAILCALL_FRAME
A frame representing a tail call. See Section 11.2 [Tail Call Frames], page 156.

gdb.SIGTRAMP_FRAME
A signal trampoline frame. This is the frame created by the OS when it calls into a signal handler.

gdb.ARCH_FRAME
A fake stack frame representing a cross-architecture call.

gdb.SENTINEL_FRAME
This is like gdb.NORMAL_FRAME, but it is only used for the newest frame.

Frame.unwind_stop_reason () [Function]
Return an integer representing the reason why it’s not possible to find more frames toward the outermost frame. Use gdb.frame_stop_reason_string to convert the value returned by this function to a string. The value can be one of:

gdb.FRAME_UNWIND_NO_REASON
No particular reason (older frames should be available).
gdb.FRAME_UNWIND_NULL_ID
The previous frame’s analyzer returns an invalid result. This is no longer used by GDB, and is kept only for backward compatibility.

gdb.FRAME_UNWIND_OUTERMOST
This frame is the outermost.

gdb.FRAME_UNWIND_UNAVAILABLE
Cannot unwind further, because that would require knowing the values of registers or memory that have not been collected.

gdb.FRAME_UNWIND_INNER_ID
This frame ID looks like it ought to belong to a NEXT frame, but we got it for a PREV frame. Normally, this is a sign of unwinder failure. It could also indicate stack corruption.

gdb.FRAME_UNWIND_SAME_ID
This frame has the same ID as the previous one. That means that unwinding further would almost certainly give us another frame with exactly the same ID, so break the chain. Normally, this is a sign of unwinder failure. It could also indicate stack corruption.

gdb.FRAME_UNWIND_NO_SAVED_PC
The frame unwinder did not find any saved PC, but we needed one to unwind further.

gdb.FRAME_UNWIND_MEMORY_ERROR
The frame unwinder caused an error while trying to access memory.

gdb.FRAME_UNWIND_FIRST_ERROR
Any stop reason greater or equal to this value indicates some kind of error. This special value facilitates writing code that tests for errors in unwinding in a way that will work correctly even if the list of the other values is modified in future GDB versions. Using it, you could write:

```python
reason = gdb.selected_frame().unwind_stop_reason ()
reason_str = gdb.frame_stop_reason_string (reason)
if reason >= gdb.FRAME_UNWIND_FIRST_ERROR:
    print "An error occurred: %s" % reason_str
```

Frame.pc ()
Returns the frame’s resume address.

Frame.block ()
Return the frame’s code block. See Section 23.2.2.25 [Blocks In Python], page 375.

Frame.function ()
Return the symbol for the function corresponding to this frame. See Section 23.2.2.26 [Symbols In Python], page 377.

Frame.older ()
Return the frame that called this frame.

Frame.newer ()
Return the frame called by this frame.
Frame.find_sal()  
Return the frame's symtab and line object. See Section 23.2.2.27 [Symbol Tables In Python], page 380.

Frame.read_register(register)  
Return the value of register in this frame. The register argument must be a string (e.g., 'sp' or 'rax'). Returns a Gdb.Value object. Throws an exception if register does not exist.

Frame.read_var(variable[, block])  
Return the value of variable in this frame. If the optional argument block is provided, search for the variable from that block; otherwise start at the frame's current block (which is determined by the frame's current program counter). The variable argument must be a string or a gdb.Symbol object; block must be a gdb.Block object.

Frame.select()  
Set this frame to be the selected frame. See Chapter 8 [Examining the Stack], page 93.

23.2.2.25 Accessing blocks from Python.

In gdb, symbols are stored in blocks. A block corresponds roughly to a scope in the source code. Blocks are organized hierarchically, and are represented individually in Python as a gdb.Block. Blocks rely on debugging information being available.

A frame has a block. Please see Section 23.2.2.24 [Frames In Python], page 372, for a more in-depth discussion of frames.

The outermost block is known as the global block. The global block typically holds public global variables and functions.

The block nested just inside the global block is the static block. The static block typically holds file-scoped variables and functions.

GDB provides a method to get a block's superblock, but there is currently no way to examine the sub-blocks of a block, or to iterate over all the blocks in a symbol table (see Section 23.2.2.27 [Symbol Tables In Python], page 380).

Here is a short example that should help explain blocks:

```c
/* This is in the global block. */
int global;

/* This is in the static block. */
static int file_scope;

/* 'function' is in the global block, and 'argument' is in a block nested inside of 'function'. */
int function (int argument)
{
    /* 'local' is in a block inside 'function'. It may or may not be in the same block as 'argument'. */
    int local;

    {
        /* 'inner' is in a block whose superblock is the one holding 'local'. */
        int inner;
    }
```
/* If this call is expanded by the compiler, you may see
a nested block here whose function is 'inline_function'
and whose superblock is the one holding 'inner'. */
inline_function ();
}
}

A **gdb.Block** is iterable. The iterator returns the symbols (see Section 23.2.2.26 [Symbols In Python], page 377) local to the block. Python programs should not assume that a specific block object will always contain a given symbol, since changes in GDB features and infrastructure may cause symbols move across blocks in a symbol table.

The following block-related functions are available in the **gdb** module:

```python
gdb.block_for_pc (pc)  # [Function]
```
Return the innermost **gdb.Block** containing the given pc value. If the block cannot be found for the pc value specified, the function will return **None**.

A **gdb.Block** object has the following methods:

```python
Block.is_valid ()  # [Function]
```
Returns **True** if the **gdb.Block** object is valid, **False** if not. A block object can become invalid if the block it refers to doesn’t exist anymore in the inferior. All other **gdb.Block** methods will throw an exception if it is invalid at the time the method is called. The block’s validity is also checked during iteration over symbols of the block.

A **gdb.Block** object has the following attributes:

```python
Block.start  # [Variable]
The start address of the block. This attribute is not writable.
```

```python
Block.end  # [Variable]
The end address of the block. This attribute is not writable.
```

```python
Block.function  # [Variable]
The name of the block represented as a **gdb.Symbol**. If the block is not named, then this attribute holds **None**. This attribute is not writable.
```
For ordinary function blocks, the superblock is the static block. However, you should note that it is possible for a function block to have a superblock that is not the static block – for instance this happens for an inlined function.

```python
Block.superblock  # [Variable]
The block containing this block. If this parent block does not exist, this attribute holds **None**. This attribute is not writable.
```

```python
Block.global_block  # [Variable]
The global block associated with this block. This attribute is not writable.
```

```python
Block.static_block  # [Variable]
The static block associated with this block. This attribute is not writable.
```
Block.is_global

True if the `gdb.Block` object is a global block, False if not. This attribute is not writable.

Block.is_static

True if the `gdb.Block` object is a static block, False if not. This attribute is not writable.

23.2.2.26 Python representation of Symbols.

GDB represents every variable, function and type as an entry in a symbol table. See Chapter 16 [Examining the Symbol Table], page 217. Similarly, Python represents these symbols in GDB with the `gdb.Symbol` object.

The following symbol-related functions are available in the `gdb` module:

gdb.lookup_symbol (name [, block [, domain]])

This function searches for a symbol by name. The search scope can be restricted to the parameters defined in the optional domain and block arguments.

name is the name of the symbol. It must be a string. The optional block argument restricts the search to symbols visible in that block. The block argument must be a `gdb.Block` object. If omitted, the block for the current frame is used. The optional domain argument restricts the search to the domain type. The domain argument must be a domain constant defined in the `gdb` module and described later in this chapter.

The result is a tuple of two elements. The first element is a `gdb.Symbol` object or None if the symbol is not found. If the symbol is found, the second element is True if the symbol is a field of a method’s object (e.g., this in C++), otherwise it is False. If the symbol is not found, the second element is False.

gdb.lookup_global_symbol (name [, domain])

This function searches for a global symbol by name. The search scope can be restricted to by the domain argument.

name is the name of the symbol. It must be a string. The optional domain argument restricts the search to the domain type. The domain argument must be a domain constant defined in the `gdb` module and described later in this chapter.

The result is a `gdb.Symbol` object or None if the symbol is not found.

A `gdb.Symbol` object has the following attributes:

Symbol.type

The type of the symbol or None if no type is recorded. This attribute is represented as a `gdb.Type` object. See Section 23.2.2.4 [Types In Python], page 332. This attribute is not writable.

Symbol.symtab

The symbol table in which the symbol appears. This attribute is represented as a `gdb.Symtab` object. See Section 23.2.2.27 [Symbol Tables In Python], page 380. This attribute is not writable.
Symbol.line
   The line number in the source code at which the symbol was defined. This is an integer.

Symbol.name
   The name of the symbol as a string. This attribute is not writable.

Symbol.linkage_name
   The name of the symbol, as used by the linker (i.e., may be mangled). This attribute is not writable.

Symbol.print_name
   The name of the symbol in a form suitable for output. This is either name or linkage_name, depending on whether the user asked GDB to display demangled or mangled names.

Symbol.addr_class
   The address class of the symbol. This classifies how to find the value of a symbol. Each address class is a constant defined in the gdb module and described later in this chapter.

Symbol.needs_frame
   This is True if evaluating this symbol’s value requires a frame (see Section 23.2.2.24 [Frames In Python], page 372) and False otherwise. Typically, local variables will require a frame, but other symbols will not.

Symbol.is_argument
   True if the symbol is an argument of a function.

Symbol.is_constant
   True if the symbol is a constant.

Symbol.is_function
   True if the symbol is a function or a method.

Symbol.is_variable
   True if the symbol is a variable.

A gdb.Symbol object has the following methods:

Symbol.is_valid ()
   Returns True if the gdb.Symbol object is valid, False if not. A gdb.Symbol object can become invalid if the symbol it refers to does not exist in GDB any longer. All other gdb.Symbol methods will throw an exception if it is invalid at the time the method is called.

Symbol.value ([frame])
   Compute the value of the symbol, as a gdb.Value. For functions, this computes the address of the function, cast to the appropriate type. If the symbol requires a frame in order to compute its value, then frame must be given. If frame is not given, or if frame is invalid, then this method will throw an exception.
The available domain categories in `gdb.Symbol` are represented as constants in the `gdb` module:

`gdb.SYMBOL_UNDEF_DOMAIN`
This is used when a domain has not been discovered or none of the following domains apply. This usually indicates an error either in the symbol information or in GDB’s handling of symbols.

`gdb.SYMBOL_VAR_DOMAIN`
This domain contains variables, function names, typedef names and enum type values.

`gdb.SYMBOL_STRUCT_DOMAIN`
This domain holds struct, union and enum type names.

`gdb.SYMBOL_LABEL_DOMAIN`
This domain contains names of labels (for gotos).

`gdb.SYMBOL_VARIABLES_DOMAIN`
This domain holds a subset of the `SYMBOLS_VAR_DOMAIN`; it contains everything minus functions and types.

`gdb.SYMBOL_FUNCTION_DOMAIN`
This domain contains all functions.

`gdb.SYMBOL_TYPES_DOMAIN`
This domain contains all types.

The available address class categories in `gdb.Symbol` are represented as constants in the `gdb` module:

`gdb.SYMBOL_LOC_UNDEF`
If this is returned by address class, it indicates an error either in the symbol information or in GDB’s handling of symbols.

`gdb.SYMBOL_LOC_CONST`
Value is constant int.

`gdb.SYMBOL_LOC_STATIC`
Value is at a fixed address.

`gdb.SYMBOL_LOC_REGISTER`
Value is in a register.

`gdb.SYMBOL_LOC_ARG`
Value is an argument. This value is at the offset stored within the symbol inside the frame’s argument list.

`gdb.SYMBOL_LOC_REF_ARG`
Value address is stored in the frame’s argument list. Just like `LOC_ARG` except that the value’s address is stored at the offset, not the value itself.

`gdb.SYMBOL_LOC_REGPARM_ADDR`
Value is a specified register. Just like `LOC_REGISTER` except the register holds the address of the argument instead of the argument itself.
380 Debugging with GDB

gdb.SYMBOL_LOC_LOCAL  
Value is a local variable.

gdb.SYMBOL_LOC_TYPEDEF  
Value not used. Symbols in the domain SYMBOL_STRUCT_DOMAIN all have this class.

gdb.SYMBOL_LOC_BLOCK  
Value is a block.

gdb.SYMBOL_LOC_CONST_BYTES  
Value is a byte-sequence.

gdb.SYMBOL_LOC_UNRESOLVED  
Value is at a fixed address, but the address of the variable has to be determined from the minimal symbol table whenever the variable is referenced.

gdb.SYMBOL_LOC_OPTIMIZED_OUT  
The value does not actually exist in the program.

gdb.SYMBOL_LOC_COMPUTED  
The value’s address is a computed location.

23.2.2.27 Symbol table representation in Python.

Access to symbol table data maintained by GDB on the inferior is exposed to Python via two objects: gdb.Symtab_and_line and gdb.Symtab. Symbol table and line data for a frame is returned from the find_sal method in gdb.Frame object. See Section 23.2.2.24 [Frames In Python], page 372.

For more information on GDB’s symbol table management, see Chapter 16 [Examining the Symbol Table], page 217, for more information.

A gdb.Symtab_and_line object has the following attributes:

Symtab_and_line.symtab  
[Variable]  
The symbol table object (gdb.Symtab) for this frame. This attribute is not writable.

Symtab_and_line.pc  
[Variable]  
Indicates the start of the address range occupied by code for the current source line. This attribute is not writable.

Symtab_and_line.last  
[Variable]  
Indicates the end of the address range occupied by code for the current source line. This attribute is not writable.

Symtab_and_line.line  
[Variable]  
Indicates the current line number for this object. This attribute is not writable.

A gdb.Symtab_and_line object has the following methods:

Symtab_and_line.is_valid ()  
[Function]  
Returns True if the gdb.Symtab_and_line object is valid, False if not. A gdb.Symtab_and_line object can become invalid if the Symbol table and line object it refers to does not exist in GDB any longer. All other gdb.Symtab_and_line methods will throw an exception if it is invalid at the time the method is called.
A `gdb.Symtab` object has the following attributes:

**Symtab.filename**
- The symbol table’s source filename. This attribute is not writable.

**Symtab.objfile**
- The symbol table’s backing object file. See Section 23.2.2.23 [Objfiles In Python], page 370. This attribute is not writable.

**Symtab.producer**
- The name and possibly version number of the program that compiled the code in the symbol table. The contents of this string is up to the compiler. If no producer information is available then `None` is returned. This attribute is not writable.

A `gdb.Symtab` object has the following methods:

**Symtab.is_valid ()**
- Returns `True` if the `gdb.Symtab` object is valid, `False` if not. A `gdb.Symtab` object can become invalid if the symbol table it refers to does not exist in GDB any longer. All other `gdb.Symtab` methods will throw an exception if it is invalid at the time the method is called.

**Symtab.fullname ()**
- Return the symbol table’s source absolute file name.

**Symtab.global_block ()**
- Return the global block of the underlying symbol table. See Section 23.2.2.25 [Blocks In Python], page 375.

**Symtab.static_block ()**
- Return the static block of the underlying symbol table. See Section 23.2.2.25 [Blocks In Python], page 375.

**Symtab.linetable ()**
- Return the line table associated with the symbol table. See Section 23.2.2.28 [Line Tables In Python], page 381.

### 23.2.2.28 Manipulating line tables using Python

Python code can request and inspect line table information from a symbol table that is loaded in GDB. A line table is a mapping of source lines to their executable locations in memory. To acquire the line table information for a particular symbol table, use the `linetable` function (see Section 23.2.2.27 [Symbol Tables In Python], page 380).

A `gdb.LineTable` is iterable. The iterator returns `LineTableEntry` objects that correspond to the source line and address for each line table entry. `LineTableEntry` objects have the following attributes:

**LineTableEntry.line**
- The source line number for this line table entry. This number corresponds to the actual line of source. This attribute is not writable.
LineTableEntry.pc  [Variable]
The address that is associated with the line table entry where the executable code for
that source line resides in memory. This attribute is not writable.

As there can be multiple addresses for a single source line, you may receive multiple LineTableEntry objects with matching line attributes, but with different pc attributes. The iterator is sorted in ascending pc order. Here is a small example illustrating iterating over a line table.

```python
symtab = gdb.selected_frame().find_sal().symtab
linetable = symtab.linetable()
for line in linetable:
    print "Line: "+str(line.line)+" Address: "+hex(line.pc)
```

This will have the following output:

```
Line: 33 Address: 0x4005c8L
Line: 37 Address: 0x4005caL
Line: 39 Address: 0x4005d2L
Line: 40 Address: 0x4005f8L
Line: 42 Address: 0x4005ffL
Line: 44 Address: 0x400608L
Line: 42 Address: 0x40060cL
Line: 45 Address: 0x400615L
```

In addition to being able to iterate over a LineTable, it also has the following direct access methods:

**LineTable.line (line)**  [Function]
Return a Python Tuple of LineTableEntry objects for any entries in the line table
for the given line, which specifies the source code line. If there are no entries for that
source code line, the Python None is returned.

**LineTable.has_line (line)**  [Function]
Return a Python Boolean indicating whether there is an entry in the line table for
this source line. Return True if an entry is found, or False if not.

**LineTable.source_lines ()**  [Function]
Return a Python List of the source line numbers in the symbol table. Only lines
with executable code locations are returned. The contents of the List will just be
the source line entries represented as Python Long values.

### 23.2.2.29 Manipulating breakpoints using Python
Python code can manipulate breakpoints via the gdb.Breakpoint class.

**Breakpoint.__init__ (spec [, type [, wp_class [,internal [,temporary]]]])**  [Function]
Create a new breakpoint according to spec, which is a string naming the location
of the breakpoint, or an expression that defines a watchpoint. The contents can be
any location recognized by the break command, or in the case of a watchpoint, by
the watch command. The optional type denotes the breakpoint to create from the
types defined later in this chapter. This argument can be either gdb.BP_BREAKPOINT
or gdb.BP_WATCHPOINT; it defaults to gdb.BP_BREAKPOINT. The optional internal
argument allows the breakpoint to become invisible to the user. The breakpoint
will neither be reported when created, nor will it be listed in the output from info
breakpoints (but will be listed with the \texttt{maint info breakpoints} command). The optional \texttt{temporary} argument makes the breakpoint a temporary breakpoint. Temporary breakpoints are deleted after they have been hit. Any further access to the Python breakpoint after it has been hit will result in a runtime error (as that breakpoint has now been automatically deleted). The optional \texttt{wp\_class} argument defines the class of watchpoint to create, if \texttt{type} is \texttt{gdb.BP\_WATCHPOINT}. If a watchpoint class is not provided, it is assumed to be a \texttt{gdb.WP\_WRITE} class.

\begin{verbatim}
Breakpoint.stop (self)

The \texttt{gdb.Breakpoint} class can be sub-classed and, in particular, you may choose to implement the \texttt{stop} method. If this method is defined in a sub-class of \texttt{gdb.Breakpoint}, it will be called when the inferior reaches any location of a breakpoint which instantiates that sub-class. If the method returns \texttt{True}, the inferior will be stopped at the location of the breakpoint, otherwise the inferior will continue.

If there are multiple breakpoints at the same location with a \texttt{stop} method, each one will be called regardless of the return status of the previous. This ensures that all \texttt{stop} methods have a chance to execute at that location. In this scenario if one of the methods returns \texttt{True} but the others return \texttt{False}, the inferior will still be stopped.

You should not alter the execution state of the inferior (i.e., step, next, etc.), alter the current frame context (i.e., change the current active frame), or alter, add or delete any breakpoint. As a general rule, you should not alter any data within \texttt{GDB} or the inferior at this time.

Example \texttt{stop} implementation:

\begin{verbatim}
class MyBreakpoint (gdb.Breakpoint):
    def stop (self):
        inf_val = gdb.parse_and_eval("foo")
        if inf_val == 3:
            return True
        return False
\end{verbatim}

The available watchpoint types represented by constants are defined in the \texttt{gdb} module:

\begin{verbatim}
gdb.WP\_READ
    Read only watchpoint.
gdb.WP\_WRITE
    Write only watchpoint.
gdb.WP\_ACCESS
    Read/Write watchpoint.
\end{verbatim}

\begin{verbatim}
Breakpoint.is_valid ()

[Function]

Return \texttt{True} if this \texttt{Breakpoint} object is valid, \texttt{False} otherwise. A \texttt{Breakpoint} object can become invalid if the user deletes the breakpoint. In this case, the object still exists, but the underlying breakpoint does not. In the cases of watchpoint scope, the watchpoint remains valid even if execution of the inferior leaves the scope of that watchpoint.
\end{verbatim}
Breakpoint.delete ()

Permanently deletes the GDB breakpoint. This also invalidates the Python Breakpoint object. Any further access to this object’s attributes or methods will raise an error.

Breakpoint.enabled

This attribute is True if the breakpoint is enabled, and False otherwise. This attribute is writable. You can use it to enable or disable the breakpoint.

Breakpoint.silent

This attribute is True if the breakpoint is silent, and False otherwise. This attribute is writable.

Note that a breakpoint can also be silent if it has commands and the first command is silent. This is not reported by the silent attribute.

Breakpoint.thread

If the breakpoint is thread-specific, this attribute holds the thread id. If the breakpoint is not thread-specific, this attribute is None. This attribute is writable.

Breakpoint.task

If the breakpoint is Ada task-specific, this attribute holds the Ada task id. If the breakpoint is not task-specific (or the underlying language is not Ada), this attribute is None. This attribute is writable.

Breakpoint.ignore_count

This attribute holds the ignore count for the breakpoint, an integer. This attribute is writable.

Breakpoint.number

This attribute holds the breakpoint’s number — the identifier used by the user to manipulate the breakpoint. This attribute is not writable.

Breakpoint.type

This attribute holds the breakpoint’s type — the identifier used to determine the actual breakpoint type or use-case. This attribute is not writable.

Breakpoint.visible

This attribute tells whether the breakpoint is visible to the user when set, or when the ‘info breakpoints’ command is run. This attribute is not writable.

Breakpoint.temporary

This attribute indicates whether the breakpoint was created as a temporary breakpoint. Temporary breakpoints are automatically deleted after that breakpoint has been hit. Access to this attribute, and all other attributes and functions other than the is_valid function, will result in an error after the breakpoint has been hit (as it has been automatically deleted). This attribute is not writable.

The available types are represented by constants defined in the gdb module:

gdb.BP_BREAKPOINT

Normal code breakpoint.
gdb.BP_WATCHPOINT
Watchpoint breakpoint.

gdb.BP_HARDWARE_WATCHPOINT
Hardware assisted watchpoint.

gdb.BP_READ_WATCHPOINT
Hardware assisted read watchpoint.

gdb.BP_ACCESS_WATCHPOINT
Hardware assisted access watchpoint.

Breakpoint.hit_count
[Variable]
This attribute holds the hit count for the breakpoint, an integer. This attribute is writable, but currently it can only be set to zero.

Breakpoint.location
[Variable]
This attribute holds the location of the breakpoint, as specified by the user. It is a string. If the breakpoint does not have a location (that is, it is a watchpoint) the attribute's value is None. This attribute is not writable.

Breakpoint.expression
[Variable]
This attribute holds a breakpoint expression, as specified by the user. It is a string. If the breakpoint does not have an expression (the breakpoint is not a watchpoint) the attribute's value is None. This attribute is not writable.

Breakpoint.condition
[Variable]
This attribute holds the condition of the breakpoint, as specified by the user. It is a string. If there is no condition, this attribute's value is None. This attribute is writable.

Breakpoint.commands
[Variable]
This attribute holds the commands attached to the breakpoint. If there are commands, this attribute's value is a string holding all the commands, separated by newlines. If there are no commands, this attribute is None. This attribute is not writable.

23.2.2.30 Finish Breakpoints
A finish breakpoint is a temporary breakpoint set at the return address of a frame, based on the finish command. gdb.FinishBreakpoint extends gdb.Breakpoint. The underlying breakpoint will be disabled and deleted when the execution will run out of the breakpoint scope (i.e. Breakpoint.stop or FinishBreakpoint.out_of_scope triggered). Finish breakpoints are thread specific and must be create with the right thread selected.

FinishBreakpoint.__init__ ([frame], [internal])
[Function]
Create a finish breakpoint at the return address of the gdb.Frame object frame. If frame is not provided, this defaults to the newest frame. The optional internal argument allows the breakpoint to become invisible to the user. See Section 23.2.2.29 [Breakpoints In Python], page 382, for further details about this argument.
386 Debugging with GDB

FinishBreakpoint.out_of_scope (self)  [Function]
In some circumstances (e.g. longjmp, C++ exceptions, GDB return command, . . .), a
function may not properly terminate, and thus never hit the finish breakpoint. When
GDB notices such a situation, the out_of_scope callback will be triggered.

You may want to sub-class gdb.FinishBreakpoint and override this method:

class MyFinishBreakpoint (gdb.FinishBreakpoint)
    def stop (self):
        print "normal finish"
        return True

    def out_of_scope ():
        print "abnormal finish"

FinishBreakpoint.return_value  [Variable]
When GDB is stopped at a finish breakpoint and the frame used to build the
gdb.FinishBreakpoint object had debug symbols, this attribute will contain a
gdb.Value object corresponding to the return value of the function. The value will
be None if the function return type is void or if the return value was not computable.
This attribute is not writable.

23.2.2.31 Python representation of lazy strings.
A lazy string is a string whose contents is not retrieved or encoded until it is needed.

A gdb.LazyString is represented in GDB as an address that points to a region of mem-
ory, an encoding that will be used to encode that region of memory, and a length to delimit
the region of memory that represents the string. The difference between a gdb.LazyString
and a string wrapped within a gdb.Value is that a gdb.LazyString will be treated differ-
ently by GDB when printing. A gdb.LazyString is retrieved and encoded during printing,
while a gdb.Value wrapping a string is immediately retrieved and encoded on creation.

A gdb.LazyString object has the following functions:

LazyString.value ()  [Function]
Convert the gdb.LazyString to a gdb.Value. This value will point to the string
in memory, but will lose all the delayed retrieval, encoding and handling that GDB
applies to a gdb.LazyString.

LazyString.address  [Variable]
This attribute holds the address of the string. This attribute is not writable.

LazyString.length  [Variable]
This attribute holds the length of the string in characters. If the length is -1, then
the string will be fetched and encoded up to the first null of appropriate width. This
attribute is not writable.

LazyString.encoding  [Variable]
This attribute holds the encoding that will be applied to the string when the string
is printed by GDB. If the encoding is not set, or contains an empty string, then GDB
will select the most appropriate encoding when the string is printed. This attribute is
not writable.
LazyString.type

This attribute holds the type that is represented by the lazy string’s type. For a lazy string this will always be a pointer type. To resolve this to the lazy string’s character type, use the type’s target method. See Section 23.2.2.4 [Types In Python], page 332. This attribute is not writable.

23.2.2.32 Python representation of architectures

GDB uses architecture specific parameters and artifacts in a number of its various computations. An architecture is represented by an instance of the gdb.Architecture class.

A gdb.Architecture class has the following instance methods:

Architecture.name ()

Return the name (string value) of the architecture.

Architecture.disassemble (start_pc [, end_pc [, count]])

Return a list of disassembled instructions starting from the memory address start_pc. The optional arguments end_pc and count determine the number of instructions in the returned list. If both the optional arguments end_pc and count are specified, then a list of at most count disassembled instructions whose start address falls in the closed memory address interval from start_pc to end_pc are returned. If end_pc is not specified, but count is specified, then count number of instructions starting from the address start_pc are returned. If count is not specified but end_pc is specified, then all instructions whose start address falls in the closed memory address interval from start_pc to end_pc are returned. If neither end_pc nor count are specified, then a single instruction at start_pc is returned. For all of these cases, each element of the returned list is a Python dict with the following string keys:

addr The value corresponding to this key is a Python long integer capturing the memory address of the instruction.

asm The value corresponding to this key is a string value which represents the instruction with assembly language mnemonics. The assembly language flavor used is the same as that specified by the current CLI variable disassembly-flavor. See Section 9.6 [Machine Code], page 108.

length The value corresponding to this key is the length (integer value) of the instruction in bytes.

23.2.3 Python Auto-loading

When a new object file is read (for example, due to the file command, or because the inferior has loaded a shared library), GDB will look for Python support scripts in several ways: ‘objfile-gdb.py’ and .debug_gdb_scripts section. See Section 23.4 [Auto-loading extensions], page 442.

The auto-loading feature is useful for supplying application-specific debugging commands and scripts.

Auto-loading can be enabled or disabled, and the list of auto-loaded scripts can be printed.
set auto-load python-scripts [on|off]
Enable or disable the auto-loading of Python scripts.

show auto-load python-scripts
Show whether auto-loading of Python scripts is enabled or disabled.

info auto-load python-scripts [regexp]
Print the list of all Python scripts that \texttt{gdb} auto-loaded. Also printed is the list of Python scripts that were mentioned in the .debug_gdb_scripts section and were either not found (see Section 23.4.2 [dotdebug_gdb_scripts section], page 443) or were not auto-loaded due to auto-load safe-path rejection (see Section 22.7 [Auto-loading], page 302). This is useful because their names are not printed when \texttt{gdb} tries to load them and fails. There may be many of them, and printing an error message for each one is problematic.
If \texttt{regexp} is supplied only Python scripts with matching names are printed.
Example:
\begin{verbatim}
(gdb) info auto-load python-scripts
Loaded Script
  Yes py-section-script.py full name: /tmp/py-section-script.py
  No my-foo.pretty-printers.py
\end{verbatim}

When reading an auto-loaded file or script, \texttt{gdb} sets the current objfile. This is available via the \texttt{gdb.current_objfile} function (see Section 23.2.2.23 [Objfiles In Python], page 370). This can be useful for registering objfile-specific pretty-printers and frame-filters.

23.2.4 Python modules
\texttt{GDB} comes with several modules to assist writing Python code.

23.2.4.1 \texttt{gdb.printing}
This module provides a collection of utilities for working with pretty-printers.

\texttt{PrettyPrinter (name, subprinters=None)}
This class specifies the API that makes \texttt{'info pretty-printer', 'enable pretty-printer'} and \texttt{'disable pretty-printer'} work. Pretty-printers should generally inherit from this class.

\texttt{SubPrettyPrinter (name)}
For printers that handle multiple types, this class specifies the corresponding API for the subprinters.

\texttt{RegexpCollectionPrettyPrinter (name)}
Utility class for handling multiple printers, all recognized via regular expressions. See Section 23.2.2.7 [Writing a Pretty-Printer], page 338, for an example.

\texttt{FlagEnumerationPrinter (name)}
A pretty-printer which handles printing of \texttt{enum} values. Unlike \texttt{GDB}'s built-in \texttt{enum} printing, this printer attempts to work properly when there is some overlap between the enumeration constants. The argument \texttt{name} is the name of the printer and also the name of the \texttt{enum} type to look up.
register_pretty_printer (obj, printer, replace=False)

Register printer with the pretty-printer list of obj. If replace is True then any existing copy of the printer is replaced. Otherwise a RuntimeError exception is raised if a printer with the same name already exists.

23.2.4.2 gdb.types

This module provides a collection of utilities for working with gdb.Type objects.

get_basic_type (type)

Return type with const and volatile qualifiers stripped, and with typedefs and C++ references converted to the underlying type.

C++ example:

typedef const int const_int;
const_int foo (3);
const_int& foo_ref (foo);
int main () { return 0; }

Then in gdb:

(gdb) start
(gdb) python import gdb.types
(gdb) python foo_ref = gdb.parse_and_eval("foo_ref")
(gdb) python print gdb.types.get_basic_type(foo_ref.type)
int

has_field (type, field)

Return True if type, assumed to be a type with fields (e.g., a structure or union), has field field.

make_enum_dict (enum_type)

Return a Python dictionary type produced from enum_type.

deep_items (type)

Returns a Python iterator similar to the standard gdb.Type.iteritems method, except that the iterator returned by deep_items will recursively traverse anonymous struct or union fields. For example:

struct A
{
    int a;
    union {
        int b0;
        int b1;
    };
};

Then in GDB:

(gdb) python import gdb.types
(gdb) python struct_a = gdb.lookup_type("struct A")
(gdb) python print struct_a.keys ()
["a", "]"
(gdb) python print [k for k,v in gdb.types.deep_items(struct_a)]
["a", 'b0', 'b1']

get_type_recognizers ()

Return a list of the enabled type recognizers for the current context. This is called by GDB during the type-printing process (see Section 23.2.2.8 [Type Printing API], page 340).
apply_type_recognizers (recognizers, type_obj)
Apply the type recognizers, recognizers, to the type object type_obj. If any recognizer returns a string, return that string. Otherwise, return None. This is called by GDB during the type-printing process (see Section 23.2.2.8 [Type Printing API], page 340).

register_type_printer (locus, printer)
This is a convenience function to register a type printer printer. The printer must implement the type printer protocol. The locus argument is either a gdb.Objfile, in which case the printer is registered with that objfile; a gdb.Progspace, in which case the printer is registered with that progspace; or None, in which case the printer is registered globally.

TypePrinter
This is a base class that implements the type printer protocol. Type printers are encouraged, but not required, to derive from this class. It defines a constructor:

__init__ (self, name) [Method on TypePrinter]
Initialize the type printer with the given name. The new printer starts in the enabled state.

23.2.4.3 gdb.prompt
This module provides a method for prompt value-substitution.

substitute_prompt (string)
Return string with escape sequences substituted by values. Some escape sequences take arguments. You can specify arguments inside “{}” immediately following the escape sequence.

The escape sequences you can pass to this function are:

\ Backslash.
\e ESC character.
\f Selected frame; an argument names a frame parameter.
\n Newline.
\p Parameter’s value; the argument names the parameter.
\r Carriage return.
\t Selected thread; an argument names a thread parameter.
\v Version of GDB.
\w Current working directory.
\[ Begin a sequence of non-printing characters. These sequences are typically used with the ESC character, and are not counted in the string length. Example: “\[\e[0;34m\](gdb)\[\e[0m\]” will return a blue-colored “(gdb)” prompt where the length is five.
\] End a sequence of non-printing characters.

For example:

```
substitute_prompt ('"frame: \f,
print arguments: \p{print frame-arguments}"')
```

will return the string:

"frame: main, print arguments: scalars"

### 23.3 Extending GDB using Guile

You can extend GDB using the Guile implementation of the Scheme programming language. This feature is available only if GDB was configured using `--with-guile`.

#### 23.3.1 Guile Introduction

Guile is an implementation of the Scheme programming language and is the GNU project’s official extension language.

Guile support in GDB follows the Python support in GDB reasonably closely, so concepts there should carry over. However, some things are done differently where it makes sense.

GDB requires Guile version 2.0 or greater. Older versions are not supported.

Guile scripts used by GDB should be installed in `data-directory/guile`, where `data-directory` is the data directory as determined at GDB startup (see Section 18.7 [Data Files], page 252). This directory, known as the guile directory, is automatically added to the Guile Search Path in order to allow the Guile interpreter to locate all scripts installed at this location.

#### 23.3.2 Guile Commands

GDB provides two commands for accessing the Guile interpreter:

- **guile-repl**
- **gr**

  The `guile-repl` command can be used to start an interactive Guile prompt or repl. To return to GDB, type `,q` or the EOF character (e.g., `Ctrl-D` on an empty prompt). These commands do not take any arguments.

- **guile** `[scheme-expression]`
- **gu** `[scheme-expression]`

  The `guile` command can be used to evaluate a Scheme expression. If given an argument, GDB will pass the argument to the Guile interpreter for evaluation.

  ```
  (gdb) guile (display (+ 20 3)) (newline)
  23
  ```

  The result of the Scheme expression is displayed using normal Guile rules.

  ```
  (gdb) guile (+ 20 3)
  23
  ```

  If you do not provide an argument to `guile`, it will act as a multi-line command, like `define`. In this case, the Guile script is made up of subsequent command lines, given after the `guile` command. This command list is terminated using a line containing `end`. For example:
It is also possible to execute a Guile script from the GDB interpreter:

\begin{verbatim}
source 'script-name'
\end{verbatim}

The script name must end with ".scm" and GDB must be configured to recognize the script language based on filename extension using the \texttt{script-extension} setting. See Chapter 23 \[Extending GDB\], page 315.

\texttt{guile (load "script-name")}

This method uses the \texttt{load} Guile function. It takes a string argument that is the name of the script to load. See the Guile documentation for a description of this function. (see Section \texttt{“Loading”} in GNU Guile Reference Manual).

\subsection*{23.3.3 Guile API}

You can get quick online help for GDB’s Guile API by issuing the command \texttt{help guile}, or by issuing the command \texttt{,help} from an interactive Guile session. Furthermore, most Guile procedures provided by GDB have doc strings which can be obtained with \texttt{,describe procedure-name} or \texttt{,d procedure-name} from the Guile interactive prompt.

\subsubsection*{23.3.3.1 Basic Guile}

At startup, GDB overrides Guile’s \texttt{current-output-port} and \texttt{current-error-port} to print using GDB’s output-paging streams. A Guile program which outputs to one of these streams may have its output interrupted by the user (see Section 22.4 \[Screen Size\], page 299). In this situation, a Guile \texttt{signal} exception is thrown with value \texttt{SIGINT}.

Guile’s history mechanism uses the same naming as GDB’s, namely the user of dollar-variables (e.g., $1, $2, etc.). The results of evaluations in Guile and in GDB are counted separately, $1$ in Guile is not the same value as $1$ in GDB.

GDB is not thread-safe. If your Guile program uses multiple threads, you must be careful to only call GDB-specific functions in the GDB thread.

Some care must be taken when writing Guile code to run in GDB. Two things are worth noting in particular:

\begin{itemize}
  \item GDB installs handlers for \texttt{SIGCHLD} and \texttt{SIGINT}. Guile code must not override these, or even change the options using \texttt{sigaction}. If your program changes the handling of these signals, GDB will most likely stop working correctly. Note that it is unfortunately common for GUI toolkits to install a \texttt{SIGCHLD} handler.
  \item GDB takes care to mark its internal file descriptors as close-on-exec. However, this cannot be done in a thread-safe way on all platforms. Your Guile programs should be aware of this and should both create new file descriptors with the close-on-exec flag set and arrange to close unneeded file descriptors before starting a child process.
\end{itemize}

GDB introduces a new Guile module, named \texttt{gdb}. All methods and classes added by GDB are placed in this module. GDB does not automatically \texttt{import} the \texttt{gdb} module, scripts must do this themselves. There are various options for how to import a module, so GDB
leaves the choice of how the \texttt{gdb} module is imported to the user. To simplify interactive use, it is recommended to add one of the following to your \texttt{~/.gdbinit}.

\begin{verbatim}
guile (use-modules (gdb))
guile (use-modules ((gdb) #:renamer (symbol-prefix-proc 'gdb:)))
\end{verbatim}

Which one to choose depends on your preference. The second one adds \texttt{gdb:} as a prefix to all module functions and variables.

The rest of this manual assumes the \texttt{gdb} module has been imported without any prefix. See the Guile documentation for \texttt{use-modules} for more information (see Section “Using Guile Modules” in \textit{GNU Guile Reference Manual}).

Example:

\begin{verbatim}
(gdb) guile (value-type (make-value 1))
ERROR: Unbound variable: value-type
Error while executing Scheme code.
(gdb) guile (use-modules (gdb))
(gdb) guile (value-type (make-value 1))
int
(gdb)
\end{verbatim}

The \texttt{(gdb)} module provides these basic Guile functions.

\begin{description}
\item[execute \texttt{command} \texttt{[#:from-tty boolean] \texttt{[#:to-string boolean]}] \[Scheme Procedure\]}]
Evaluate \texttt{command}, a string, as a \texttt{gdb} CLI command. If a \texttt{gdb} exception happens while \texttt{command} runs, it is translated as described in Section 23.3.3.4 [Guile Exception Handling], page 396.

\texttt{from-tty} specifies whether \texttt{gdb} ought to consider this command as having originated from the user invoking it interactively. It must be a boolean value. If omitted, it defaults to \texttt{#f}.

By default, any output produced by \texttt{command} is sent to \texttt{gdb}’s standard output (and to the log output if logging is turned on). If the \texttt{to-string} parameter is \texttt{#t}, then output will be collected by \texttt{execute} and returned as a string. The default is \texttt{#f}, in which case the return value is unspecified. If \texttt{to-string} is \texttt{#t}, the \texttt{gdb} virtual terminal will be temporarily set to unlimited width and height, and its pagination will be disabled; see Section 22.4 [Screen Size], page 299.

\item[history-ref \texttt{number}] \[Scheme Procedure\]
Return a value from \texttt{gdb}’s value history (see Section 10.10 [Value History], page 136). The \texttt{number} argument indicates which history element to return. If \texttt{number} is negative, then \texttt{gdb} will take its absolute value and count backward from the last element (i.e., the most recent element) to find the value to return. If \texttt{number} is zero, then \texttt{gdb} will return the most recent element. If the element specified by \texttt{number} doesn’t exist in the value history, a \texttt{gdb:error} exception will be raised.

If no exception is raised, the return value is always an instance of \texttt{<gdb:value>} (see Section 23.3.3.5 [Values From Inferior In Guile], page 397).

\textit{Note:} \texttt{gdb}’s value history is independent of Guile’s. \texttt{$1} in \texttt{gdb}’s value history contains the result of evaluating an expression from \texttt{gdb}’s command line and \texttt{$1} from Guile’s history contains the result of evaluating an expression from Guile’s command line.
history-append! value

Append value, an instance of `<gdb:value>`, to GDB’s value history. Return its index in the history.

Putting into history values returned by Guile extensions will allow the user convenient access to those values via CLI history facilities.

parse-and-eval expression

Parse expression as an expression in the current language, evaluate it, and return the result as a `<gdb:value>`. The expression must be a string.

This function can be useful when implementing a new command (see Section 23.3.3.11 [Commands In Guile], page 413), as it provides a way to parse the command’s arguments as an expression. It is also is useful when computing values. For example, it is the only way to get the value of a convenience variable (see Section 10.11 [Convenience Vars], page 137) as a `<gdb:value>`.

### 23.3.3.2 Guile Configuration

GDB provides these Scheme functions to access various configuration parameters.

data-directory

Return a string containing GDB’s data directory. This directory contains GDB’s ancillary files.

guile-data-directory

Return a string containing GDB’s Guile data directory. This directory contains the Guile modules provided by GDB.

gdb-version

Return a string containing the GDB version.

host-config

Return a string containing the host configuration. This is the string passed to `--host` when GDB was configured.

target-config

Return a string containing the target configuration. This is the string passed to `--target` when GDB was configured.

### 23.3.3.3 GDB Scheme Data Types

The values exposed by GDB to Guile are known as GDB objects. There are several kinds of GDB object, and each is disjoint from all other types known to Guile.

gdb-object-kind object

Return the kind of the GDB object, e.g., `<gdb:breakpoint>`, as a symbol.

GDB defines the following object types:

<gdb:arch>

See Section 23.3.3.21 [Architectures In Guile], page 434.
<gdb:block>
See Section 23.3.3.16 [Blocks In Guile], page 424.
</gdb:block>

<gdb:block-symbols-iterator>
See Section 23.3.3.16 [Blocks In Guile], page 424.
</gdb:block-symbols-iterator>

<gdb:breakpoint>
See Section 23.3.3.19 [Breakpoints In Guile], page 430.
</gdb:breakpoint>

<gdb:command>
See Section 23.3.3.11 [Commands In Guile], page 413.
</gdb:command>

<gdb:exception>
See Section 23.3.3.4 [Guile Exception Handling], page 396.
</gdb:exception>

<gdb:frame>
See Section 23.3.3.15 [Frames In Guile], page 421.
</gdb:frame>

<gdb:iterator>
See Section 23.3.3.25 [Iterators In Guile], page 438.
</gdb:iterator>

<gdb:lazy-string>
See Section 23.3.3.20 [Lazy Strings In Guile], page 433.
</gdb:lazy-string>

<gdb:objfile>
See Section 23.3.3.14 [Objfiles In Guile], page 420.
</gdb:objfile>

<gdb:parameter>
See Section 23.3.3.12 [Parameters In Guile], page 417.
</gdb:parameter>

<gdb:pretty-printer>
See Section 23.3.3.8 [Guile Pretty Printing API], page 408.
</gdb:pretty-printer>

<gdb:pretty-printer-worker>
See Section 23.3.3.8 [Guile Pretty Printing API], page 408.
</gdb:pretty-printer-worker>

<gdb:progspace>
See Section 23.3.3.13 [Progspaces In Guile], page 419.
</gdb:progspace>

<gdb:symbol>
See Section 23.3.3.17 [Symbols In Guile], page 425.
</gdb:symbol>

<gdb:symtab>
See Section 23.3.3.18 [Symbol Tables In Guile], page 429.
</gdb:symtab>

<gdb:sal>
See Section 23.3.3.18 [Symbol Tables In Guile], page 429.
</gdb:sal>

<gdb:type>
See Section 23.3.3.7 [Types In Guile], page 404.
</gdb:type>

<gdb:field>
See Section 23.3.3.7 [Types In Guile], page 404.
</gdb:field>

<gdb:value>
See Section 23.3.3.5 [Values From Inferior In Guile], page 397.
</gdb:value>
The following GDB objects are managed internally so that the Scheme function eq? may be applied to them.

<gdb:arch>
<gdb:block>
<gdb:breakpoint>
<gdb:frame>
<gdb:objfile>
<gdb:progspace>
<gdb:symbol>
<gdb:symtab>
<gdb:type>

23.3.3.4 Guile Exception Handling

When executing the guile command, Guile exceptions uncaught within the Guile code are translated to calls to the GDB error-reporting mechanism. If the command that called guile does not handle the error, GDB will terminate it and report the error according to the setting of the guile print-stack parameter.

The guile print-stack parameter has three settings:

none Nothing is printed.
message An error message is printed containing the Guile exception name, the associated value, and the Guile call stack backtrace at the point where the exception was raised. Example:

```
(gdb) guile (display foo)
ERROR: In procedure memoize-variable-access!:
ERROR: Unbound variable: foo
Error while executing Scheme code.
```

full In addition to an error message a full backtrace is printed.

```
(gdb) set guile print-stack full
(gdb) guile (display foo)
Guile Backtrace:
In ice-9/boot-9.scm:
157: 10 [catch #t #<catch-closure 2c76e20> ...]
In unknown file:
?: 9 [apply-smob/1 #<catch-closure 2c76e20>]
In ice-9/boot-9.scm:
157: 8 [catch #t #<catch-closure 2c76d20> ...]
In unknown file:
?: 7 [apply-smob/1 #<catch-closure 2c76d20>]
?: 6 [call-with-input-string "(display foo)" ...]
In ice-9/boot-9.scm:
2320: 5 [save-module-excursion #<procedure 2c2dc30 ... ()>]
In ice-9/eval-string.scm:
44: 4 [read-and-eval #<input: string 27cb410> #:lang ...]
37: 3 [lp (display foo)]
In ice-9/eval.scm:
387: 2 [eval # ()]
393: 1 [eval #<memoized foo> ()]
In unknown file:
?: 0 [memoize-variable-access! #<memoized foo> ...]
```
Chapter 23: Extending GDB

397

ERROR: In procedure memoize-variable-access!:
ERROR: Unbound variable: foo
Error while executing Scheme code.

GDB errors that happen in GDB commands invoked by Guile code are converted to Guile exceptions. The type of the Guile exception depends on the error.

Guile procedures provided by GDB can throw the standard Guile exceptions like wrong-type-arg and out-of-range.

User interrupt (via C-c or by typing q at a pagination prompt) is translated to a Guile signal exception with value SIGINT.

GDB Guile procedures can also throw these exceptions:

**gdb:error**
This exception is a catch-all for errors generated from within GDB.

**gdb:invalid-object**
This exception is thrown when accessing Guile objects that wrap underlying GDB objects have become invalid. For example, a `<gdb:breakpoint>` object becomes invalid if the user deletes it from the command line. The object still exists in Guile, but the object it represents is gone. Further operations on this breakpoint will throw this exception.

**gdb:memory-error**
This exception is thrown when an operation tried to access invalid memory in the inferior.

**gdb:pp-type-error**
This exception is thrown when a Guile pretty-printer passes a bad object to GDB.

The following exception-related procedures are provided by the `(gdb)` module.

**make-exception** `key` `args`
[Scheme Procedure]
Return a `<gdb:exception>` object given by its `key` and `args`, which are the standard Guile parameters of an exception. See the Guile documentation for more information (see Section “Exceptions” in GNU Guile Reference Manual).

**exception?** `object`
[Scheme Procedure]
Return `#t` if `object` is a `<gdb:exception>` object. Otherwise return `#f`.

**exception-key** `exception`
[Scheme Procedure]
Return the `args` field of a `<gdb:exception>` object.

**exception-args** `exception`
[Scheme Procedure]
Return the `args` field of a `<gdb:exception>` object.

### 23.3.3.5 Values From Inferior In Guile

GDB provides values it obtains from the inferior program in an object of type `<gdb:value>`. GDB uses this object for its internal bookkeeping of the inferior’s values, and for fetching values when necessary.

GDB does not memoize `<gdb:value>` objects. `make-value` always returns a fresh object.
(gdb) guile (eq? (make-value 1) (make-value 1))
$1 = #f
(gdb) guile (equal? (make-value 1) (make-value 1))
$1 = #t

A <gdb:value> that represents a function can be executed via inferior function call with value-call. Any arguments provided to the call must match the function’s prototype, and must be provided in the order specified by that prototype.

For example, some-val is a <gdb:value> instance representing a function that takes two integers as arguments. To execute this function, call it like so:

(define result (value-call some-val 10 20))

Any values returned from a function call are <gdb:value> objects.

Note: Unlike Python scripting in GDB, inferior values that are simple scalars cannot be used directly in Scheme expressions that are valid for the value’s data type. For example, (+ (parse-and-eval "int_variable") 2) does not work. And inferior values that are structures or instances of some class cannot be accessed using any special syntax, instead value-field must be used.

The following value-related procedures are provided by the (gdb) module.

value? object                     [Scheme Procedure]
Return #t if object is a <gdb:value> object. Otherwise return #f.

make-value value [#:type type]    [Scheme Procedure]
Many Scheme values can be converted directly to a <gdb:value> with this procedure. If type is specified, the result is a value of this type, and if value can’t be represented with this type an exception is thrown. Otherwise the type of the result is determined from value as described below.

See Section 23.3.3.21 [Architectures In Guile], page 434, for a list of the builtin types for an architecture.

Here’s how Scheme values are converted when type argument to make-value is not specified:

Scheme boolean
A Scheme boolean is converted the boolean type for the current language.

Scheme integer
A Scheme integer is converted to the first of a C int, unsigned int, long, unsigned long, long long or unsigned long long type for the current architecture that can represent the value.
If the Scheme integer cannot be represented as a target integer an out-of-range exception is thrown.

Scheme real
A Scheme real is converted to the C double type for the current architecture.

Scheme string
A Scheme string is converted to a string in the current target language using the current target encoding. Characters that cannot be represented in
the current target encoding are replaced with the corresponding escape sequence. This is Guile’s SCM_FAILED_CONVERSION_ESCAPE_SEQUENCE conversion strategy (see Section “Strings” in GNU Guile Reference Manual).

Passing type is not supported in this case, if it is provided a wrong-type-arg exception is thrown.

<gdb:lazy-string>

If value is a <gdb:lazy-string> object (see Section 23.3.3.20 [Lazy Strings In Guile], page 433), then the lazy-string->value procedure is called, and its result is used.

Passing type is not supported in this case, if it is provided a wrong-type-arg exception is thrown.

Scheme bytevector

If value is a Scheme bytevector and type is provided, value must be the same size, in bytes, of values of type type, and the result is essentially created by using memcpy.

If value is a Scheme bytevector and type is not provided, the result is an array of type uint8 of the same length.

value-optimized-out? value

Return #t if the compiler optimized out value, thus it is not available for fetching from the inferior. Otherwise return #f.

value-address value

If value is addressable, returns a <gdb:value> object representing the address. Otherwise, #f is returned.

value-type value

Return the type of value as a <gdb:type> object (see Section 23.3.3.7 [Types In Guile], page 404).

value-dynamic-type value

Return the dynamic type of value. This uses C++ run-time type information (RTTI) to determine the dynamic type of the value. If the value is of class type, it will return the class in which the value is embedded, if any. If the value is of pointer or reference to a class type, it will compute the dynamic type of the referenced object, and return a pointer or reference to that type, respectively. In all other cases, it will return the value’s static type.

Note that this feature will only work when debugging a C++ program that includes RTTI for the object in question. Otherwise, it will just return the static type of the value as in ptype foo. See Chapter 16 [Symbols], page 217.

value-cast value type

Return a new instance of <gdb:value> that is the result of casting value to the type described by type, which must be a <gdb:type> object. If the cast cannot be performed for some reason, this method throws an exception.
value-dynamic-cast value type

Like value-cast, but works as if the C++ \texttt{dynamic
d_cast} operator were used. Consult a C++ reference for
details.

value-reinterpret-cast value type

Like value-cast, but works as if the C++ \texttt{reinterpret
cast} operator were used. Consult a C++ reference for
details.

value-dereference value

For pointer data types, this method returns a new \texttt{<gdb:value>}
object whose contents is the object pointed to by \texttt{value}. For example, if \texttt{foo}
is a C pointer to an \texttt{int}, declared in your C program as
\begin{verbatim}
int *foo;
\end{verbatim}
then you can use the corresponding \texttt{<gdb:value>} to access what \texttt{foo}
points to like this:
\begin{verbatim}
(define bar (value-dereference foo))
\end{verbatim}
The result \texttt{bar} will be a \texttt{<gdb:value>} object holding the value pointed to by \texttt{foo}.
A similar function \texttt{value-referenced-value} exists which also returns
\texttt{<gdb:value>} objects corresponding to the values pointed to by pointer values (and additionally,
values referenced by reference values). However, the behavior of \texttt{value-dereference}
differs from \texttt{value-referenced-value} by the fact that the behavior of \texttt{value-
dereference} is identical to applying the C unary operator \texttt{*} on a given value. For example, consider a reference to a pointer \texttt{ptrref}, declared in your C++ program as
\begin{verbatim}
typedef int *intptr;
...
int val = 10;
intptr ptr = &val;
intptr &ptrref = ptr;
\end{verbatim}
Though \texttt{ptrref} is a reference value, one can apply the method \texttt{value-dereference} to the
\texttt{<gdb:value>} object corresponding to it and obtain a \texttt{<gdb:value>} which is
identical to that corresponding to \texttt{val}. However, if you apply the method \texttt{value-
referenced-value}, the result would be a \texttt{<gdb:value>} object identical to that
responding to \texttt{ptr}.
\begin{verbatim}
(define scm-ptrref (parse-and-eval "ptrref"))
(define scm-val (value-dereference scm-ptrref))
(define scm-ptr (value-referenced-value scm-ptrref))
\end{verbatim}
The \texttt{<gdb:value>} object \texttt{scm-val} is identical to that corresponding to \texttt{val}, and \texttt{scm-
ptr} is identical to that corresponding to \texttt{ptr}. In general, \texttt{value-dereference} can be
applied whenever the C unary operator \texttt{*} can be applied to the corresponding C value.
For those cases where applying both \texttt{value-dereference} and \texttt{value-referenced-
value} is allowed, the results obtained need not be identical (as we have seen in the
above example). The results are however identical when applied on \texttt{<gdb:value>} objects
responding to pointers (\texttt{<gdb:value>} objects with type code \texttt{TYPE\_CODE\_PTR}) in a C/C++ program.

value-referenced-value value

For pointer or reference data types, this method returns a new \texttt{<gdb:value>}
object corresponding to the value referenced by the pointer/reference value. For pointer data
types, \texttt{value-dereference} and \texttt{value-referenced-value} produce identical results. The difference between these methods is that \texttt{value-dereference} cannot get the values referenced by reference values. For example, consider a reference to an \texttt{int}, declared in your C++ program as

\begin{verbatim}
  int val = 10;
  int &ref = val;
\end{verbatim}

then applying \texttt{value-dereference} to the \texttt{<gdb:value>} object corresponding to \texttt{ref} will result in an error, while applying \texttt{value-referenced-value} will result in a \texttt{<gdb:value>} object identical to that corresponding to \texttt{val}.

\begin{verbatim}
  (define scm-ref (parse-and-eval "ref"))
  (define err-ref (value-dereference scm-ref)) ;; error
  (define scm-val (value-referenced-value scm-ref)) ;; ok
\end{verbatim}

The \texttt{<gdb:value>} object \texttt{scm-val} is identical to that corresponding to \texttt{val}.

\texttt{value-field value field-name} \quad [\text{Scheme Procedure}]
\begin{description}
  \item Return field \texttt{field-name} from \texttt{<gdb:value>} object \texttt{value}.
\end{description}

\texttt{value-subscript value index} \quad [\text{Scheme Procedure}]
\begin{description}
  \item Return the value of array \texttt{value} at index \texttt{index}. The \texttt{value} argument must be a subscriptable \texttt{<gdb:value>} object.
\end{description}

\texttt{value-call value arg-list} \quad [\text{Scheme Procedure}]
\begin{description}
  \item Perform an inferior function call, taking \texttt{value} as a pointer to the function to call. Each element of list \texttt{arg-list} must be a \texttt{<gdb:value>} object or an object that can be converted to a value. The result is the value returned by the function.
\end{description}

\texttt{value->bool value} \quad [\text{Scheme Procedure}]
\begin{description}
  \item Return the Scheme boolean representing \texttt{<gdb:value>} \texttt{value}. The value must be “integer like”. Pointers are ok.
\end{description}

\texttt{value->integer} \quad [\text{Scheme Procedure}]
\begin{description}
  \item Return the Scheme integer representing \texttt{<gdb:value>} \texttt{value}. The value must be “integer like”. Pointers are ok.
\end{description}

\texttt{value->real} \quad [\text{Scheme Procedure}]
\begin{description}
  \item Return the Scheme real number representing \texttt{<gdb:value>} \texttt{value}. The value must be a number.
\end{description}

\texttt{value->bytevector} \quad [\text{Scheme Procedure}]
\begin{description}
  \item Return a Scheme bytevector with the raw contents of \texttt{<gdb:value>} \texttt{value}. No transformation, endian or otherwise, is performed.
\end{description}

\texttt{value->string value [#:encoding encoding] [#:errors errors] [#:length length]} \quad [\text{Scheme Procedure}]
\begin{description}
  \item If \texttt{value} represents a string, then this method converts the contents to a Guile string. Otherwise, this method will throw an exception.
  \item Values are interpreted as strings according to the rules of the current language. If the optional length argument is given, the string will be converted to that length, and will include any embedded zeroes that the string may contain. Otherwise, for languages where the string is zero-terminated, the entire string will be converted.
\end{description}
For example, in C-like languages, a value is a string if it is a pointer to or an array of characters or ints of type wchar_t, char16_t, or char32_t.

If the optional encoding argument is given, it must be a string naming the encoding of the string in the <gdb:value>, such as "ascii", "iso-8859-6" or "utf-8". It accepts the same encodings as the corresponding argument to Guile's scm_from_stringn function, and the Guile codec machinery will be used to convert the string. If encoding is not given, or if encoding is the empty string, then either the target_charset (see Section 10.20 [Character Sets], page 149) will be used, or a language-specific encoding will be used, if the current language is able to supply one.

The optional errors argument is one of #f, error or substitute. error and substitute must be symbols. If errors is not specified, or if its value is #f, then the default conversion strategy is used, which is set with the Scheme function set-port-conversion-strategy!. If the value is 'error then an exception is thrown if there is any conversion error. If the value is 'substitute then any conversion error is replaced with question marks. See Section “Strings” in GNU Guile Reference Manual.

If the optional length argument is given, the string will be fetched and converted to the given length. The length must be a Scheme integer and not a <gdb:value> integer.

value->lazy-string value [#:encoding encoding] [#:length length] [Scheme Procedure]

If this <gdb:value> represents a string, then this method converts value to a <gdb:lazy-string> (see Section 23.3.3.20 [Lazy Strings In Guile], page 433). Otherwise, this method will throw an exception.

If the optional encoding argument is given, it must be a string naming the encoding of the <gdb:lazy-string>. Some examples are: "ascii", "iso-8859-6" or "utf-8". If the encoding argument is an encoding that GDB does not recognize, GDB will raise an error.

When a lazy string is printed, the GDB encoding machinery is used to convert the string during printing. If the optional encoding argument is not provided, or is an empty string, GDB will automatically select the encoding most suitable for the string type. For further information on encoding in GDB please see Section 10.20 [Character Sets], page 149.

If the optional length argument is given, the string will be fetched and encoded to the length of characters specified. If the length argument is not provided, the string will be fetched and encoded until a null of appropriate width is found. The length must be a Scheme integer and not a <gdb:value> integer.

value-lazy? value [Scheme Procedure]

Return #t if value has not yet been fetched from the inferior. Otherwise return #f. GDB does not fetch values until necessary, for efficiency. For example:

(define myval (parse-and-eval "somevar"))

The value of somevar is not fetched at this time. It will be fetched when the value is needed, or when the fetch-lazy procedure is invoked.
make-lazy-value type address

Return a `<gdb:value>` that will be lazily fetched from the target. The object of type `<gdb:type>` whose value to fetch is specified by its `type` and its target memory `address`, which is a Scheme integer.

value-fetch-lazy! value

If `value` is a lazy value ((value-lazy? value) is #t), then the value is fetched from the inferior. Any errors that occur in the process will produce a Guile exception.

If `value` is not a lazy value, this method has no effect.

The result of this function is unspecified.

value-print value

Return the string representation (print form) of `<gdb:value>` `value`.

23.3.3.6 Arithmetic In Guile

The `(gdb)` module provides several functions for performing arithmetic on `<gdb:value>` objects. The arithmetic is performed as if it were done by the target, and therefore has target semantics which are not necessarily those of Scheme. For example operations work with a fixed precision, not the arbitrary precision of Scheme.

Wherever a function takes an integer or pointer as an operand, GDB will convert appropriate Scheme values to perform the operation.

value-add a b

value-sub a b

value-mul a b

value-div a b

value-rem a b

value-mod a b

value-pow a b

value-not a

value-neg a

value-pos a

value-abs a

value-lsh a b

value-rsh a b

value-min a b

value-max a b

value-lognot a

value-logand a b

value-logior a b
value-logxor a b
value=? a b
value<? a b
value<=? a b
value>? a b
value>=? a b

Scheme does not provide a not-equal function, and thus Guile support in GDB does not either.

23.3.3.7 Types In Guile

GDB represents types from the inferior in objects of type <gdb:type>.

The following type-related procedures are provided by the (gdb) module.

**type? object**

Return #t if object is an object of type <gdb:type>. Otherwise return #f.

**lookup-type name [#:block block]**

This function looks up a type by its name, which must be a string.

If block is given, it is an object of type <gdb:block>, and name is looked up in that scope. Otherwise, it is searched for globally.

Ordinarily, this function will return an instance of <gdb:type>. If the named type cannot be found, it will throw an exception.

**type-code type**

Return the type code of type. The type code will be one of the TYPE_CODE_ constants defined below.

**type-tag type**

Return the tag name of type. The tag name is the name after struct, union, or enum in C and C++; not all languages have this concept. If this type has no tag name, then #f is returned.

**type-name type**

Return the name of type. If this type has no name, then #f is returned.

**type-print-name type**

Return the print name of type. This returns something even for anonymous types. For example, for an anonymous C struct "struct {...}" is returned.

**type-sizeof type**

Return the size of this type, in target char units. Usually, a target’s char type will be an 8-bit byte. However, on some unusual platforms, this type may have a different size.

**type-strip-typedefs type**

Return a new <gdb:type> that represents the real type of type, after removing all layers of typedefs.
**type-array** `type n1 [n2]` [Scheme Procedure]
Return a new `<gdb:type>` object which represents an array of this type. If one argument is given, it is the inclusive upper bound of the array; in this case the lower bound is zero. If two arguments are given, the first argument is the lower bound of the array, and the second argument is the upper bound of the array. An array’s length must not be negative, but the bounds can be.

**type-vector** `type n1 [n2]` [Scheme Procedure]
Return a new `<gdb:type>` object which represents a vector of this type. If one argument is given, it is the inclusive upper bound of the vector; in this case the lower bound is zero. If two arguments are given, the first argument is the lower bound of the vector, and the second argument is the upper bound of the vector. A vector’s length must not be negative, but the bounds can be.

The difference between an array and a vector is that arrays behave like in C: when used in expressions they decay to a pointer to the first element whereas vectors are treated as first class values.

**type-pointer** `type` [Scheme Procedure]
Return a new `<gdb:type>` object which represents a pointer to `type`.

**type-range** `type` [Scheme Procedure]
Return a list of two elements: the low bound and high bound of `type`. If `type` does not have a range, an exception is thrown.

**type-reference** `type` [Scheme Procedure]
Return a new `<gdb:type>` object which represents a reference to `type`.

**type-target** `type` [Scheme Procedure]
Return a new `<gdb:type>` object which represents the target type of `type`.

For a pointer type, the target type is the type of the pointed-to object. For an array type (meaning C-like arrays), the target type is the type of the elements of the array. For a function or method type, the target type is the type of the return value. For a complex type, the target type is the type of the elements. For a typedef, the target type is the aliased type.

If the type does not have a target, this method will throw an exception.

**type-const** `type` [Scheme Procedure]
Return a new `<gdb:type>` object which represents a `const`-qualified variant of `type`.

**type-volatile** `type` [Scheme Procedure]
Return a new `<gdb:type>` object which represents a `volatile`-qualified variant of `type`.

**type-unqualified** `type` [Scheme Procedure]
Return a new `<gdb:type>` object which represents an unqualified variant of `type`. That is, the result is neither `const` nor `volatile`.

**type-num-fields** [Scheme Procedure]
Return the number of fields of `<gdb:type> type`. 
type-fields type  
[Scheme Procedure]  
Return the fields of type as a list. For structure and union types, fields has the usual meaning. Range types have two fields, the minimum and maximum values. Enum types have one field per enum constant. Function and method types have one field per parameter. The base types of C++ classes are also represented as fields. If the type has no fields, or does not fit into one of these categories, an empty list will be returned. See [Fields of a type in Guile], page 407.

make-field-iterator type  
[Scheme Procedure]  
Return the fields of type as a <gdb:iterator> object. See Section 23.3.3.25 [Iterators In Guile], page 438.

type-field type field-name  
[Scheme Procedure]  
Return field named field-name in type. The result is an object of type <gdb:field>. See [Fields of a type in Guile], page 407. If the type does not have fields, or field-name is not a field of type, an exception is thrown.

For example, if some-type is a <gdb:type> instance holding a structure type, you can access its foo field with:

(define bar (type-field some-type "foo"))

bar will be a <gdb:field> object.

type-has-field? type name  
[Scheme Procedure]  
Return #t if <gdb:type> type has field named name. Otherwise return #f.

Each type has a code, which indicates what category this type falls into. The available type categories are represented by constants defined in the (gdb) module:

TYPE_CODE_PTR  
The type is a pointer.

TYPE_CODE_ARRAY  
The type is an array.

TYPE_CODE_STRUCT  
The type is a structure.

TYPE_CODE_UNION  
The type is a union.

TYPE_CODE_ENUM  
The type is an enum.

TYPE_CODE_FLAGS  
a bit flags type, used for things such as status registers.

TYPE_CODE_FUNC  
The type is a function.

TYPE_CODE_INT  
The type is an integer type.

TYPE_CODE_FLT  
a floating point type.
TYPE_CODE_VOID
The special type void.

TYPE_CODE_SET
A Pascal set type.

TYPE_CODE_RANGE
A range type, that is, an integer type with bounds.

TYPE_CODE_STRING
A string type. Note that this is only used for certain languages with language-defined string types; C strings are not represented this way.

TYPE_CODE_BITSTRING
A string of bits. It is deprecated.

TYPE_CODE_ERROR
An unknown or erroneous type.

TYPE_CODE_METHOD
A method type, as found in C++ or Java.

TYPE_CODE_METHODPTR
A pointer-to-member-function.

TYPE_CODE_MEMBERPTR
A pointer-to-member.

TYPE_CODE_REF
A reference type.

TYPE_CODE_CHAR
A character type.

TYPE_CODE_BOOL
A boolean type.

TYPE_CODE_COMPLEX
A complex float type.

TYPE_CODE_TYPEDEF
A typedef to some other type.

TYPE_CODE_NAMESPACE
A C++ namespace.

TYPE_CODE_DECFLOAT
A decimal floating point type.

TYPE_CODE_INTERNAL_FUNCTION
A function internal to GDB. This is the type used to represent convenience functions (see Section 10.12 [Convenience Funs], page 139).

Further support for types is provided in the (gdb types) Guile module (see Section 23.3.5.2 [Guile Types Module], page 441).

Each field is represented as an object of type <gdb:field>.

The following field-related procedures are provided by the (gdb) module:
field?  object  
[Scheme Procedure]
  Return #t if object is an object of type <gdb:field>. Otherwise return #f.

field-name  field  
[Scheme Procedure]
  Return the name of the field, or #f for anonymous fields.

field-type  field  
[Scheme Procedure]
  Return the type of the field. This is usually an instance of <gdb:type>, but it can be #f in some situations.

field-enumval  field  
[Scheme Procedure]
  Return the enum value represented by <gdb:field> field.

field-bitpos  field  
[Scheme Procedure]
  Return the bit position of <gdb:field> field. This attribute is not available for static fields (as in C++ or Java).

field-bitsize  field  
[Scheme Procedure]
  If the field is packed, or is a bitfield, return the size of <gdb:field> field in bits. Otherwise, zero is returned; in which case the field's size is given by its type.

field-artificial?  field  
[Scheme Procedure]
  Return #t if the field is artificial, usually meaning that it was provided by the compiler and not the user. Otherwise return #f.

field-base-class?  field  
[Scheme Procedure]
  Return #t if the field represents a base class of a C++ structure. Otherwise return #f.

### 23.3.3.8 Guile Pretty Printing API

An example output is provided (see Section 10.9 [Pretty Printing], page 133).

A pretty-printer is represented by an object of type <gdb:pretty-printer>. Pretty-printer objects are created with make-pretty-printer.

The following pretty-printer-related procedures are provided by the (gdb) module:

make-pretty-printer  name  lookup-function  
[Scheme Procedure]
  Return a <gdb:pretty-printer> object named name.
  lookup-function is a function of one parameter: the value to be printed. If the value is handled by this pretty-printer, then lookup-function returns an object of type <gdb:pretty-printer-worker> to perform the actual pretty-printing. Otherwise lookup-function returns #f.

pretty-printer?  object  
[Scheme Procedure]
  Return #t if object is a <gdb:pretty-printer> object. Otherwise return #f.

pretty-printer-enabled?  pretty-printer  
[Scheme Procedure]
  Return #t if pretty-printer is enabled. Otherwise return #f.

set-pretty-printer-enabled!  pretty-printer  flag  
[Scheme Procedure]
  Set the enabled flag of pretty-printer to flag. The value returned is unspecified.
pretty-printers
Return the list of global pretty-printers.

set-pretty-printers!  pretty-printers
Set the list of global pretty-printers to pretty-printers. The value returned is unspecified.

make-pretty-printer-worker  display-hint  to-string  children
Return an object of type <gdb:pretty-printer-worker>. This function takes three parameters:

‘display-hint’
display-hint provides a hint to GDB or GDB front end via MI to change the formatting of the value being printed. The value must be a string or #f (meaning there is no hint). Several values for display-hint are predefined by GDB:

‘array’  Indicate that the object being printed is “array-like”. The CLI uses this to respect parameters such as set print elements and set print array.

‘map’  Indicate that the object being printed is “map-like”, and that the children of this value can be assumed to alternate between keys and values.

‘string’  Indicate that the object being printed is “string-like”. If the printer’s to-string function returns a Guile string of some kind, then GDB will call its internal language-specific string-printing function to format the string. For the CLI this means adding quotation marks, possibly escaping some characters, respecting set print elements, and the like.

‘to-string’
to-string is either a function of one parameter, the <gdb:pretty-printer-worker> object, or #f.

When printing from the CLI, if the to-string method exists, then GDB will prepend its result to the values returned by children. Exactly how this formatting is done is dependent on the display hint, and may change as more hints are added. Also, depending on the print settings (see Section 10.8 [Print Settings], page 125), the CLI may print just the result of to-string in a stack trace, omitting the result of children.

If this method returns a string, it is printed verbatim.

Otherwise, if this method returns an instance of <gdb:value>, then GDB prints this value. This may result in a call to another pretty-printer.

If instead the method returns a Guile value which is convertible to a <gdb:value>, then GDB performs the conversion and prints the resulting value. Again, this may result in a call to another pretty-printer. Guile scalars (integers, floats, and booleans) and strings are convertible to <gdb:value>; other types are not.
Finally, if this method returns \texttt{#f} then no further operations are performed in this method and nothing is printed.

If the result is not one of these types, an exception is raised. \texttt{to-string} may also be \texttt{#f} in which case it is left to \texttt{children} to print the value.

\texttt{children}

\texttt{children} is either a function of one parameter, the \texttt{<gdb:pretty-printer-worker>} object, or \texttt{#f}.

GDB will call this function on a pretty-printer to compute the children of the pretty-printer’s value.

This function must return a \texttt{<gdb:iterator>} object. Each item returned by the iterator must be a tuple holding two elements. The first element is the “name” of the child; the second element is the child’s value. The value can be any Guile object which is convertible to a GDB value.

If \texttt{children} is \texttt{#f}, GDB will act as though the value has no children.

GDB provides a function which can be used to look up the default pretty-printer for a \texttt{<gdb:value>}: 

\begin{verbatim}
default-visualizer value [Scheme Procedure]

This function takes a \texttt{<gdb:value>} object as an argument. If a pretty-printer for this value exists, then it is returned. If no such printer exists, then this returns \texttt{#f}.
\end{verbatim}

23.3.3.9 Selecting Guile Pretty-Printers

There are three sets of pretty-printers that GDB searches:

- Per-objfile list of pretty-printers (see Section 23.3.3.14 [Objfiles In Guile], page 420).
- Per-progspace list of pretty-printers (see Section 23.3.3.13 [Progspaces In Guile], page 419).
- The global list of pretty-printers (see Section 23.3.3.8 [Guile Pretty Printing API], page 408). These printers are available when debugging any inferior.

Pretty-printer lookup is done by passing the value to be printed to the lookup function of each enabled object in turn. Lookup stops when a lookup function returns a non-\texttt{#f} value or when the list is exhausted. Lookup functions must return either a \texttt{<gdb:pretty-printer-worker>} object or \texttt{#f}. Otherwise an exception is thrown.

GDB first checks the result of \texttt{objfile-pretty-printers} of each \texttt{<gdb:objfile>} in the current program space and iteratively calls each enabled lookup function in the list for that \texttt{<gdb:objfile>} until a non-\texttt{#f} object is returned. If no pretty-printer is found in the objfile lists, GDB then searches the result of \texttt{progspace-pretty-printers} of the current program space, calling each enabled function until a non-\texttt{#f} object is returned. After these lists have been exhausted, it tries the global pretty-printers list, obtained with \texttt{pretty-printers}, again calling each enabled function until a non-\texttt{#f} object is returned.

The order in which the objfiles are searched is not specified. For a given list, functions are always invoked from the head of the list, and iterated over sequentially until the end of the list, or a \texttt{<gdb:pretty-printer-worker>} object is returned.
For various reasons a pretty-printer may not work. For example, the underlying data structure may have changed and the pretty-printer is out of date.

The consequences of a broken pretty-printer are severe enough that GDB provides support for enabling and disabling individual printers. For example, if `print frame-arguments` is on, a backtrace can become highly illegible if any argument is printed with a broken printer.

Pretty-printers are enabled and disabled from Scheme by calling `set-pretty-printer-enabled!`. See Section 23.3.3.8 [Guile Pretty Printing API], page 408.

### 23.3.3.10 Writing a Guile Pretty-Printer

A pretty-printer consists of two basic parts: a lookup function to determine if the type is supported, and the printer itself.

Here is an example showing how a `std::string` printer might be written. See Section 23.3.3.8 [Guile Pretty Printing API], page 408, for details.

```scheme
(define (make-my-string-printer value)
  "Print a my::string string"
  (make-pretty-printer-worker "string"
    (lambda (printer)
      (value-field value "_data"))
    #f))
```

And here is an example showing how a lookup function for the printer example above might be written.

```scheme
(define (str-lookup-function pretty-printer value)
  (let ((tag (type-tag (value-type value))))
    (and tag
         (string-prefix? "std::string<" tag)
         (make-my-string-printer value))))
```

Then to register this printer in the global printer list:

```scheme
(append-pretty-printer!
 (make-pretty-printer "my-string" str-lookup-function))
```

The example lookup function extracts the value’s type, and attempts to match it to a type that it can pretty-print. If it is a type the printer can pretty-print, it will return a `<gdb:pretty-printer-worker>` object. If not, it returns `#f`.

We recommend that you put your core pretty-printers into a Guile package. If your pretty-printers are for use with a library, we further recommend embedding a version number into the package name. This practice will enable GDB to load multiple versions of your pretty-printers at the same time, because they will have different names.

You should write auto-loaded code (see Section 23.3.4 [Guile Auto-loading], page 440) such that it can be evaluated multiple times without changing its meaning. An ideal auto-load file will consist solely of `import`s of your printer modules, followed by a call to a register pretty-printers with the current objfile.

Taken as a whole, this approach will scale nicely to multiple inferiors, each potentially using a different library version. Embedding a version number in the Guile package name will ensure that GDB is able to load both sets of printers simultaneously. Then, because the search for pretty-printers is done by objfile, and because your auto-loaded code took care to register your library’s printers with a specific objfile, GDB will find the correct printers for the specific version of the library used by each inferior.
To continue the my::string example, this code might appear in (my-project my-library v1):

(use-modules (gdb))
(define (register-printers objfile)
  (append-objfile-pretty-printer!
    (make-pretty-printer "my-string" str-lookup-function)))

And then the corresponding contents of the auto-load file would be:

(use-modules (gdb) (my-project my-library v1))
(register-printers (current-objfile))

The previous example illustrates a basic pretty-printer. There are a few things that can be improved on. The printer only handles one type, whereas a library typically has several types. One could install a lookup function for each desired type in the library, but one could also have a single lookup function recognize several types. The latter is the conventional way this is handled. If a pretty-printer can handle multiple data types, then its subprinters are the printers for the individual data types.

The (gdb printing) module provides a formal way of solving this problem (see Section 23.3.5.1 [Guile Printing Module], page 441). Here is another example that handles multiple types.

These are the types we are going to pretty-print:

struct foo { int a, b; }
struct bar { struct foo x, y; }

Here are the printers:

(define (make-foo-printer value)
  "Print a foo object"
  (make-pretty-printer-worker
   "foo"
   (lambda (printer)
     (format #f "a=<~a> b=<~a>" (value-field value "a") (value-field value "b"))))
)

(define (make-bar-printer value)
  "Print a bar object"
  (make-pretty-printer-worker
   "foo"
   (lambda (printer)
     (format #f "x=<~a> y=<~a>" (value-field value "x") (value-field value "y"))))
)

This example doesn’t need a lookup function, that is handled by the (gdb printing) module. Instead a function is provided to build up the object that handles the lookup.

(use-modules (gdb printing))

(define (build-pretty-printer)
  (let ((pp (make-pretty-printer-collection "my-library")))
    (pp-collection-add-tag-printer "foo" make-foo-printer)
    (pp-collection-add-tag-printer "bar" make-bar-printer)
    pp))

And here is the autoload support:

(use-modules (gdb) (my-library))
(append-objfile-pretty-printer! (current-objfile) (build-pretty-printer))
Finally, when this printer is loaded into GDB, here is the corresponding output of `info pretty-printer`:

```
(gdb) info pretty-printer
my_library.so:
  my-library
    foo
    bar
```

### 23.3.3.11 Commands In Guile

You can implement new GDB CLI commands in Guile. A CLI command object is created with the `make-command` Guile function, and added to GDB with the `register-command!` Guile function. This two-step approach is taken to separate out the side-effect of adding the command to GDB from `make-command`.

There is no support for multi-line commands, that is commands that consist of multiple lines and are terminated with `end`.

```
(make-command name [#:invoke invoke] [#:command-class command-class] [#:completer-class completer] [#:prefix? prefix] [#:doc doc-string])
```

The argument `name` is the name of the command. If `name` consists of multiple words, then the initial words are looked for as prefix commands. In this case, if one of the prefix commands does not exist, an exception is raised.

The result is the `<gdb:command>` object representing the command. The command is not usable until it has been registered with GDB with `register-command!`.

The rest of the arguments are optional.

The argument `invoke` is a procedure of three arguments: `self`, `args` and `from-tty`. The argument `self` is the `<gdb:command>` object representing the command. The argument `args` is a string representing the arguments passed to the command, after leading and trailing whitespace has been stripped. The argument `from-tty` is a boolean flag and specifies whether the command should consider itself to have been originated from the user invoking it interactively. If this function throws an exception, it is turned into a GDB `error` call. Otherwise, the return value is ignored.

The argument `command-class` is one of the `'COMMAND_'` constants defined below. This argument tells GDB how to categorize the new command in the help system. The default is `COMMAND_NONE`.

The argument `completer` is either `#f`, one of the `'COMPLETE_'` constants defined below, or a procedure, also defined below. This argument tells GDB how to perform completion for this command. If not provided or if the value is `#f`, then no completion is performed on the command.

The argument `prefix` is a boolean flag indicating whether the new command is a prefix command; sub-commands of this command may be registered.

The argument `doc-string` is help text for the new command. If no documentation string is provided, the default value “This command is not documented.” is used.

```
register-command! command
```

Add `command`, a `<gdb:command>` object, to GDB’s list of commands. It is an error to register a command more than once. The result is unspecified.
command? object

[Scheme Procedure]

Return #t if object is a <gdb:command> object. Otherwise return #f.

dont-repeat

[Scheme Procedure]

By default, a GDB command is repeated when the user enters a blank line at the command prompt. A command can suppress this behavior by invoking the dont-repeat function. This is similar to the user command dont-repeat, see Section 23.1.1 [Define], page 315.

string->argv string

[Scheme Procedure]

Convert a string to a list of strings split up according to GDB’s argv parsing rules. It is recommended to use this for consistency. Arguments are separated by spaces and may be quoted. Example:
scheme@(guile-user)> (string->argv "1 2\ \"3 '4 "5' "6 '7\"")
$1 = ("1" "2 \"3" "4 \"5" "6 '7")

throw-user-error message . args

[Scheme Procedure]

Throw a gdb:user-error exception. The argument message is the error message as a format string, like the fmt argument to the format Scheme function. See Section “Formatted Output” in GNU Guile Reference Manual. The argument args is a list of the optional arguments of message.

This is used when the command detects a user error of some kind, say a bad command argument.

(gdb) guile (use-modules (gdb))
(gdb) guile
(register-command! (make-command "test-user-error"
 #:command-class COMMAND_OBSCURE
 #:invoke (lambda (self arg from-tty)
 (throw-user-error "Bad argument ~a" arg))))
end
(gdb) test-user-error ugh
ERROR: Bad argument ugh

self text word

[completer]

If the completer option to make-command is a procedure, it takes three arguments: self which is the <gdb:command> object, and text and word which are both strings. The argument text holds the complete command line up to the cursor’s location. The argument word holds the last word of the command line; this is computed using a word-breaking heuristic.

All forms of completion are handled by this function, that is, the TAB and M−? key bindings (see Section 3.2 [Completion], page 19, and the complete command (see Section 3.3 [Help], page 22).

This procedure can return several kinds of values:

- If the return value is a list, the contents of the list are used as the completions. It is up to completer to ensure that the contents actually do complete the word. An empty list is allowed, it means that there were no completions available. Only string elements of the list are used; other elements in the list are ignored.
- If the return value is a <gdb:iterator> object, it is iterated over to obtain the completions. It is up to completer-procedure to ensure that the results actually
do complete the word. Only string elements of the result are used; other elements in the sequence are ignored.

- All other results are treated as though there were no available completions.

When a new command is registered, it will have been declared as a member of some general class of commands. This is used to classify top-level commands in the on-line help system; note that prefix commands are not listed under their own category but rather that of their top-level command. The available classifications are represented by constants defined in the `gdb` module:

**COMMAND_NONE**
The command does not belong to any particular class. A command in this category will not be displayed in any of the help categories. This is the default.

**COMMAND_RUNNING**
The command is related to running the inferior. For example, `start`, `step`, and `continue` are in this category. Type `help running` at the GDB prompt to see a list of commands in this category.

**COMMAND_DATA**
The command is related to data or variables. For example, `call`, `find`, and `print` are in this category. Type `help data` at the GDB prompt to see a list of commands in this category.

**COMMAND_STACK**
The command has to do with manipulation of the stack. For example, `backtrace`, `frame`, and `return` are in this category. Type `help stack` at the GDB prompt to see a list of commands in this category.

**COMMAND_FILES**
This class is used for file-related commands. For example, `file`, `list` and `section` are in this category. Type `help files` at the GDB prompt to see a list of commands in this category.

**COMMAND_SUPPORT**
This should be used for “support facilities”, generally meaning things that are useful to the user when interacting with GDB, but not related to the state of the inferior. For example, `help`, `make`, and `shell` are in this category. Type `help support` at the GDB prompt to see a list of commands in this category.

**COMMAND_STATUS**
The command is an ‘info’-related command, that is, related to the state of GDB itself. For example, `info`, `macro`, and `show` are in this category. Type `help status` at the GDB prompt to see a list of commands in this category.

**COMMAND_BREAKPOINTS**
The command has to do with breakpoints. For example, `break`, `clear`, and `delete` are in this category. Type `help breakpoints` at the GDB prompt to see a list of commands in this category.
Debugging with gdb

COMMAND_TRACEPOINTS
The command has to do with tracepoints. For example, trace, actions, and tfind are in this category. Type help tracepoints at the GDB prompt to see a list of commands in this category.

COMMAND_USER
The command is a general purpose command for the user, and typically does not fit in one of the other categories. Type help user-defined at the GDB prompt to see a list of commands in this category, as well as the list of gdb macros (see Section 23.1 [Sequences], page 315).

COMMAND_OBSCURE
The command is only used in unusual circumstances, or is not of general interest to users. For example, checkpoint, fork, and stop are in this category. Type help obscure at the GDB prompt to see a list of commands in this category.

COMMAND_MAINTENANCE
The command is only useful to GDB maintainers. The maintenance and flushregs commands are in this category. Type help internals at the GDB prompt to see a list of commands in this category.

A new command can use a predefined completion function, either by specifying it via an argument at initialization, or by returning it from the completer procedure. These predefined completion constants are all defined in the gdb module:

COMPLETE_NONE
This constant means that no completion should be done.

COMPLETE_FILENAME
This constant means that filename completion should be performed.

COMPLETE_LOCATION
This constant means that location completion should be done. See Section 9.2 [Specify Location], page 102.

COMPLETE_COMMAND
This constant means that completion should examine GDB command names.

COMPLETE_SYMBOL
This constant means that completion should be done using symbol names as the source.

COMPLETE_EXPRESSION
This constant means that completion should be done on expressions. Often this means completing on symbol names, but some language parsers also have support for completing on field names.

The following code snippet shows how a trivial CLI command can be implemented in Guile:

(gdb) guile
(register-command! (make-command "hello-world"
 #:command-class COMMAND_USER
 #:doc "Greet the whole world."
 #:invoke (lambda (self args from-tty) (display "Hello, World!\n"))))
(make-parameter name [#:command-class command-class] #:parameter-type parameter-type [#:show-func show-func] #:doc doc #:set-doc set-doc #:show-doc show-doc #:initial-value initial-value)

The argument name is the name of the new parameter. If name consists of multiple words, then the initial words are looked for as prefix parameters. An example of this can be illustrated with the set print set of parameters. If name is print foo, then print will be searched as the prefix parameter. In this case the parameter can subsequently be accessed in GDB as set print foo. If name consists of multiple words, and no prefix parameter group can be found, an exception is raised.

The result is the <gdb:parameter> object representing the parameter. The parameter is not usable until it has been registered with GDB with register-parameter!.

The rest of the arguments are optional.

The argument command-class should be one of the ‘COMMAND_’ constants (see Section 23.3.3.11 [Commands In Guile], page 413). This argument tells GDB how to categorize the new parameter in the help system. The default is COMMAND_NONE.

The argument parameter-type should be one of the ‘PARAM_’ constants defined below. This argument tells GDB the type of the new parameter; this information is used for input validation and completion. The default is PARAM_BOOLEAN.

If parameter-type is PARAM_ENUM, then enum-list must be a list of strings. These strings represent the possible values for the parameter.

If parameter-type is not PARAM_ENUM, then the presence of enum-list will cause an exception to be thrown.

The argument set-func is a function of one argument: self which is the <gdb:parameter> object representing the parameter. GDB will call this function when a parameter’s value has been changed via the set API (for example, set foo off). The value of the parameter has already been set to the new value. This

1 Note that GDB parameters must not be confused with Guile’s parameter objects (see Section “Parameters” in GNU Guile Reference Manual).
function must return a string to be displayed to the user. GDB will add a trailing newline if the string is non-empty. GDB generally doesn’t print anything when a parameter is set, thus typically this function should return ‘”’. A non-empty string result should typically be used for displaying warnings and errors.

The argument show-func is a function of two arguments: self which is the <gdb:parameter> object representing the parameter, and svalue which is the string representation of the current value. GDB will call this function when a parameter’s show API has been invoked (for example, show foo). This function must return a string, and will be displayed to the user. GDB will add a trailing newline.

The argument doc is the help text for the new parameter. If there is no documentation string, a default value is used.

The argument set-doc is the help text for this parameter’s set command.

The argument show-doc is the help text for this parameter’s show command.

The argument initial-value specifies the initial value of the parameter. If it is a function, it takes one parameter, the <gdb:parameter> object and its result is used as the initial value of the parameter. The initial value must be valid for the parameter type, otherwise an exception is thrown.

register-parameter! parameter [Scheme Procedure]
Add parameter, a <gdb:parameter> object, to GDB’s list of parameters. It is an error to register a parameter more than once. The result is unspecified.

parameter? object [Scheme Procedure]
Return #t if object is a <gdb:parameter> object. Otherwise return #f.

parameter-value parameter [Scheme Procedure]
Return the value of parameter which may either be a <gdb:parameter> object or a string naming the parameter.

set-parameter-value! parameter new-value [Scheme Procedure]
Assign parameter the value of new-value. The argument parameter must be an object of type <gdb:parameter>. GDB does validation when assignments are made.

When a new parameter is defined, its type must be specified. The available types are represented by constants defined in the gdb module:

PARAM_BOOLEAN
The value is a plain boolean. The Guile boolean values, #t and #f are the only valid values.

PARAM_AUTO_BOOLEAN
The value has three possible states: true, false, and ‘auto’. In Guile, true and false are represented using boolean constants, and ‘auto’ is represented using #:auto.

PARAM_UINTEGER
The value is an unsigned integer. The value of 0 should be interpreted to mean “unlimited”.

PARAM_ZINTEGER
The value is an integer.

PARAM_ZUINTEGER
The value is an unsigned integer.

PARAM_ZUINTEGER_UNLIMITED
The value is an integer in the range ‘[0, INT_MAX]’. A value of ‘-1’ means “unlimited”, and other negative numbers are not allowed.

PARAM_STRING
The value is a string. When the user modifies the string, any escape sequences, such as ‘\t’, ‘\f’, and octal escapes, are translated into corresponding characters and encoded into the current host charset.

PARAM_STRING_NOESCAPE
The value is a string. When the user modifies the string, escapes are passed through untranslated.

PARAM_OPTIONAL_FILENAME
The value is a either a filename (a string), or #f.

PARAM_FILENAME
The value is a filename. This is just like PARAM_STRING_NOESCAPE, but uses file names for completion.

PARAM_ENUM
The value is a string, which must be one of a collection of string constants provided when the parameter is created.

23.3.3.13 Program Spaces In Guile
A program space, or progspace, represents a symbolic view of an address space. It consists of all of the objfiles of the program. See Section 23.3.3.14 [Objfiles In Guile], page 420. See Section 4.9 [Inferiors and Programs], page 33, for more details about program spaces.

Each progspace is represented by an instance of the <gdb:progspace> smob. See Section 23.3.3.3 [GDB Scheme Data Types], page 394.

The following progspace-related functions are available in the (gdb) module:

progspace? object [Scheme Procedure]
Return #t if object is a <gdb:progspace> object. Otherwise return #f.

progspace-valid? progspace [Scheme Procedure]
Return #t if progspace is valid, #f if not. A <gdb:progspace> object can become invalid if the program it refers to is not loaded in GDB any longer.

current-progspace [Scheme Procedure]
This function returns the program space of the currently selected inferior. There is always a current progspace, this never returns #f. See Section 4.9 [Inferiors and Programs], page 33.

progspaces [Scheme Procedure]
Return a list of all the progspaces currently known to GDB.
progspace-filename progspace

Return the absolute file name of progspace as a string. This is the name of the file passed as the argument to the file or symbol-file commands. If the program space does not have an associated file name, then #f is returned. This occurs, for example, when GDB is started without a program to debug.

A gdb:invalid-object-error exception is thrown if progspace is invalid.

progspace-objfiles progspace

Return the list of objfiles of progspace. The order of objfiles in the result is arbitrary. Each element is an object of type <gdb:objfile>. See Section 23.3.3.14 [Objfiles In Guile], page 420.

A gdb:invalid-object-error exception is thrown if progspace is invalid.

progspace-pretty-printers progspace

Return the list of pretty-printers of progspace. Each element is an object of type <gdb:pretty-printer>. See Section 23.3.3.8 [Guile Pretty Printing API], page 408, for more information.

set-progspace-pretty-printers! progspace printer-list

Set the list of registered <gdb:pretty-printer> objects for progspace to printer-list. See Section 23.3.3.8 [Guile Pretty Printing API], page 408, for more information.

23.3.3.14 Objfiles In Guile

GDB loads symbols for an inferior from various symbol-containing files (see Section 18.1 [Files], page 237). These include the primary executable file, any shared libraries used by the inferior, and any separate debug info files (see Section 18.3 [Separate Debug Files], page 246). GDB calls these symbol-containing files objfiles.

Each objfile is represented as an object of type <gdb:objfile>.

The following objfile-related procedures are provided by the (gdb) module:

objfile? object

Return #t if object is a <gdb:objfile> object. Otherwise return #f.

objfile-valid? objfile

Return #t if objfile is valid, #f if not. A <gdb:objfile> object can become invalid if the object file it refers to is not loaded in GDB any longer. All other <gdb:objfile> procedures will throw an exception if it is invalid at the time the procedure is called.

objfile-filename objfile

Return the file name of objfile as a string, with symbolic links resolved.

objfile-progspace objfile

Return the <gdb:progspace> that this object file lives in. See Section 23.3.3.13 [Progspaces In Guile], page 419, for more on progspaces.

objfile-pretty-printers objfile

Return the list of registered <gdb:pretty-printer> objects for objfile. See Section 23.3.3.8 [Guile Pretty Printing API], page 408, for more information.
set-objfile-pretty-printers! objfile printer-list

Set the list of registered <gdb:pretty-printer> objects for objfile to printer-list. The printer-list must be a list of <gdb:pretty-printer> objects. See Section 23.3.3.8 [Guile Pretty Printing API], page 408, for more information.

current-objfile

When auto-loading a Guile script (see Section 23.3.4 [Guile Auto-loading], page 440), GDB sets the “current objfile” to the corresponding objfile. This function returns the current objfile. If there is no current objfile, this function returns #f.

objfiles

Return a list of all the objfiles in the current program space.

23.3.3.15 Accessing inferior stack frames from Guile.

When the debugged program stops, GDB is able to analyze its call stack (see Section 8.1 [Stack frames], page 93). The <gdb:frame> class represents a frame in the stack. A <gdb:frame> object is only valid while its corresponding frame exists in the inferior’s stack. If you try to use an invalid frame object, GDB will throw a gdb:invalid-object exception (see Section 23.3.3.4 [Guile Exception Handling], page 396).

Two <gdb:frame> objects can be compared for equality with the equal? function, like:

```guile
(gdb) guile (equal? (newest-frame) (selected-frame))
#t
```

The following frame-related procedures are provided by the (gdb) module:

frame? object

Return #t if object is a <gdb:frame> object. Otherwise return #f.

frame-valid? frame

Returns #t if frame is valid, #f if not. A frame object can become invalid if the frame it refers to doesn’t exist anymore in the inferior. All <gdb:frame> procedures will throw an exception if the frame is invalid at the time the procedure is called.

frame-name frame

Return the function name of frame, or #f if it can’t be obtained.

frame-arch frame

Return the <gdb:architecture> object corresponding to frame’s architecture. See Section 23.3.3.21 [Architectures In Guile], page 434.

frame-type frame

Return the type of frame. The value can be one of:

NORMAL_FRAME

An ordinary stack frame.

DUMMY_FRAME

A fake stack frame that was created by GDB when performing an inferior function call.
INLINE_FRAME
A frame representing an inlined function. The function was inlined into a NORMAL_FRAME that is older than this one.

TAILCALL_FRAME
A frame representing a tail call. See Section 11.2 [Tail Call Frames], page 156.

SIGTRAMP_FRAME
A signal trampoline frame. This is the frame created by the OS when it calls into a signal handler.

ARCH_FRAME
A fake stack frame representing a cross-architecture call.

SENTINEL_FRAME
This is like NORMAL_FRAME, but it is only used for the newest frame.

frame-unwind-stop-reason frame
[Scheme Procedure]
Return an integer representing the reason why it’s not possible to find more frames toward the outermost frame. Use unwind-stop-reason-string to convert the value returned by this function to a string. The value can be one of:

FRAME_UNWIND_NO_REASON
No particular reason (older frames should be available).

FRAME_UNWIND_NULL_ID
The previous frame’s analyzer returns an invalid result.

FRAME_UNWIND_OUTERMOST
This frame is the outermost.

FRAME_UNWIND_UNAVAILABLE
Cannot unwind further, because that would require knowing the values of registers or memory that have not been collected.

FRAME_UNWIND_INNER_ID
This frame ID looks like it ought to belong to a NEXT frame, but we got it for a PREV frame. Normally, this is a sign of unwinder failure. It could also indicate stack corruption.

FRAME_UNWINDSAME_ID
This frame has the same ID as the previous one. That means that unwinding further would almost certainly give us another frame with exactly the same ID, so break the chain. Normally, this is a sign of unwinder failure. It could also indicate stack corruption.

FRAME_UNWIND_NO_SAVED_PC
The frame unwinder did not find any saved PC, but we needed one to unwind further.

FRAME_UNWIND_MEMORY_ERROR
The frame unwinder caused an error while trying to access memory.
FRAME_UNWIND_FIRST_ERROR
Any stop reason greater or equal to this value indicates some kind of error. This special value facilitates writing code that tests for errors in unwinding in a way that will work correctly even if the list of the other values is modified in future GDB versions. Using it, you could write:

```scheme
(define reason (frame-unwind-stop-readon (selected-frame)))
(define reason-str (unwind-stop-reason-string reason))
(if (>= reason FRAME_UNWIND_FIRST_ERROR)
   (format #t "An error occurred: ~s\n" reason-str))
```

frame-pc frame
Return the frame’s resume address.

frame-block frame
Return the frame’s code block as a `<gdb:block>` object. See Section 23.3.3.16 [Blocks In Guile], page 424.

frame-function frame
Return the symbol for the function corresponding to this frame as a `<gdb:symbol>` object, or `#f` if there isn’t one. See Section 23.3.3.17 [Symbols In Guile], page 425.

frame-older frame
Return the frame that called frame.

frame-newer frame
Return the frame called by frame.

frame-sal frame
Return the frame’s `<gdb:sal>` (symtab and line) object. See Section 23.3.3.18 [Symbol Tables In Guile], page 429.

frame-read-register frame register
Return the value of register in frame. register should be a string, like ‘pc’.

frame-read-var frame variable [#:block block]
Return the value of variable in frame. If the optional argument block is provided, search for the variable from that block; otherwise start at the frame’s current block (which is determined by the frame’s current program counter). The variable must be given as a string or a `<gdb:symbol>` object, and block must be a `<gdb:block>` object.

frame-select frame
Set frame to be the selected frame. See Chapter 8 [Examining the Stack], page 93.

selected-frame
Return the selected frame object. See Section 8.4 [Selecting a Frame], page 99.

newest-frame
Return the newest frame object for the selected thread.

unwind-stop-reason-string reason
Return a string explaining the reason why GDB stopped unwinding frames, as expressed by the given reason code (an integer, see the frame-unwind-stop-reason procedure above in this section).
### 23.3.3.16 Accessing blocks from Guile.

In GDB, symbols are stored in blocks. A block corresponds roughly to a scope in the source code. Blocks are organized hierarchically, and are represented individually in Guile as an object of type `<gdb:block>`. Blocks rely on debugging information being available.

A frame has a block. Please see Section 23.3.3.15 [Frames In Guile], page 421, for a more in-depth discussion of frames.

The outermost block is known as the global block. The global block typically holds public global variables and functions.

The block nested just inside the global block is the static block. The static block typically holds file-scoped variables and functions.

GDB provides a method to get a block’s superblock, but there is currently no way to examine the sub-blocks of a block, or to iterate over all the blocks in a symbol table (see Section 23.3.3.18 [Symbol Tables In Guile], page 429).

Here is a short example that should help explain blocks:

```scheme
/* This is in the global block. */
int global;

/* This is in the static block. */
static int file_scope;

/* 'function' is in the global block, and 'argument' is
in a block nested inside of 'function'. */
int function (int argument)
{
    /* 'local' is in a block inside 'function'. It may or may
not be in the same block as 'argument'. */
    int local;

    {
        /* 'inner' is in a block whose superblock is the one holding
'local'. */
        int inner;

        /* If this call is expanded by the compiler, you may see
a nested block here whose function is 'inline_function'
and whose superblock is the one holding 'inner'. */
        inline_function ();
    }
}
```

The following block-related procedures are provided by the `(gdb)` module:

- **block? object**
  - [Scheme Procedure]
  - Return `#t` if `object` is a `<gdb:block>` object. Otherwise return `#f`.

- **block-valid? block**
  - [Scheme Procedure]
  - Returns `#t` if `<gdb:block> block` is valid, `#f` if not. A block object can become invalid if the block it refers to doesn’t exist anymore in the inferior. All other `<gdb:block>` methods will throw an exception if it is invalid at the time the procedure is called. The block’s validity is also checked during iteration over symbols of the block.

- **block-start block**
  - [Scheme Procedure]
  - Return the start address of `<gdb:block> block`. 
block-end block  
Return the end address of <gdb:block> block.

block-function block  
Return the name of <gdb:block> block represented as a <gdb:symbol> object. If the block is not named, then #f is returned.  
For ordinary function blocks, the superblock is the static block. However, you should note that it is possible for a function block to have a superblock that is not the static block – for instance this happens for an inlined function.

block-superblock block  
Return the block containing <gdb:block> block. If the parent block does not exist, then #f is returned.

block-global-block block  
Return the global block associated with <gdb:block> block.

block-static-block block  
Return the static block associated with <gdb:block> block.

block-global? block  
Return #t if <gdb:block> block is a global block. Otherwise return #f.

block-static? block  
Return #t if <gdb:block> block is a static block. Otherwise return #f.

block-symbols  
Return a list of all symbols (as <gdb:symbol> objects) in <gdb:block> block.

make-block-symbols-iterator block  
Return an object of type <gdb:iterator> that will iterate over all symbols of the block. Guile programs should not assume that a specific block object will always contain a given symbol, since changes in GDB features and infrastructure may cause symbols move across blocks in a symbol table. See Section 23.3.3.25 [Iterators In Guile], page 438.

block-symbols-progress?  
Return #t if the object is a <gdb:block-symbols-progress> object. This object would be obtained from the progress element of the <gdb:iterator> object returned by make-block-symbols-iterator.

lookup-block pc  
Return the innermost <gdb:block> containing the given pc value. If the block cannot be found for the pc value specified, the function will return #f.

23.3.3.17 Guile representation of Symbols.  
GDB represents every variable, function and type as an entry in a symbol table. See Chapter 16 [Examining the Symbol Table], page 217. Guile represents these symbols in GDB with the <gdb:symbol> object.

The following symbol-related procedures are provided by the (gdb) module:
symbol? object

Return #t if object is an object of type <gdb:symbol>. Otherwise return #f.

symbol-valid? symbol

Return #t if the <gdb:symbol> object is valid, #f if not. A <gdb:symbol> object can become invalid if the symbol it refers to does not exist in GDB any longer. All other <gdb:symbol> procedures will throw an exception if it is invalid at the time the procedure is called.

symbol-type symbol

Return the type of symbol or #f if no type is recorded. The result is an object of type <gdb:type>. See Section 23.3.3.7 [Types In Guile], page 404.

symbol-symtab symbol

Return the symbol table in which symbol appears. The result is an object of type <gdb:symtab>. See Section 23.3.3.18 [Symbol Tables In Guile], page 429.

symbol-line symbol

Return the line number in the source code at which symbol was defined. This is an integer.

symbol-name symbol

Return the name of symbol as a string.

symbol-linkage-name symbol

Return the name of symbol, as used by the linker (i.e., may be mangled).

symbol-print-name symbol

Return the name of symbol in a form suitable for output. This is either name or linkage_name, depending on whether the user asked GDB to display demangled or mangled names.

symbol-addr-class symbol

Return the address class of the symbol. This classifies how to find the value of a symbol. Each address class is a constant defined in the (gdb) module and described later in this chapter.

symbol-needs-frame? symbol

Return #t if evaluating symbol’s value requires a frame (see Section 23.3.3.15 [Frames In Guile], page 421) and #f otherwise. Typically, local variables will require a frame, but other symbols will not.

symbol-argument? symbol

Return #t if symbol is an argument of a function. Otherwise return #f.

symbol-constant? symbol

Return #t if symbol is a constant. Otherwise return #f.

symbol-function? symbol

Return #t if symbol is a function or a method. Otherwise return #f.
symbol-variable? symbol
   Return #t if symbol is a variable. Otherwise return #f.

symbol-value symbol [#:frame frame]
   Compute the value of symbol, as a <gdb:value>. For functions, this computes the
   address of the function, cast to the appropriate type. If the symbol requires a frame
   in order to compute its value, then frame must be given. If frame is not given, or if
   frame is invalid, then an exception is thrown.

lookup-symbol name [#:block block] [#:domain domain]
   This function searches for a symbol by name. The search scope can be restricted to
   the parameters defined in the optional domain and block arguments.
   name is the name of the symbol. It must be a string. The optional block argument
   restricts the search to symbols visible in that block. The block argument must be a
   <gdb:block> object. If omitted, the block for the current frame is used. The optional
   domain argument restricts the search to the domain type. The domain argument must
   be a domain constant defined in the (gdb) module and described later in this chapter.
   The result is a list of two elements. The first element is a <gdb:symbol> object or
   #f if the symbol is not found. If the symbol is found, the second element is #t if the
   symbol is a field of a method’s object (e.g., this in C++), otherwise it is #f. If the
   symbol is not found, the second element is #f.

lookup-global-symbol name [#:domain domain]
   This function searches for a global symbol by name. The search scope can be restricted
   by the domain argument.
   name is the name of the symbol. It must be a string. The optional domain argument
   restricts the search to the domain type. The domain argument must be a domain
   constant defined in the (gdb) module and described later in this chapter.
   The result is a <gdb:symbol> object or #f if the symbol is not found.

The available domain categories in <gdb:symbol> are represented as constants in the
(gdb) module:

SYMBOL_UNDEF_DOMAIN
   This is used when a domain has not been discovered or none of the following
   domains apply. This usually indicates an error either in the symbol information
   or in GDB’s handling of symbols.

SYMBOL_VAR_DOMAIN
   This domain contains variables, function names, typedef names and enum type
   values.

SYMBOL_STRUCT_DOMAIN
   This domain holds struct, union and enum type names.

SYMBOL_LABEL_DOMAIN
   This domain contains names of labels (for gotos).

SYMBOL_VARIABLES_DOMAIN
   This domain holds a subset of the SYMBOLS_VAR_DOMAIN; it contains everything
   minus functions and types.
SYMBOL_FUNCTION_DOMAIN
This domain contains all functions.

SYMBOL_TYPES_DOMAIN
This domain contains all types.

The available address class categories in `<gdb:symbol>` are represented as constants in the `gdb` module:

SYMBOL_LOC_UNDEF
If this is returned by address class, it indicates an error either in the symbol information or in GDB's handling of symbols.

SYMBOL_LOC_CONST
Value is constant int.

SYMBOL_LOC_STATIC
Value is at a fixed address.

SYMBOL_LOC_REGISTER
Value is in a register.

SYMBOL_LOC_ARG
Value is an argument. This value is at the offset stored within the symbol inside the frame's argument list.

SYMBOL_LOC_REF_ARG
Value address is stored in the frame's argument list. Just like LOC_ARG except that the value's address is stored at the offset, not the value itself.

SYMBOL_LOC_REGPARM_ADDR
Value is a specified register. Just like LOC_REGISTER except the register holds the address of the argument instead of the argument itself.

SYMBOL_LOC_LOCAL
Value is a local variable.

SYMBOL_LOC_TYPEDEF
Value not used. Symbols in the domain SYMBOL_STRUCT_DOMAIN all have this class.

SYMBOL_LOC_BLOCK
Value is a block.

SYMBOL_LOC_CONST_BYTES
Value is a byte-sequence.

SYMBOL_LOC_UNRESOLVED
Value is at a fixed address, but the address of the variable has to be determined from the minimal symbol table whenever the variable is referenced.

SYMBOL_LOC_OPTIMIZED_OUT
The value does not actually exist in the program.

SYMBOL_LOC_COMPUTED
The value's address is a computed location.
23.3.3.18 Symbol table representation in Guile.

Access to symbol table data maintained by GDB on the inferior is exposed to Guile via two objects: <gdb:sal> (symtab-and-line) and <gdb:symtab>. Symbol table and line data for a frame is returned from the frame-find-sal <gdb:frame> procedure. See Section 23.3.3.15 [Frames In Guile], page 421.

For more information on GDB’s symbol table management, see Chapter 16 [Examining the Symbol Table], page 217.

The following symtab-related procedures are provided by the (gdb) module:

-symtab? object  
  [Scheme Procedure]  
  Return #t if object is an object of type <gdb:symtab>. Otherwise return #f.

-symtab-valid? symtab  
  [Scheme Procedure]  
  Return #t if the <gdb:symtab> object is valid, #f if not. A <gdb:symtab> object becomes invalid when the symbol table it refers to no longer exists in GDB. All other <gdb:symtab> procedures will throw an exception if it is invalid at the time the procedure is called.

-symtab-filename symtab  
  [Scheme Procedure]  
  Return the symbol table’s source filename.

-symtab-fullname symtab  
  [Scheme Procedure]  
  Return the symbol table’s source absolute file name.

-symtab-objfile symtab  
  [Scheme Procedure]  
  Return the symbol table’s backing object file. See Section 23.3.3.14 [Objfiles In Guile], page 420.

-symtab-global-block symtab  
  [Scheme Procedure]  
  Return the global block of the underlying symbol table. See Section 23.3.3.16 [Blocks In Guile], page 424.

-symtab-static-block symtab  
  [Scheme Procedure]  
  Return the static block of the underlying symbol table. See Section 23.3.3.16 [Blocks In Guile], page 424.

The following symtab-and-line-related procedures are provided by the (gdb) module:

-sal? object  
  [Scheme Procedure]  
  Return #t if object is an object of type <gdb:sal>. Otherwise return #f.

-sal-valid? sal  
  [Scheme Procedure]  
  Return #t if sal is valid, #f if not. A <gdb:sal> object becomes invalid when the Symbol table object it refers to no longer exists in GDB. All other <gdb:sal> procedures will throw an exception if it is invalid at the time the procedure is called.

-sal-symtab sal  
  [Scheme Procedure]  
  Return the symbol table object (<gdb:symtab>) for sal.

-sal-line sal  
  [Scheme Procedure]  
  Return the line number for sal.
sal-pc sal  
Return the start of the address range occupied by code for sal.  

sal-last sal  
Return the end of the address range occupied by code for sal.  

find-pc-line pc  
Return the <gdb:sal> object corresponding to the pc value. If an invalid value of pc is passed as an argument, then the symtab and line attributes of the returned <gdb:sal> object will be #f and 0 respectively.

23.3.3.19 Manipulating breakpoints using Guile

Breakpoints in Guile are represented by objects of type <gdb:breakpoint>. New breakpoints can be created with the make-breakpoint Guile function, and then added to GDB with the register-breakpoint! Guile function. This two-step approach is taken to separate out the side-effect of adding the breakpoint to GDB from make-breakpoint.

Support is also provided to view and manipulate breakpoints created outside of Guile.

The following breakpoint-related procedures are provided by the (gdb) module:

make-breakpoint location [#:type type] [#:wp-class wp-class]  
Create a new breakpoint at location, a string naming the location of the breakpoint, or an expression that defines a watchpoint. The contents can be any location recognized by the break command, or in the case of a watchpoint, by the watch command.

The breakpoint is initially marked as ‘invalid’. The breakpoint is not usable until it has been registered with GDB with register-breakpoint!, at which point it becomes ‘valid’. The result is the <gdb:breakpoint> object representing the breakpoint.

The optional type denotes the breakpoint to create. This argument can be either BP_BREAKPOINT or BP_WATCHPOINT, and defaults to BP_BREAKPOINT.

The optional wp-class argument defines the class of watchpoint to create, if type is BP_WATCHPOINT. If a watchpoint class is not provided, it is assumed to be a WP_WRITE class.

The optional internal argument allows the breakpoint to become invisible to the user. The breakpoint will neither be reported when registered, nor will it be listed in the output from info breakpoints (but will be listed with the maint info breakpoints command). If an internal flag is not provided, the breakpoint is visible (non-internal).

When a watchpoint is created, GDB will try to create a hardware assisted watchpoint. If successful, the type of the watchpoint is changed from BP_WATCHPOINT to BP_HARDWARE_WATCHPOINT for WP_WRITE, BP_READ_WATCHPOINT for WP_READ, and BP_ACCESS_WATCHPOINT for WP_ACCESS. If not successful, the type of the watchpoint is left as WP_WATCHPOINT.

The available types are represented by constants defined in the gdb module:

BP_BREAKPOINT  
Normal code breakpoint.

BP_WATCHPOINT  
Watchpoint breakpoint.
BP_HARDWARE_WATCHPOINT
Hardware assisted watchpoint. This value cannot be specified when creating the breakpoint.

BP_READ_WATCHPOINT
Hardware assisted read watchpoint. This value cannot be specified when creating the breakpoint.

BP_ACCESS_WATCHPOINT
Hardware assisted access watchpoint. This value cannot be specified when creating the breakpoint.

The available watchpoint types represented by constants are defined in the (gdb) module:

WP_READ   Read only watchpoint.
WP_WRITE  Write only watchpoint.
WP_ACCESS Read/Write watchpoint.

register-breakpoint! breakpoint  [Scheme Procedure]
Add breakpoint, a <gdb:breakpoint> object, to GDB’s list of breakpoints. The breakpoint must have been created with make-breakpoint. One cannot register breakpoints that have been created outside of Guile. Once a breakpoint is registered it becomes 'valid'. It is an error to register an already registered breakpoint. The result is unspecified.

delete-breakpoint! breakpoint  [Scheme Procedure]
Remove breakpoint from GDB’s list of breakpoints. This also invalidates the Guile breakpoint object. Any further attempt to access the object will throw an exception. If breakpoint was created from Guile with make-breakpoint it may be re-registered with GDB, in which case the breakpoint becomes valid again.

breakpoints  [Scheme Procedure]
Return a list of all breakpoints. Each element of the list is a <gdb:breakpoint> object.

breakpoint? object  [Scheme Procedure]
Return #t if object is a <gdb:breakpoint> object, and #f otherwise.

breakpoint-valid? breakpoint  [Scheme Procedure]
Return #t if breakpoint is valid, #f otherwise. Breakpoints created with make-breakpoint are marked as invalid until they are registered with GDB with register-breakpoint!. A <gdb:breakpoint> object can become invalid if the user deletes the breakpoint. In this case, the object still exists, but the underlying breakpoint does not. In the cases of watchpoint scope, the watchpoint remains valid even if execution of the inferior leaves the scope of that watchpoint.

breakpoint-number breakpoint  [Scheme Procedure]
Return the breakpoint’s number — the identifier used by the user to manipulate the breakpoint.
breakpoint-type breakpoint
   Return the breakpoint’s type — the identifier used to determine the actual breakpoint type or use-case.

breakpoint-visible? breakpoint
   Return #t if the breakpoint is visible to the user when hit, or when the `info breakpoints` command is run. Otherwise return #f.

breakpoint-location breakpoint
   Return the location of the breakpoint, as specified by the user. It is a string. If the breakpoint does not have a location (that is, it is a watchpoint) return #f.

breakpoint-expression breakpoint
   Return the breakpoint expression, as specified by the user. It is a string. If the breakpoint does not have an expression (the breakpoint is not a watchpoint) return #f.

breakpoint-enabled? breakpoint
   Return #t if the breakpoint is enabled, and #f otherwise.

set-breakpoint-enabled! breakpoint flag
   Set the enabled state of breakpoint to flag. If flag is #f it is disabled, otherwise it is enabled.

breakpoint-silent? breakpoint
   Return #t if the breakpoint is silent, and #f otherwise.

   Note that a breakpoint can also be silent if it has commands and the first command is silent. This is not reported by the silent attribute.

set-breakpoint-silent! breakpoint flag
   Set the silent state of breakpoint to flag. If flag is #f the breakpoint is made silent, otherwise it is made non-silent (or noisy).

breakpoint-ignore-count breakpoint
   Return the ignore count for breakpoint.

set-breakpoint-ignore-count! breakpoint count
   Set the ignore count for breakpoint to count.

breakpoint-hit-count breakpoint
   Return hit count of breakpoint.

set-breakpoint-hit-count! breakpoint count
   Set the hit count of breakpoint to count. At present, count must be zero.

breakpoint-thread breakpoint
   Return the thread-id for thread-specific breakpoint breakpoint. Return #f if breakpoint is not thread-specific.

set-breakpoint-thread! breakpoint thread-id #f
   Set the thread-id for breakpoint to thread-id. If set to #f, the breakpoint is no longer thread-specific.
breakpoint-task breakpoint

If the breakpoint is Ada task-specific, return the Ada task id. If the breakpoint is not task-specific (or the underlying language is not Ada), return #f.

set-breakpoint-task! breakpoint task

Set the Ada task of breakpoint to task. If set to #f, the breakpoint is no longer task-specific.

breakpoint-condition breakpoint

Return the condition of breakpoint, as specified by the user. It is a string. If there is no condition, return #f.

set-breakpoint-condition! breakpoint condition

Set the condition of breakpoint to condition, which must be a string. If set to #f then the breakpoint becomes unconditional.

breakpoint-stop breakpoint

Return the stop predicate of breakpoint. See set-breakpoint-stop! below in this section.

set-breakpoint-stop! breakpoint procedure|#f

Set the stop predicate of breakpoint. The predicate procedure takes one argument: the <gdb:breakpoint> object. If this predicate is set to a procedure then it is invoked whenever the inferior reaches this breakpoint. If it returns #t, or any non-#f value, then the inferior is stopped, otherwise the inferior will continue.

If there are multiple breakpoints at the same location with a stop predicate, each one will be called regardless of the return status of the previous. This ensures that all stop predicates have a chance to execute at that location. In this scenario if one of the methods returns #t but the others return #f, the inferior will still be stopped.

You should not alter the execution state of the inferior (i.e., step, next, etc.), alter the current frame context (i.e., change the current active frame), or alter, add or delete any breakpoint. As a general rule, you should not alter any data within GDB or the inferior at this time.

Example stop implementation:

```
(define (my-stop? bkpt)
  (let ((int-val (parse-and-eval "foo")))
    (value=? int-val 3)))
(define bkpt (make-breakpoint "main.c:42"))
(register-breakpoint! bkpt)
(set-breakpoint-stop! bkpt (my-stop?))
```

breakpoint-commands breakpoint

Return the commands attached to breakpoint as a string, or #f if there are none.

23.3.3.20 Guile representation of lazy strings.

A lazy string is a string whose contents is not retrieved or encoded until it is needed.

A <gdb:lazy-string> is represented in GDB as an address that points to a region of memory, an encoding that will be used to encode that region of memory, and a length to delimit the region of memory that represents the string. The difference between a <gdb:lazy-string> and a string wrapped within a <gdb:value> is that a <gdb:lazy-string> will be
treated differently by GDB when printing. A `<gdb:lazy-string>` is retrieved and encoded during printing, while a `<gdb:value>` wrapping a string is immediately retrieved and encoded on creation.

The following lazy-string-related procedures are provided by the `(gdb)` module:

```scheme
[Scheme Procedure]
lazy-string? object
Return #t if object is an object of type `<gdb:lazy-string>`. Otherwise return #f.
```

```scheme
[Scheme Procedure]
lazy-string-address lazy-string
Return the address of lazy-string.
```

```scheme
[Scheme Procedure]
lazy-string-length lazy-string
Return the length of lazy-string in characters. If the length is -1, then the string will be fetched and encoded up to the first null of appropriate width.
```

```scheme
[Scheme Procedure]
lazy-string-encoding lazy-string
Return the encoding that will be applied to lazy-string when the string is printed by GDB. If the encoding is not set, or contains an empty string, then GDB will select the most appropriate encoding when the string is printed.
```

```scheme
[Scheme Procedure]
lazy-string-type lazy-string
Return the type that is represented by lazy-string’s type. For a lazy string this will always be a pointer type. To resolve this to the lazy string’s character type, use type-target-type. See Section 23.3.3.7 [Types In Guile], page 404.
```

```scheme
[Scheme Procedure]
lazy-string->value lazy-string
Convert the `<gdb:lazy-string>` to a `<gdb:value>`. This value will point to the string in memory, but will lose all the delayed retrieval, encoding and handling that GDB applies to a `<gdb:lazy-string>`.
```

23.3.3.21 Guile representation of architectures

GDB uses architecture specific parameters and artifacts in a number of its various computations. An architecture is represented by an instance of the `<gdb:arch>` class.

The following architecture-related procedures are provided by the `(gdb)` module:

```scheme
[Scheme Procedure]
arch? object
Return #t if object is an object of type `<gdb:arch>`. Otherwise return #f.
```

```scheme
[Scheme Procedure]
current-arch
Return the current architecture as a `<gdb:arch>` object.
```

```scheme
[Scheme Procedure]
arch-name arch
Return the name (string value) of `<gdb:arch> arch`.
```

```scheme
[Scheme Procedure]
arch-charset arch
Return name of target character set of `<gdb:arch> arch`.
```

```scheme
[Scheme Procedure]
arch-wide-charset
Return name of target wide character set of `<gdb:arch> arch`.
```
Each architecture provides a set of predefined types, obtained by the following functions.

**arch-void-type arch**
Return the `<gdb:type>` object for a `void` type of architecture `arch`.

**arch-char-type arch**
Return the `<gdb:type>` object for a `char` type of architecture `arch`.

**arch-short-type arch**
Return the `<gdb:type>` object for a `short` type of architecture `arch`.

**arch-int-type arch**
Return the `<gdb:type>` object for an `int` type of architecture `arch`.

**arch-long-type arch**
Return the `<gdb:type>` object for a `long` type of architecture `arch`.

**arch-schar-type arch**
Return the `<gdb:type>` object for a `signed char` type of architecture `arch`.

**arch-uchar-type arch**
Return the `<gdb:type>` object for an `unsigned char` type of architecture `arch`.

**arch-ushort-type arch**
Return the `<gdb:type>` object for an `unsigned short` type of architecture `arch`.

**arch-uint-type arch**
Return the `<gdb:type>` object for an `unsigned int` type of architecture `arch`.

**arch-ulong-type arch**
Return the `<gdb:type>` object for an `unsigned long` type of architecture `arch`.

**arch-float-type arch**
Return the `<gdb:type>` object for a `float` type of architecture `arch`.

**arch-double-type arch**
Return the `<gdb:type>` object for a `double` type of architecture `arch`.

**arch-longdouble-type arch**
Return the `<gdb:type>` object for a `long double` type of architecture `arch`.

**arch-bool-type arch**
Return the `<gdb:type>` object for a `bool` type of architecture `arch`.

**arch-longlong-type arch**
Return the `<gdb:type>` object for a `long long` type of architecture `arch`.

**arch-ulonglong-type arch**
Return the `<gdb:type>` object for an `unsigned long long` type of architecture `arch`.

**arch-int8-type arch**
Return the `<gdb:type>` object for an `int8` type of architecture `arch`. 
arch-uint8-type arch
Return the <gdb:type> object for a uint8 type of architecture arch.

arch-int16-type arch
Return the <gdb:type> object for an int16 type of architecture arch.

arch-uint16-type arch
Return the <gdb:type> object for a uint16 type of architecture arch.

arch-int32-type arch
Return the <gdb:type> object for an int32 type of architecture arch.

arch-uint32-type arch
Return the <gdb:type> object for a uint32 type of architecture arch.

arch-int64-type arch
Return the <gdb:type> object for an int64 type of architecture arch.

arch-uint64-type arch
Return the <gdb:type> object for a uint64 type of architecture arch.

Example:
(gdb) guile (type-name (arch-uchar-type (current-arch)))
"unsigned char"

23.3.3.22 Disassembly In Guile
The disassembler can be invoked from Scheme code. Furthermore, the disassembler can
take a Guile port as input, allowing one to disassemble from any source, and not just target
memory.

arch-disassemble arch start-pc [#:port port] [#:offset offset] [#:size size] [#:count count]
Return a list of disassembled instructions starting from the memory address start-pc.
The optional argument port specifies the input port to read bytes from. If port is #f
then bytes are read from target memory.
The optional argument offset specifies the address offset of the first byte in port.
This is useful, for example, when port specifies a 'bytevector' and you want the
bytevector to be disassembled as if it came from that address. The start-pc passed
to the reader for port is offset by the same amount.
Example:
(gdb) guile (use-modules (rnrs io ports))
(gdb) guile (define pc (value->integer (parse-and-eval "$pc")))
(gdb) guile (define mem (open-memory #:start pc))
(gdb) guile (define bv (get-bytevector-n mem 10))
(gdb) guile (define bv-port (open-bytevector-input-port bv))
(gdb) guile (define arch (current-arch))
(gdb) guile (arch-disassemble arch pc #:port bv-port #:offset pc)
(((address . 4195516) (asm . "mov 0x4005c8,%edi") (length . 5)))

The optional arguments size and count determine the number of instructions in the
returned list. If either size or count is specified as zero, then no instructions are
disassembled and an empty list is returned. If both the optional arguments *size* and *count* are specified, then a list of at most *count* disassembled instructions whose start address falls in the closed memory address interval from *start-pc* to (*start-pc* + *size* - 1) are returned. If *size* is not specified, but *count* is specified, then *count* number of instructions starting from the address *start-pc* are returned. If *count* is not specified but *size* is specified, then all instructions whose start address falls in the closed memory address interval from *start-pc* to (*start-pc* + *size* - 1) are returned. If neither *size* nor *count* are specified, then a single instruction at *start-pc* is returned.

Each element of the returned list is an alist (associative list) with the following keys:

- **address**: The value corresponding to this key is a Guile integer of the memory address of the instruction.
- **asm**: The value corresponding to this key is a string value which represents the instruction with assembly language mnemonics. The assembly language flavor used is the same as that specified by the current CLI variable *disassembly-flavor*. See Section 9.6 [Machine Code], page 108.
- **length**: The value corresponding to this key is the length of the instruction in bytes.

### 23.3.3.23 I/O Ports in Guile

- **input-port**
  
  Return GDB’s input port as a Guile port object.

- **output-port**
  
  Return GDB’s output port as a Guile port object.

- **error-port**
  
  Return GDB’s error port as a Guile port object.

- **stdio-port? object**
  
  Return #t if object is a GDB stdio port. Otherwise return #f.

### 23.3.3.24 Memory Ports in Guile

GDB provides a port interface to target memory. This allows Guile code to read/write target memory using Guile’s port and bytevector functionality. The main routine is **open-memory** which returns a port object. One can then read/write memory using that object.

- **open-memory [#:mode mode] [#:start address] [#:size size]**
  
  Return a port object that can be used for reading and writing memory. The port will be open according to *mode*, which is the standard mode argument to Guile port open routines, except that the “a” and “l” modes are not supported. See Section “File Ports” in GNU Guile Reference Manual. The “b” (binary) character may be present, but is ignored: memory ports are binary only. If “0” is appended then the port is marked as unbuffered. The default is “rb”, read-only and buffered.

  The chunk of memory that can be accessed can be bounded. If both *start* and *size* are unspecified, all of memory can be accessed. If only *start* is specified, all of memory from that point on can be accessed. If only *size* if specified, all memory in the range
[0,\text{size}) \text{ can be accessed. If both are specified, all memory in the range } [\text{start},\text{start+size}) \text{ can be accessed.}

\textbf{memory-port?} \quad \text{[Scheme Procedure]}
\begin{itemize}
\item Return \#t if \textit{object} is an object of type \texttt{<gdb:memory-port>}. Otherwise return \#f.
\end{itemize}

\textbf{memory-port-range memory-port} \quad \text{[Scheme Procedure]}
\begin{itemize}
\item Return the range of \texttt{<gdb:memory-port>} \textit{memory-port} as a list of two elements: (\textit{start} \textit{end}). The range is \textit{start} to \textit{end} inclusive.
\end{itemize}

\textbf{memory-port-read-buffer-size memory-port} \quad \text{[Scheme Procedure]}
\begin{itemize}
\item Return the size of the read buffer of \texttt{<gdb:memory-port>} \textit{memory-port}.
\end{itemize}

\textbf{set-memory-port-read-buffer-size! memory-port size} \quad \text{[Scheme Procedure]}
\begin{itemize}
\item Set the size of the read buffer of \texttt{<gdb:memory-port>} \textit{memory-port} to \textit{size}. The result is unspecified.
\end{itemize}

\textbf{memory-port-write-buffer-size memory-port} \quad \text{[Scheme Procedure]}
\begin{itemize}
\item Return the size of the write buffer of \texttt{<gdb:memory-port>} \textit{memory-port}.
\end{itemize}

\textbf{set-memory-port-write-buffer-size! memory-port size} \quad \text{[Scheme Procedure]}
\begin{itemize}
\item Set the size of the write buffer of \texttt{<gdb:memory-port>} \textit{memory-port} to \textit{size}. The result is unspecified.
\end{itemize}

A memory port is closed like any other port, with close-port.

Combined with Guile’s bytevectors, memory ports provide a lot of utility. For example, to fill a buffer of 10 integers in memory, one can do something like the following.

```scheme
;; In the program: int buffer[10];
(use-modules (rnrs bytevectors))
(use-modules (rnrs io ports))
(define addr (parse-and-eval "buffer"))
(define n 10)
(define byte-size (* n 4))
(define mem-port (open-memory #:mode "r+" #:start
  (value->integer addr) #:size byte-size))
(define byte-vec (make-bytevector byte-size))
(do ((i 0 (+ i 1)))
    ((>= i n))
  (bytevector-s32-native-set! byte-vec (* i 4) (* i 42)))
(put-bytevector mem-port byte-vec)
(close-port mem-port)
```

\textbf{23.3.3.25 Iterators In Guile}

A simple iterator facility is provided to allow, for example, iterating over the set of program symbols without having to first construct a list of all of them. A useful contribution would be to add support for SRFI 41 and SRFI 45.

\textbf{make-iterator object progress next!} \quad \text{[Scheme Procedure]}
\begin{itemize}
\item A \texttt{<gdb:iterator>} object is constructed with the \texttt{make-iterator} procedure. It takes three arguments: the object to be iterated over, an object to record the progress of the iteration, and a procedure to return the next element in the iteration, or an implementation chosen value to denote the end of iteration.
\end{itemize}
By convention, end of iteration is marked with \texttt{(end-of-iteration)}, and may be tested with the \texttt{end-of-iteration?} predicate. The result of \texttt{(end-of-iteration)} is chosen so that it is not otherwise used by the \texttt{(gdb)} module. If you are using \texttt{<gdb:iterator>} in your own code it is your responsibility to maintain this invariant.

A trivial example for illustration’s sake:

\begin{verbatim}
(use-modules (gdb iterator))
(define my-list (list 1 2 3))
(define iter
  (make-iterator my-list my-list
    (lambda (iter)
      (let ((l (iterator-progress iter)))
        (if (eq? l '())
          (end-of-iteration)
          (begin
            (set-iterator-progress! iter (cdr l))
            (car l)))))))
\end{verbatim}

Here is a slightly more realistic example, which computes a list of all the functions in \texttt{my-global-block}.

\begin{verbatim}
(use-modules (gdb iterator))
(define this-sal (find-pc-line (frame-pc (selected-frame))))
(define this-symtab (sal-symtab this-sal))
(define this-global-block (symtab-global-block this-symtab))
(define syms-iter (make-block-symbols-iterator this-global-block))
(define functions (iterator-filter symbol-function? syms-iter))
\end{verbatim}

These functions are provided by the \texttt{(gdb iterator)} module to assist in using iterators.
make-list-iterator list
   Return a <gdb:iterator> object that will iterate over list.

iterator->list iterator
   Return the elements pointed to by iterator as a list.

iterator-map proc iterator
   Return the list of objects obtained by applying proc to the object pointed to by
   iterator and to each subsequent object.

iterator-for-each proc iterator
   Apply proc to each element pointed to by iterator. The result is unspecified.

iterator-filter pred iterator
   Return the list of elements pointed to by iterator that satisfy pred.

iterator-until pred iterator
   Run iterator until the result of (pred element) is true and return that as the result.
   Otherwise return #f.

23.3.4 Guile Auto-loading

When a new object file is read (for example, due to the file command, or because the
inferior has loaded a shared library), GDB will look for Guile support scripts in two ways:
‘objfile-gdb.scm’ and the .debug_gdb_scripts section. See Section 23.4 [Auto-loading
extensions], page 442.

The auto-loading feature is useful for supplying application-specific debugging commands
and scripts.

Auto-loading can be enabled or disabled, and the list of auto-loaded scripts can be
printed.

set auto-load guile-scripts [on|off]
   Enable or disable the auto-loading of Guile scripts.

show auto-load guile-scripts
   Show whether auto-loading of Guile scripts is enabled or disabled.

info auto-load guile-scripts [regexp]
   Print the list of all Guile scripts that GDB auto-loaded.
   Also printed is the list of Guile scripts that were mentioned in the .debug_
gdb_scripts section and were not found. This is useful because their names
   are not printed when GDB tries to load them and fails. There may be many of
   them, and printing an error message for each one is problematic.
   If regexp is supplied only Guile scripts with matching names are printed.
   Example:

   (gdb) info auto-load guile-scripts
   Loaded Script
   Yes  scm-section-script.scm
        full name: /tmp/scm-section-script.scm
   No   my-foo-pretty-printers.scm
When reading an auto-loaded file, GDB sets the current objfile. This is available via the current-objfile procedure (see Section 23.3.3.14 [Objfiles In Guile], page 420). This can be useful for registering objfile-specific pretty-printers.

23.3.5 Guile Modules

GDB comes with several modules to assist writing Guile code.

23.3.5.1 Guile Printing Module

This module provides a collection of utilities for working with pretty-printers.

Usage:

```scheme
(use-modules (gdb printing))
```

**prepend-pretty-printer!** *object printer*  
Add `printer` to the front of the list of pretty-printers for `object`. The `object` must either be a `<gdb:objfile>` object, or `#f` in which case `printer` is added to the global list of printers.

**append-pretty-printer!** *object printer*  
Add `printer` to the end of the list of pretty-printers for `object`. The `object` must either be a `<gdb:objfile>` object, or `#f` in which case `printer` is added to the global list of printers.

23.3.5.2 Guile Types Module

This module provides a collection of utilities for working with `<gdb:type>` objects.

Usage:

```scheme
(use-modules (gdb types))
```

**get-basic-type** *type*  
Return `type` with const and volatile qualifiers stripped, and with typedefs and C++ references converted to the underlying type.

C++ example:

```c
typedef const int const_int;
const_int foo (3);
const_int& foo_ref (foo);
int main () { return 0; }
```

Then in gdb:

```bash
(gdb) start
(gdb) guile (use-modules (gdb) (gdb types))
(gdb) guile (define foo-ref (parse-and-eval "foo_ref"))
(gdb) guile (get-basic-type (value-type foo-ref))
int
```

**type-has-field-deep?** *type field*  
Return `#t` if `type`, assumed to be a type with fields (e.g., a structure or union), has field `field`. Otherwise return `#f`. This searches baseclasses, whereas **type-has-field?** does not.

**make-enum-hashtable** *enum-type*  
Return a Guile hash table produced from `enum-type`. Elements in the hash table are referenced with `hashq-ref`. 
23.4 Auto-loading extensions

GDB provides two mechanisms for automatically loading extensions when a new object file is read (for example, due to the file command, or because the inferior has loaded a shared library): ‘objfile-gdb.ext’ and the .debug_gdb_scripts section of modern file formats like ELF.

The auto-loading feature is useful for supplying application-specific debugging commands and features.

Auto-loading can be enabled or disabled, and the list of auto-loaded scripts can be printed. See the ‘auto-loading’ section of each extension language for more information. For GDB command files see Section 23.1.5 [Auto-loading sequences], page 321. For Python files see Section 23.2.3 [Python Auto-loading], page 387.

Note that loading of this script file also requires accordingly configured auto-load safe-path (see Section 22.7.3 [Auto-loading safe path], page 305).

23.4.1 The ‘objfile-gdb.ext’ file

When a new object file is read, GDB looks for a file named ‘objfile-gdb.ext’ (we call it script-name below), where objfile is the object file’s name and where ext is the file extension for the extension language:

‘objfile-gdb.gdb’
  GDB’s own command language

‘objfile-gdb.py’
  Python

‘objfile-gdb.scm’
  Guile

script-name is formed by ensuring that the file name of objfile is absolute, following all symlinks, and resolving . and .. components, and appending the ‘-gdb.ext’ suffix. If this file exists and is readable, GDB will evaluate it as a script in the specified extension language.

If this file does not exist, then GDB will look for script-name file in all of the directories as specified below.

Note that loading of these files requires an accordingly configured auto-load safe-path (see Section 22.7.3 [Auto-loading safe path], page 305).

For object files using ‘.exe’ suffix GDB tries to load first the scripts normally according to its ‘.exe’ filename. But if no scripts are found GDB also tries script filenames matching the object file without its ‘.exe’ suffix. This ‘.exe’ stripping is case insensitive and it is attempted on any platform. This makes the script filenames compatible between Unix and MS-Windows hosts.

set auto-load scripts-directory [directories]

Control GDB auto-loaded scripts location. Multiple directory entries may be delimited by the host platform path separator in use (‘;’ on Unix, ‘;’ on MS-Windows and MS-DOS).

Each entry here needs to be covered also by the security setting set auto-load safe-path (see [set auto-load safe-path], page 305).
This variable defaults to `$debugdir:$datadir/auto-load`. The default set auto-load safe-path value can be also overriden by GDB configuration option `--with-auto-load-dir`.

Any reference to `$debugdir` will get replaced by debug-file-directory value (see Section 18.3 [Separate Debug Files], page 246) and any reference to `$datadir` will get replaced by data-directory which is determined at GDB startup (see Section 18.7 [Data Files], page 252). `$debugdir` and `$datadir` must be placed as a directory component — either alone or delimited by ‘/’ or ‘\’ directory separators, depending on the host platform.

The list of directories uses path separator (‘;’ on GNU and Unix systems, ‘;’ on MS-Windows and MS-DOS) to separate directories, similarly to the PATH environment variable.

```
show auto-load scripts-directory
Show GDB auto-loaded scripts location.

add-auto-load-scripts-directory [directories...]
Add an entry (or list of entries) to the list of auto-loaded scripts locations.
Multiple entries may be delimited by the host platform path separator in use.
```

GDB does not track which files it has already auto-loaded this way. GDB will load the associated script every time the corresponding objfile is opened. So your ‘-gdb.ext’ file should be careful to avoid errors if it is evaluated more than once.

### 23.4.2 The `.debug_gdb_scripts` section

For systems using file formats like ELF and COFF, when GDB loads a new object file it will look for a special section named `.debug_gdb_scripts`. If this section exists, its contents is a list of null-terminated entries specifying scripts to load. Each entry begins with a non-null prefix byte that specifies the kind of entry, typically the extension language and whether the script is in a file or inlined in `.debug_gdb_scripts`.

The following entries are supported:

```
SECTION_SCRIPT_ID_PYTHON_FILE = 1
SECTION_SCRIPT_ID_SCHEME_FILE = 3
SECTION_SCRIPT_ID_PYTHON_TEXT = 4
SECTION_SCRIPT_ID_SCHEME_TEXT = 6
```

#### 23.4.2.1 Script File Entries

If the entry specifies a file, GDB will look for the file first in the current directory and then along the source search path (see Section 9.5 [Specifying Source Directories], page 105), except that `$cdir` is not searched, since the compilation directory is not relevant to scripts.

File entries can be placed in section `.debug_gdb_scripts` with, for example, this GCC macro for Python scripts.

```
/* Note: The "MS" section flags are to remove duplicates. */
#define DEFINE_GDB_PYSCRIPT(script_name) \
    asm("\n        .pushsection ".debug_gdb_scripts", "MS", @progbits, 1\n    \n        .byte 1 /* Python */\n
```

444 Debugging with gdb

For Guile scripts, replace .byte 1 with .byte 3. Then one can reference the macro in a
header or source file like this:

```c
DEFINE_GDB_PY_SCRIPT ("my-app-scripts.py")
```

The script name may include directories if desired.

Note that loading of this script file also requires accordingly configured auto-load safe-
path (see Section 22.7.3 [Auto-loading safe path], page 305).

If the macro invocation is put in a header, any application or library using this header
will get a reference to the specified script, and with the use of "MS" attributes on the section,
the linker will remove duplicates.

### 23.4.2.2 Script Text Entries

Script text entries allow to put the executable script in the entry itself instead of loading
it from a file. The first line of the entry, everything after the prefix byte and up to the
first newline (\0xa) character, is the script name, and must not contain any kind of space
character, e.g., spaces or tabs. The rest of the entry, up to the trailing null byte, is the
script to execute in the specified language. The name needs to be unique among all script
names, as gdb executes each script only once based on its name.

Here is an example from file ‘py-section-script.c’ in the gdb testsuite.

```c
#include "symcat.h"
#include "gdb/section-scripts.h"
asm(
   ".pushsection ".debug_gdb_scripts", "MS",@progbits,1\n"
   ".byte " XSTRING (SECTION_SCRIPT_ID_PYTHON_TEXT) "\n"
   ".byte gdb.inlined-script\n"
   ".ascii "class test_cmd (gdb.Command):\n"
   ".ascii " def __init__ (self):\n"
   ".ascii " super (test_cmd, self).__init__ (\n"
   ".ascii " test-cmd output, arg = %s\n"
   ".byte 0\n"
   ".popsection]\n"
);
```

Loading of inlined scripts requires a properly configured auto-load safe-path (see
Section 22.7.3 [Auto-loading safe path], page 305). The path to specify in auto-load
safe-path is the path of the file containing the .debug_gdb_scripts section.

### 23.4.3 Which flavor to choose?

Given the multiple ways of auto-loading extensions, it might not always be clear which one
to choose. This section provides some guidance.

Benefits of the ‘-gdb.ext’ way:
- Can be used with file formats that don’t support multiple sections.
- Ease of finding scripts for public libraries.

  Scripts specified in the `.debug_gdb_scripts` section are searched for in the source search path. For publicly installed libraries, e.g., ‘libstdc++’, there typically isn’t a source directory in which to find the script.
- Doesn’t require source code additions.

Benefits of the `.debug_gdb_scripts` way:

- Works with static linking.

  Scripts for libraries done the ‘-gdb.ext’ way require an objfile to trigger their loading. When an application is statically linked the only objfile available is the executable, and it is cumbersome to attach all the scripts from all the input libraries to the executable’s ‘-gdb.ext’ script.
- Works with classes that are entirely inlined.

  Some classes can be entirely inlined, and thus there may not be an associated shared library to attach a ‘-gdb.ext’ script to.
- Scripts needn’t be copied out of the source tree.

  In some circumstances, apps can be built out of large collections of internal libraries, and the build infrastructure necessary to install the ‘-gdb.ext’ scripts in a place where GDB can find them is cumbersome. It may be easier to specify the scripts in the `.debug_gdb_scripts` section as relative paths, and add a path to the top of the source tree to the source search path.

### 23.5 Multiple Extension Languages

The Guile and Python extension languages do not share any state, and generally do not interfere with each other. There are some things to be aware of, however.

#### 23.5.1 Python comes first

Python was GDB’s first extension language, and to avoid breaking existing behaviour Python comes first. This is generally solved by the “first one wins” principle. GDB maintains a list of enabled extension languages, and when it makes a call to an extension language, (say to pretty-print a value), it tries each in turn until an extension language indicates it has performed the request (e.g., has returned the pretty-printed form of a value). This extends to errors while performing such requests: If an error happens while, for example, trying to pretty-print an object then the error is reported and any following extension languages are not tried.

### 23.6 Creating new spellings of existing commands

It is often useful to define alternate spellings of existing commands. For example, if a new GDB command defined in Python has a long name to type, it is handy to have an abbreviated version of it that involves less typing.

GDB itself uses aliases. For example ‘s’ is an alias of the ‘step’ command even though it is otherwise an ambiguous abbreviation of other commands like ‘set’ and ‘show’.
Aliases are also used to provide shortened or more common versions of multi-word commands. For example, GDB provides the ‘tty’ alias of the ‘set inferior-tty’ command.

You can define a new alias with the ‘alias’ command.

```
alias [-a] [--] ALIAS = COMMAND
```

ALIAS specifies the name of the new alias. Each word of ALIAS must consist of letters, numbers, dashes and underscores.

COMMAND specifies the name of an existing command that is being aliased.

The ‘-a’ option specifies that the new alias is an abbreviation of the command. Abbreviations are not shown in command lists displayed by the ‘help’ command.

The ‘--’ option specifies the end of options, and is useful when ALIAS begins with a dash.

Here is a simple example showing how to make an abbreviation of a command so that there is less to type. Suppose you were tired of typing ‘disas’, the current shortest unambiguous abbreviation of the ‘disassemble’ command and you wanted an even shorter version named ‘di’. The following will accomplish this.

```
(gdb) alias -a di = disas
```

Note that aliases are different from user-defined commands. With a user-defined command, you also need to write documentation for it with the ‘document’ command. An alias automatically picks up the documentation of the existing command.

Here is an example where we make ‘elms’ an abbreviation of ‘elements’ in the ‘set print elements’ command. This is to show that you can make an abbreviation of any part of a command.

```
(gdb) alias -a set print elms = set print elements
(gdb) alias -a show print elms = show print elements
(gdb) set p elms 20
(gdb) show p elms
Limit on string chars or array elements to print is 200.
```

Note that if you are defining an alias of a ‘set’ command, and you want to have an alias for the corresponding ‘show’ command, then you need to define the latter separately.

Unambiguously abbreviated commands are allowed in COMMAND and ALIAS, just as they are normally.

```
(gdb) alias -a set pr elms = set p ele
```

Finally, here is an example showing the creation of a one word alias for a more complex command. This creates alias ‘spe’ of the command ‘set print elements’.

```
(gdb) alias spe = set print elements
(gdb) spe 20
```
24 Command Interpreters

GDB supports multiple command interpreters, and some command infrastructure to allow users or user interface writers to switch between interpreters or run commands in other interpreters.

GDB currently supports two command interpreters, the console interpreter (sometimes called the command-line interpreter or CLI) and the machine interface interpreter (or GDB/MI). This manual describes both of these interfaces in great detail.

By default, GDB will start with the console interpreter. However, the user may choose to start GDB with another interpreter by specifying the `-i` or `--interpreter` startup options. Defined interpreters include:

console The traditional console or command-line interpreter. This is the most often used interpreter with GDB. With no interpreter specified at runtime, GDB will use this interpreter.

mi The newest GDB/MI interface (currently mi2). Used primarily by programs wishing to use GDB as a backend for a debugger GUI or an IDE. For more information, see Chapter 27 [The GDB/MI Interface], page 457.

mi2 The current GDB/MI interface.

mi1 The GDB/MI interface included in GDB 5.1, 5.2, and 5.3.

The interpreter being used by GDB may not be dynamically switched at runtime. Although possible, this could lead to a very precarious situation. Consider an IDE using GDB/MI. If a user enters the command "interpreter-set console" in a console view, GDB would switch to using the console interpreter, rendering the IDE inoperable!

Although you may only choose a single interpreter at startup, you may execute commands in any interpreter from the current interpreter using the appropriate command. If you are running the console interpreter, simply use the interpreter-exec command:

```
interpreter-exec mi "-data-list-register-names"
```

GDB/MI has a similar command, although it is only available in versions of GDB which support GDB/MI version 2 (or greater).
25 GDB Text User Interface

The GDB Text User Interface (TUI) is a terminal interface which uses the *curses* library to show the source file, the assembly output, the program registers and GDB commands in separate text windows. The TUI mode is supported only on platforms where a suitable version of the *curses* library is available.

The TUI mode is enabled by default when you invoke GDB as `gdb -tui`. You can also switch in and out of TUI mode while GDB runs by using various TUI commands and key bindings, such as *tui enable* or *C-x C-a*. See Section 25.4 [TUI Commands], page 451, and Section 25.2 [TUI Key Bindings], page 450.

25.1 TUI Overview

In TUI mode, GDB can display several text windows:

*command*  This window is the GDB command window with the GDB prompt and the GDB output. The GDB input is still managed using readline.

*source*  The source window shows the source file of the program. The current line and active breakpoints are displayed in this window.

*assembly*  The assembly window shows the disassembly output of the program.

*register*  This window shows the processor registers. Registers are highlighted when their values change.

The source and assembly windows show the current program position by highlighting the current line and marking it with a ‘>’ marker. Breakpoints are indicated with two markers. The first marker indicates the breakpoint type:

- **B**  Breakpoint which was hit at least once.
- **b**  Breakpoint which was never hit.
- **H**  Hardware breakpoint which was hit at least once.
- **h**  Hardware breakpoint which was never hit.

The second marker indicates whether the breakpoint is enabled or not:

- **+**  Breakpoint is enabled.
- **-**  Breakpoint is disabled.

The source, assembly and register windows are updated when the current thread changes, when the frame changes, or when the program counter changes.

These windows are not all visible at the same time. The command window is always visible. The others can be arranged in several layouts:

- source only,
- assembly only,
- source and assembly,
- source and registers, or
- assembly and registers.
A status line above the command window shows the following information:

- **target**: Indicates the current GDB target. (see Chapter 19 [Specifying a Debugging Target], page 253).
- **process**: Gives the current process or thread number. When no process is being debugged, this field is set to *No process*.
- **function**: Gives the current function name for the selected frame. The name is demangled if demangling is turned on (see Section 10.8 [Print Settings], page 125). When there is no symbol corresponding to the current program counter, the string ?? is displayed.
- **line**: Indicates the current line number for the selected frame. When the current line number is not known, the string ?? is displayed.
- **pc**: Indicates the current program counter address.

### 25.2 TUI Key Bindings

The TUI installs several key bindings in the readline keymaps (see Chapter 32 [Command Line Editing], page 561). The following key bindings are installed for both TUI mode and the GDB standard mode.

- **C-x C-a**
- **C-x a**: Enter or leave the TUI mode. When leaving the TUI mode, the curses window management stops and GDB operates using its standard mode, writing on the terminal directly. When reentering the TUI mode, control is given back to the curses windows. The screen is then refreshed.

- **C-x 1**: Use a TUI layout with only one window. The layout will either be *source* or *assembly*. When the TUI mode is not active, it will switch to the TUI mode. Think of this key binding as the Emacs **C-x 1** binding.

- **C-x 2**: Use a TUI layout with at least two windows. When the current layout already has two windows, the next layout with two windows is used. When a new layout is chosen, one window will always be common to the previous layout and the new one. Think of it as the Emacs **C-x 2** binding.

- **C-x o**: Change the active window. The TUI associates several key bindings (like scrolling and arrow keys) with the active window. This command gives the focus to the next TUI window. Think of it as the Emacs **C-x o** binding.

- **C-x s**: Switch in and out of the TUI SingleKey mode that binds single keys to GDB commands (see Section 25.3 [TUI Single Key Mode], page 451).

The following key bindings only work in the TUI mode:

- **PgUp**: Scroll the active window one page up.
- **PgDn**: Scroll the active window one page down.
Chapter 25: GDB Text User Interface

25.3 TUI Single Key Mode

The TUI also provides a SingleKey mode, which binds several frequently used GDB commands to single keys. Type \texttt{C-x s} to switch into this mode, where the following key bindings are used:

- \texttt{c} continue
- \texttt{d} down
- \texttt{f} finish
- \texttt{n} next
- \texttt{q} exit the SingleKey mode.
- \texttt{r} run
- \texttt{s} step
- \texttt{u} up
- \texttt{v} info locals
- \texttt{w} where

Other keys temporarily switch to the GDB command prompt. The key that was pressed is inserted in the editing buffer so that it is possible to type most GDB commands without interaction with the TUI SingleKey mode. Once the command is entered the TUI SingleKey mode is restored. The only way to permanently leave this mode is by typing \texttt{q} or \texttt{C-x s}.

25.4 TUI-specific Commands

The TUI has specific commands to control the text windows. These commands are always available, even when GDB is not in the TUI mode. When GDB is in the standard mode, most of these commands will automatically switch to the TUI mode.

Note that if GDB’s stdouts is not connected to a terminal, or GDB has been started with the machine interface interpreter (see Chapter 27 [The GDB/MI Interface], page 457), most of these commands will fail with an error, because it would not be possible or desirable to enable curses window management.
tui enable
Activate TUI mode. The last active TUI window layout will be used if TUI
mode has previously been used in the current debugging session, otherwise a
default layout is used.

tui disable
Disable TUI mode, returning to the console interpreter.

info win
List and give the size of all displayed windows.

layout name
Changes which TUI windows are displayed. In each layout the command win-
dow is always displayed, the name parameter controls which additional windows
are displayed, and can be any of the following:
next Display the next layout.
prev Display the previous layout.
src Display the source and command windows.
asm Display the assembly and command windows.
split Display the source, assembly, and command windows.
regs When in src layout display the register, source, and command win-
dows. When in asm or split layout display the register, assembler,
and command windows.

focus name
Changes which TUI window is currently active for scrolling. The name param-
eter can be any of the following:
next Make the next window active for scrolling.
prev Make the previous window active for scrolling.
src Make the source window active for scrolling.
asm Make the assembly window active for scrolling.
regs Make the register window active for scrolling.
cmd Make the command window active for scrolling.

refresh
Refresh the screen. This is similar to typing C-L.

tui reg group
Changes the register group displayed in the tui register window to group. If the
register window is not currently displayed this command will cause the register
window to be displayed. The list of register groups, as well as their order is
target specific. The following groups are available on most targets:
next Repeatedly selecting this group will cause the display to cycle
through all of the available register groups.
prev Repeatedly selecting this group will cause the display to cycle
through all of the available register groups in the reverse order to
next.
Chapter 25: GDB Text User Interface

**general**  Display the general registers.

**float**  Display the floating point registers.

**system**  Display the system registers.

**vector**  Display the vector registers.

**all**  Display all registers.

**update**  Update the source window and the current execution point.

**winheight name +count**

**winheight name -count**

Change the height of the window name by count lines. Positive counts increase the height, while negative counts decrease it. The name parameter can be one of src (the source window), cmd (the command window), asm (the disassembly window), or regs (the register display window).

**tabset nchars**

Set the width of tab stops to be nchars characters. This setting affects the display of TAB characters in the source and assembly windows.

### 25.5 TUI Configuration Variables

Several configuration variables control the appearance of TUI windows.

**set tui border-kind kind**

Select the border appearance for the source, assembly and register windows. The possible values are the following:

**space**  Use a space character to draw the border.

**ascii**  Use ASCII characters ‘+’, ‘-’ and ‘|’ to draw the border.

**acs**  Use the Alternate Character Set to draw the border. The border is drawn using character line graphics if the terminal supports them.

**set tui border-mode mode**

**set tui active-border-mode mode**

Select the display attributes for the borders of the inactive windows or the active window. The mode can be one of the following:

**normal**  Use normal attributes to display the border.

**standout**  Use standout mode.

**reverse**  Use reverse video mode.

**half**  Use half bright mode.

**half-standout**  Use half bright and standout mode.

**bold**  Use extra bright or bold mode.

**bold-standout**  Use extra bright or bold and standout mode.
## 26 Using GDB under GNU Emacs

A special interface allows you to use GNU Emacs to view (and edit) the source files for the program you are debugging with GDB.

To use this interface, use the command `M-x gdb` in Emacs. Give the executable file you want to debug as an argument. This command starts GDB as a subprocess of Emacs, with input and output through a newly created Emacs buffer.

Running GDB under Emacs can be just like running GDB normally except for two things:
- All “terminal” input and output goes through an Emacs buffer, called the GUD buffer. This applies both to GDB commands and their output, and to the input and output done by the program you are debugging.
  - This is useful because it means that you can copy the text of previous commands and input them again; you can even use parts of the output in this way.
  - All the facilities of Emacs’ Shell mode are available for interacting with your program. In particular, you can send signals the usual way—for example, `C-c C-c` for an interrupt, `C-c C-z` for a stop.
- GDB displays source code through Emacs. Each time GDB displays a stack frame, Emacs automatically finds the source file for that frame and puts an arrow (‘=>’) at the left margin of the current line. Emacs uses a separate buffer for source display, and splits the screen to show both your GDB session and the source.
  - Explicit GDB `list` or search commands still produce output as usual, but you probably have no reason to use them from Emacs.

We call this text command mode. Emacs 22.1, and later, also uses a graphical mode, enabled by default, which provides further buffers that can control the execution and describe the state of your program. See Section “GDB Graphical Interface” in The GNU Emacs Manual.

If you specify an absolute file name when prompted for the `M-x gdb` argument, then Emacs sets your current working directory to where your program resides. If you only specify the file name, then Emacs sets your current working directory to the directory associated with the previous buffer. In this case, GDB may find your program by searching your environment’s PATH variable, but on some operating systems it might not find the source. So, although the GDB input and output session proceeds normally, the auxiliary buffer does not display the current source and line of execution.

The initial working directory of GDB is printed on the top line of the GUD buffer and this serves as a default for the commands that specify files for GDB to operate on. See Section 18.1 [Commands to Specify Files], page 237.

By default, `M-x gdb` calls the program called ‘gdb’. If you need to call GDB by a different name (for example, if you keep several configurations around, with different names) you can customize the Emacs variable `gud-gdb-command-name` to run the one you want.

In the GUD buffer, you can use these special Emacs commands in addition to the standard Shell mode commands:

- `C-h m` Describe the features of Emacs’ GUD Mode.
Execute to another source line, like the GDB `step` command; also update the display window to show the current file and location.

Execute to next source line in this function, skipping all function calls, like the GDB `next` command. Then update the display window to show the current file and location.

Execute one instruction, like the GDB `stepi` command; update display window accordingly.

Execute until exit from the selected stack frame, like the GDB `finish` command.

Continue execution of your program, like the GDB `continue` command.

Go up the number of frames indicated by the numeric argument (see Section “Numeric Arguments” in The GNU Emacs Manual), like the GDB `up` command.

Go down the number of frames indicated by the numeric argument, like the GDB `down` command.

In any source file, the Emacs command `C-x SPC (gud-break)` tells GDB to set a breakpoint on the source line point is on.

In text command mode, if you type `M-x speedbar`, Emacs displays a separate frame which shows a backtrace when the GUD buffer is current. Move point to any frame in the stack and type `RET` to make it become the current frame and display the associated source in the source buffer. Alternatively, click `Mouse-2` to make the selected frame become the current one. In graphical mode, the speedbar displays watch expressions.

If you accidentally delete the source-display buffer, an easy way to get it back is to type the command `f` in the GDB buffer, to request a frame display; when you run under Emacs, this recreates the source buffer if necessary to show you the context of the current frame.

The source files displayed in Emacs are in ordinary Emacs buffers which are visiting the source files in the usual way. You can edit the files with these buffers if you wish; but keep in mind that GDB communicates with Emacs in terms of line numbers. If you add or delete lines from the text, the line numbers that GDB knows cease to correspond properly with the code.

A more detailed description of Emacs’ interaction with GDB is given in the Emacs manual (see Section “Debuggers” in The GNU Emacs Manual).
27 The GDB/MI Interface

Function and Purpose

GDB/MI is a line based machine oriented text interface to GDB and is activated by specifying using the ‘--interpreter’ command line option (see Section 2.1.2 [Mode Options], page 13). It is specifically intended to support the development of systems which use the debugger as just one small component of a larger system.

This chapter is a specification of the GDB/MI interface. It is written in the form of a reference manual.

Note that GDB/MI is still under construction, so some of the features described below are incomplete and subject to change (see Section 27.6 [GDB/MI Development and Front Ends], page 463).

Notation and Terminology

This chapter uses the following notation:

- | separates two alternatives.
- [ something ] indicates that something is optional: it may or may not be given.
- ( group )* means that group inside the parentheses may repeat zero or more times.
- ( group )+ means that group inside the parentheses may repeat one or more times.
- "string" means a literal string.

27.3 GDB/MI General Design

Interaction of a GDB/MI frontend with GDB involves three parts—commands sent to GDB, responses to those commands and notifications. Each command results in exactly one response, indicating either successful completion of the command, or an error. For the commands that do not resume the target, the response contains the requested information. For the commands that resume the target, the response only indicates whether the target was successfully resumed. Notifications is the mechanism for reporting changes in the state of the target, or in GDB state, that cannot conveniently be associated with a command and reported as part of that command response.

The important examples of notifications are:

- Exec notifications. These are used to report changes in target state—when a target is resumed, or stopped. It would not be feasible to include this information in response of resuming commands, because one resume commands can result in multiple events in different threads. Also, quite some time may pass before any event happens in the target, while a frontend needs to know whether the resuming command itself was successfully executed.
- Console output, and status notifications. Console output notifications are used to report output of CLI commands, as well as diagnostics for other commands. Status notifications are used to report the progress of a long-running operation. Naturally, including this information in command response would mean no output is produced until the command is finished, which is undesirable.
• General notifications. Commands may have various side effects on the GDB or target state beyond their official purpose. For example, a command may change the selected thread. Although such changes can be included in command response, using notification allows for more orthogonal frontend design.

There’s no guarantee that whenever an MI command reports an error, GDB or the target are in any specific state, and especially, the state is not reverted to the state before the MI command was processed. Therefore, whenever an MI command results in an error, we recommend that the frontend refreshes all the information shown in the user interface.

27.3.1 Context management

27.3.1.1 Threads and Frames

In most cases when GDB accesses the target, this access is done in context of a specific thread and frame (see Section 8.1 [Frames], page 93). Often, even when accessing global data, the target requires that a thread be specified. The CLI interface maintains the selected thread and frame, and supplies them to target on each command. This is convenient, because a command line user would not want to specify that information explicitly on each command, and because user interacts with GDB via a single terminal, so no confusion is possible as to what thread and frame are the current ones.

In the case of MI, the concept of selected thread and frame is less useful. First, a frontend can easily remember this information itself. Second, a graphical frontend can have more than one window, each one used for debugging a different thread, and the frontend might want to access additional threads for internal purposes. This increases the risk that by relying on implicitly selected thread, the frontend may be operating on a wrong one. Therefore, each MI command should explicitly specify which thread and frame to operate on. To make it possible, each MI command accepts the ‘--thread’ and ‘--frame’ options, the value to each is GDB identifier for thread and frame to operate on.

Usually, each top-level window in a frontend allows the user to select a thread and a frame, and remembers the user selection for further operations. However, in some cases GDB may suggest that the current thread be changed. For example, when stopping on a breakpoint it is reasonable to switch to the thread where breakpoint is hit. For another example, if the user issues the CLI ‘thread’ command via the frontend, it is desirable to change the frontend’s selected thread to the one specified by user. GDB communicates the suggestion to change current thread using the ‘=thread-selected’ notification. No such notification is available for the selected frame at the moment.

Note that historically, MI shares the selected thread with CLI, so frontends used the -thread-select to execute commands in the right context. However, getting this to work right is cumbersome. The simplest way is for frontend to emit -thread-select command before every command. This doubles the number of commands that need to be sent. The alternative approach is to suppress -thread-select if the selected thread in GDB is supposed to be identical to the thread the frontend wants to operate on. However, getting this optimization right can be tricky. In particular, if the frontend sends several commands to GDB, and one of the commands changes the selected thread, then the behaviour of subsequent commands will change. So, a frontend should either wait for response from such problematic commands, or explicitly add -thread-select for all subsequent commands.
Chapter 27: The GDB/MI Interface

No frontend is known to do this exactly right, so it is suggested to just always pass the ‘--thread’ and ‘--frame’ options.

27.3.1.2 Language

The execution of several commands depends on which language is selected. By default, the current language (see [show language], page 189) is used. But for commands known to be language-sensitive, it is recommended to use the ‘--language’ option. This option takes one argument, which is the name of the language to use while executing the command. For instance:

```
-data-evaluate-expression --language c "sizeof (void*)"
```

```
done, value="4"
```

(gdb)

The valid language names are the same names accepted by the ‘set language’ command (see Section 15.1.2 [Manually], page 188), excluding ‘auto’, ‘local’ or ‘unknown’.

27.3.2 Asynchronous command execution and non-stop mode

On some targets, GDB is capable of processing MI commands even while the target is running. This is called asynchronous command execution (see Section 5.5.3 [Background Execution], page 78). The frontend may specify a preference for asynchronous execution using the `-gdb-set mi-async 1` command, which should be emitted before either running the executable or attaching to the target. After the frontend has started the executable or attached to the target, it can find if asynchronous execution is enabled using the `-list-target-features` command.

```
-gdb-set mi-async on
-gdb-set mi-async off
```

Set whether MI is in asynchronous mode.

When off, which is the default, MI execution commands (e.g., `-exec-continue`) are foreground commands, and GDB waits for the program to stop before processing further commands.

When on, MI execution commands are background execution commands (e.g., `-exec-continue` becomes the equivalent of the c& CLI command), and so GDB is capable of processing MI commands even while the target is running.

```
-gdb-show mi-async
```

Show whether MI asynchronous mode is enabled.

Note: In GDB version 7.7 and earlier, this option was called target-async instead of mi-async, and it had the effect of both putting MI in asynchronous mode and making CLI background commands possible. CLI background commands are now always possible “out of the box” if the target supports them. The old spelling is kept as a deprecated alias for backwards compatibility.

Even if GDB can accept a command while target is running, many commands that access the target do not work when the target is running. Therefore, asynchronous command execution is most useful when combined with non-stop mode (see Section 5.5.2 [Non-Stop Mode], page 77). Then, it is possible to examine the state of one thread, while other threads are running.
When a given thread is running, MI commands that try to access the target in the context of that thread may not work, or may work only on some targets. In particular, commands that try to operate on thread’s stack will not work, on any target. Commands that read memory, or modify breakpoints, may work or not work, depending on the target. Note that even commands that operate on global state, such as `print`, `set`, and breakpoint commands, still access the target in the context of a specific thread, so frontend should try to find a stopped thread and perform the operation on that thread (using the `--thread` option).

Which commands will work in the context of a running thread is highly target dependent. However, the two commands `-exec-interrupt`, to stop a thread, and `-thread-info`, to find the state of a thread, will always work.

### 27.3.3 Thread groups

GDB may be used to debug several processes at the same time. On some platforms, GDB may support debugging of several hardware systems, each one having several cores with several different processes running on each core. This section describes the MI mechanism to support such debugging scenarios.

The key observation is that regardless of the structure of the target, MI can have a global list of threads, because most commands that accept the `--thread` option do not need to know what process that thread belongs to. Therefore, it is not necessary to introduce neither additional `--process` option, nor an notion of the current process in the MI interface. The only strictly new feature that is required is the ability to find how the threads are grouped into processes.

To allow the user to discover such grouping, and to support arbitrary hierarchy of machines/cores/processes, MI introduces the concept of a thread group. Thread group is a collection of threads and other thread groups. A thread group always has a string identifier, a type, and may have additional attributes specific to the type. A new command, `-list-thread-groups`, returns the list of top-level thread groups, which correspond to processes that GDB is debugging at the moment. By passing an identifier of a thread group to the `-list-thread-groups` command, it is possible to obtain the members of specific thread group.

To allow the user to easily discover processes, and other objects, he wishes to debug, a concept of available thread group is introduced. Available thread group is an thread group that GDB is not debugging, but that can be attached to, using the `-target-attach` command. The list of available top-level thread groups can be obtained using `-list-thread-groups --available`. In general, the content of a thread group may be only retrieved only after attaching to that thread group.

Thread groups are related to inferiors (see Section 4.9 [Inferiors and Programs], page 33). Each inferior corresponds to a thread group of a special type ‘process’, and some additional operations are permitted on such thread groups.

### 27.4 GDB/MI Command Syntax
27.4.1 GDB/MI Input Syntax

\[
\text{command} \mapsto \quad \text{cli-command} \mid \text{mi-command} \\
\text{cli-command} \mapsto \quad [ \text{token} ] \text{cli-command} \ \text{nl}, \text{where cli-command is any existing GDB CLI command.} \\
\text{mi-command} \mapsto \quad [ \text{token} ] '-' \text{operation} ("" \text{option}* ["--"] ("" \text{parameter})* \text{nl} \\
\text{token} \mapsto \ "\text{any sequence of digits}" \\
\text{option} \mapsto \ "-" \text{parameter} ["" \text{parameter}]
\text{parameter} \mapsto \quad \text{non-blank-sequence} \mid \text{c-string} \\
\text{operation} \mapsto \quad \text{any of the operations described in this chapter} \\
\text{non-blank-sequence} \mapsto \quad \text{anything, provided it doesn't contain special characters such as "", \text{nl}, "" and of course ""} \\
\text{c-string} \mapsto \quad ""\text{seven-bit-iso-c-string-content} ""
\]

\[
\text{nl} \mapsto \quad \text{CR} \mid \text{CR-LF}
\]

Notes:

- The CLI commands are still handled by the \texttt{mi} interpreter; their output is described below.
- The \texttt{token}, when present, is passed back when the command finishes.
- Some \texttt{mi} commands accept optional arguments as part of the parameter list. Each option is identified by a leading ‘-’ (dash) and may be followed by an optional argument parameter. Options occur first in the parameter list and can be delimited from normal parameters using ‘--’ (this is useful when some parameters begin with a dash).

Pragmatics:

- We want easy access to the existing CLI syntax (for debugging).
- We want it to be easy to spot a \texttt{mi} operation.

27.4.2 GDB/MI Output Syntax

The output from GDB/MI consists of zero or more out-of-band records followed, optionally, by a single result record. This result record is for the most recent command. The sequence of output records is terminated by ‘\texttt{(gdb)}’.

If an input command was prefixed with a \texttt{token} then the corresponding output for that command will also be prefixed by that same \texttt{token}.

\[
\text{output} \mapsto \quad ( \text{out-of-band-record})* \ [ \text{result-record} ] "\texttt{(gdb)}" \ \text{nl}
\]
result-record ↦
[ token ] "-" result-class ( "," result )* nl

out-of-band-record ↦
async-record | stream-record

async-record ↦
exec-async-output | status-async-output | notify-async-output

exec-async-output ↦
[ token ] "*" async-output nl

status-async-output ↦
[ token ] "+" async-output nl

notify-async-output ↦
[ token ] "=" async-output nl

async-output ↦
async-class ( "," result )*

result-class ↦
"done" | "running" | "connected" | "error" | "exit"

async-class ↦
"stopped" | others (where others will be added depending on the needs—this
is still in development).

result ↦
variable "=" value

variable ↦
string

value ↦
const | tuple | list

const ↦
c-string

tuple ↦
"{}" | "{" result ( "," result )* "}"

list ↦
"[]" | "[" value ( "," value )* "]" | 
"[" result ( "," result )* "]"

stream-record ↦
console-stream-output | target-stream-output | log-stream-output

console-stream-output ↦
"~" c-string nl

target-stream-output ↦
"@" c-string nl

log-stream-output ↦
"&" c-string nl

nl ↦
CR | CR-LF

token ↦
any sequence of digits.

Notes:
All output sequences end in a single line containing a period.

The token is from the corresponding request. Note that for all async output, while the token is allowed by the grammar and may be output by future versions of GDB for select async output messages, it is generally omitted. Frontends should treat all async output as reporting general changes in the state of the target and there should be no need to associate async output to any prior command.

status-async-output contains on-going status information about the progress of a slow operation. It can be discarded. All status output is prefixed by ‘+’.

eexec-async-output contains asynchronous state change on the target (stopped, started, disappeared). All async output is prefixed by ‘*’.

notify-async-output contains supplementary information that the client should handle (e.g., a new breakpoint information). All notify output is prefixed by ‘=’.

console-stream-output is output that should be displayed as is in the console. It is the textual response to a CLI command. All the console output is prefixed by ‘~’.

target-stream-output is the output produced by the target program. All the target output is prefixed by ‘@’.

log-stream-output is output text coming from GDB’s internals, for instance messages that should be displayed as part of an error log. All the log output is prefixed by ‘&’.

New GDB/MI commands should only output lists containing values.

See Section 27.7.2 [GDB/MI Stream Records], page 464, for more details about the various output records.

27.5 GDB/MI Compatibility with CLI

For the developers convenience CLI commands can be entered directly, but there may be some unexpected behaviour. For example, commands that query the user will behave as if the user replied yes, breakpoint command lists are not executed and some CLI commands, such as if, when and define, prompt for further input with ‘>’, which is not valid MI output.

This feature may be removed at some stage in the future and it is recommended that front ends use the -interpreter-exec command (see [-interpreter-exec], page 541).

27.6 GDB/MI Development and Front Ends

The application which takes the MI output and presents the state of the program being debugged to the user is called a front end.

Although GDB/MI is still incomplete, it is currently being used by a variety of front ends to GDB. This makes it difficult to introduce new functionality without breaking existing usage. This section tries to minimize the problems by describing how the protocol might change.

Some changes in MI need not break a carefully designed front end, and for these the MI version will remain unchanged. The following is a list of changes that may occur within one level, so front ends should parse MI output in a way that can handle them:

• New MI commands may be added.
• New fields may be added to the output of any MI command.
• The range of values for fields with specified values, e.g., in_scope (see [-var-update], page 510) may be extended.

If the changes are likely to break front ends, the MI version level will be increased by one. This will allow the front end to parse the output according to the MI version. Apart from mi0, new versions of GDB will not support old versions of MI and it will be the responsibility of the front end to work with the new one.

The best way to avoid unexpected changes in MI that might break your front end is to make your project known to GDB developers and follow development on gdb@sourceware.org and gdb-patches@sourceware.org.

27.7 GDB/MI Output Records

27.7.1 GDB/MI Result Records
In addition to a number of out-of-band notifications, the response to a GDB/MI command includes one of the following result indications:

"^done" [ "," results ]
The synchronous operation was successful, results are the return values.

"^running"
This result record is equivalent to ‘^done’. Historically, it was output instead of ‘^done’ if the command has resumed the target. This behaviour is maintained for backward compatibility, but all frontends should treat ‘^done’ and ‘^running’ identically and rely on the ‘*running’ output record to determine which threads are resumed.

"^connected"
GDB has connected to a remote target.

"^error" "," "msg"=" c-string [ "," "code"=" c-string ]
The operation failed. The msg=c-string variable contains the corresponding error message.
If present, the code=c-string variable provides an error code on which consumers can rely on to detect the corresponding error condition. At present, only one error code is defined:

'"undefined-command"
Indicates that the command causing the error does not exist.

"^exit"
GDB has terminated.

27.7.2 GDB/MI Stream Records
GDB internally maintains a number of output streams: the console, the target, and the log. The output intended for each of these streams is funneled through the GDB/MI interface using stream records.

Each stream record begins with a unique prefix character which identifies its stream (see Section 27.4.2 [GDB/MI Output Syntax], page 461). In addition to the prefix, each stream
record contains a string-output. This is either raw text (with an implicit new line) or a quoted C string (which does not contain an implicit newline).

"-" string-output
   The console output stream contains text that should be displayed in the CLI console window. It contains the textual responses to CLI commands.

"@" string-output
   The target output stream contains any textual output from the running target. This is only present when GDB’s event loop is truly asynchronous, which is currently only the case for remote targets.

"&" string-output
   The log stream contains debugging messages being produced by GDB’s internals.

27.7.3 GDB/MI Async Records
Async records are used to notify the GDB/MI client of additional changes that have occurred. Those changes can either be a consequence of GDB/MI commands (e.g., a breakpoint modified) or a result of target activity (e.g., target stopped).

The following is the list of possible async records:

*running,thread-id="thread"
   The target is now running. The thread field tells which specific thread is now running, and can be 'all' if all threads are running. The frontend should assume that no interaction with a running thread is possible after this notification is produced. The frontend should not assume that this notification is output only once for any command. GDB may emit this notification several times, either for different threads, because it cannot resume all threads together, or even for a single thread, if the thread must be stepped through some code before letting it run freely.

*stopped,reason="reason",thread-id="id",stopped-threads="stopped",core="core"
   The target has stopped. The reason field can have one of the following values:
      breakpoint-hit
         A breakpoint was reached.
      watchpoint-trigger
         A watchpoint was triggered.
      read-watchpoint-trigger
         A read watchpoint was triggered.
      access-watchpoint-trigger
         An access watchpoint was triggered.
      function-finished
         An -exec-finish or similar CLI command was accomplished.
      location-reached
         An -exec-until or similar CLI command was accomplished.
      watchpoint-scope
         A watchpoint has gone out of scope.
**end-stepping-range**

An `-exec-next`, `-exec-next-instruction`, `-exec-step`, `-exec-step-instruction` or similar CLI command was accomplished.

**exited-signalled**

The inferior exited because of a signal.

**exited**

The inferior exited.

**exited-normally**

The inferior exited normally.

**signal-received**

A signal was received by the inferior.

**solib-event**

The inferior has stopped due to a library being loaded or unloaded. This can happen when `stop-on-solib-events` (see Section 18.1 [Files], page 237) is set or when a `catch load` or `catch unload` catchpoint is in use (see Section 5.1.3 [Set Catchpoints], page 55).

**fork**

The inferior has forked. This is reported when `catch fork` (see Section 5.1.3 [Set Catchpoints], page 55) has been used.

**vfork**

The inferior has vforked. This is reported in when `catch vfork` (see Section 5.1.3 [Set Catchpoints], page 55) has been used.

**syscall-entry**

The inferior entered a system call. This is reported when `catch syscall` (see Section 5.1.3 [Set Catchpoints], page 55) has been used.

**syscall-return**

The inferior returned from a system call. This is reported when `catch syscall` (see Section 5.1.3 [Set Catchpoints], page 55) has been used.

**exec**

The inferior called `exec`. This is reported when `catch exec` (see Section 5.1.3 [Set Catchpoints], page 55) has been used.

The `id` field identifies the thread that directly caused the stop – for example by hitting a breakpoint. Depending on whether all-stop mode is in effect (see Section 5.5.1 [All-Stop Mode], page 76), GDB may either stop all threads, or only the thread that directly triggered the stop. If all threads are stopped, the `stopped` field will have the value of "all". Otherwise, the value of the `stopped` field will be a list of thread identifiers. Presently, this list will always include a single thread, but frontend should be prepared to see several threads in the list. The `core` field reports the processor core on which the stop event has happened. This field may be absent if such information is not available.

=thread-group-added,id="id"
=thread-group-removed,id="id"

A thread group was either added or removed. The `id` field contains the GDB identifier of the thread group. When a thread group is added, it generally might...
not be associated with a running process. When a thread group is removed, its
id becomes invalid and cannot be used in any way.

[thread-group-started,id="id",pid="pid"]
A thread group became associated with a running program, either because the
program was just started or the thread group was attached to a program. The
id field contains the GDB identifier of the thread group. The pid field contains
process identifier, specific to the operating system.

[thread-group-exited,id="id",exit-code="code"]
A thread group is no longer associated with a running program, either because
the program has exited, or because it was detached from. The id field contains
the GDB identifier of the thread group. The code field is the exit code of the
inferior; it exists only when the inferior exited with some code.

[thread-created,id="id",group-id="gid"]
[thread-exited,id="id",group-id="gid"]
A thread either was created, or has exited. The id field contains the GDB
identifier of the thread. The gid field identifies the thread group this thread
belongs to.

[thread-selected,id="id"]
Informs that the selected thread was changed as result of the last command.
This notification is not emitted as result of -thread-select command but is
emitted whenever an MI command that is not documented to change the selec
ted thread actually changes it. In particular, invoking, directly or indirectly
(via user-defined command), the CLI thread command, will generate this no
tification.

We suggest that in response to this notification, front ends highlight the selected
thread and cause subsequent commands to apply to that thread.

=library-loaded,...
Reports that a new library file was loaded by the program. This notification
has 4 fields—id, target-name, host-name, and symbols-loaded. The id field is
an opaque identifier of the library. For remote debugging case, target-name
and host-name fields give the name of the library file on the target, and on the
host respectively. For native debugging, both those fields have the same value.
The symbols-loaded field is emitted only for backward compatibility and should
not be relied on to convey any useful information. The thread-group field, if
present, specifies the id of the thread group in whose context the library was
loaded. If the field is absent, it means the library was loaded in the context of
all present thread groups.

=library-unloaded,...
Reports that a library was unloaded by the program. This notification has
3 fields—id, target-name and host-name with the same meaning as for the
=library-loaded notification. The thread-group field, if present, specifies the
id of the thread group in whose context the library was unloaded. If the field is
absent, it means the library was unloaded in the context of all present thread
groups.
=traceframe-changed,num=tfnum,tracepoint=tpnum
=traceframe-changed,end
Reports that the trace frame was changed and its new number is tfnum. The number of the tracepoint associated with this trace frame is tpnum.

=tsv-created,name=name,initial=initial
Reports that the new trace state variable name is created with initial value initial.

=tsv-deleted,name=name
=tsv-deleted
Reports that the trace state variable name is deleted or all trace state variables are deleted.

=tsv-modified,name=name,initial=initial[,current=current]
Reports that the trace state variable name is modified with the initial value initial. The current value current of trace state variable is optional and is reported if the current value of trace state variable is known.

=breakpoint-created,bkpt={...}
=breakpoint-modified,bkpt={...}
=breakpoint-deleted,id=number
Reports that a breakpoint was created, modified, or deleted, respectively. Only user-visible breakpoints are reported to the MI user.

The bkpt argument is of the same form as returned by the various breakpoint commands; See Section 27.10 [GDB/MI Breakpoint Commands], page 472. The number is the ordinal number of the breakpoint.

Note that if a breakpoint is emitted in the result record of a command, then it will not also be emitted in an async record.

=record-started,thread-group="id"
=record-stopped,thread-group="id"
Execution log recording was either started or stopped on an inferior. The id is the gdb identifier of the thread group corresponding to the affected inferior.

=cmd-param-changed,param=param,value=value
Reports that a parameter of the command set param is changed to value. In the multi-word set command, the param is the whole parameter list to set command. For example, In command set check type on, param is check type and value is on.

=memory-changed,thread-group=id,addr=addr,len=len[,type="code"]
Reports that bytes from addr to data + len were written in an inferior. The id is the identifier of the thread group corresponding to the affected inferior. The optional type="code" part is reported if the memory written to holds executable code.

### 27.7.4 GDB/MI Breakpoint Information

When GDB reports information about a breakpoint, a tracepoint, a watchpoint, or a catchpoint, it uses a tuple with the following fields:
number  The breakpoint number. For a breakpoint that represents one location of a
multi-location breakpoint, this will be a dotted pair, like ‘1.2’.

type   The type of the breakpoint. For ordinary breakpoints this will be ‘breakpoint’,
but many values are possible.

catch-type  If the type of the breakpoint is ‘catchpoint’, then this indicates the exact type
of catchpoint.
disp      This is the breakpoint disposition—either ‘del’, meaning that the breakpoint
will be deleted at the next stop, or ‘keep’, meaning that the breakpoint will
not be deleted.

enabled This indicates whether the breakpoint is enabled, in which case the value is ‘y’,
or disabled, in which case the value is ‘n’. Note that this is not the same as the
field enable.

addr     The address of the breakpoint. This may be a hexadecimal number, giving
the address; or the string ‘<PENDING>’, for a pending breakpoint; or the string
‘<MULTIPLE>’, for a breakpoint with multiple locations. This field will not be
present if no address can be determined. For example, a watchpoint does not
have an address.

func    If known, the function in which the breakpoint appears. If not known, this field
is not present.

filename  The name of the source file which contains this function, if known. If not known,
this field is not present.

fullname The full file name of the source file which contains this function, if known. If
not known, this field is not present.

line     The line number at which this breakpoint appears, if known. If not known, this
field is not present.

at       If the source file is not known, this field may be provided. If provided, this
holds the address of the breakpoint, possibly followed by a symbol name.

pending If this breakpoint is pending, this field is present and holds the text used to set
the breakpoint, as entered by the user.

evaluated-by Where this breakpoint’s condition is evaluated, either ‘host’ or ‘target’.

thread   If this is a thread-specific breakpoint, then this identifies the thread in which
the breakpoint can trigger.

task     If this breakpoint is restricted to a particular Ada task, then this field will hold
the task identifier.

cond     If the breakpoint is conditional, this is the condition expression.

ignore  The ignore count of the breakpoint.

enable   The enable count of the breakpoint.
traceframe-usage
FIXME.

static-tracepoint-marker-string-id
For a static tracepoint, the name of the static tracepoint marker.

mask
For a masked watchpoint, this is the mask.

pass
A tracepoint’s pass count.

original-location
The location of the breakpoint as originally specified by the user. This field is optional.

times
The number of times the breakpoint has been hit.

installed
This field is only given for tracepoints. This is either ‘y’, meaning that the tracepoint is installed, or ‘n’, meaning that it is not.

what
Some extra data, the exact contents of which are type-dependent.

For example, here is what the output of `-break-insert` (see Section 27.10 [GDB/MI Breakpoint Commands], page 472) might be:

```plaintext
-> -break-insert main
<- "done,bkpt={number="1",type="breakpoint",disp="keep",
   enabled="y",addr=0x08048564",func="main",file="myprog.c",
   fullname="/home/nickrob/myprog.c",line="68",thread-groups=["i1"],
   times="0"}
<- (gdb)
```

27.7.5 GDB/MI Frame Information
Response from many MI commands includes an information about stack frame. This information is a tuple that may have the following fields:

level
The level of the stack frame. The innermost frame has the level of zero. This field is always present.

func
The name of the function corresponding to the frame. This field may be absent if GDB is unable to determine the function name.

addr
The code address for the frame. This field is always present.

file
The name of the source files that correspond to the frame’s code address. This field may be absent.

line
The source line corresponding to the frames’ code address. This field may be absent.

from
The name of the binary file (either executable or shared library) the corresponds to the frame’s code address. This field may be absent.

27.7.6 GDB/MI Thread Information
Whenever GDB has to report an information about a thread, it uses a tuple with the following fields:
id The numeric id assigned to the thread by GDB. This field is always present.

target-id Target-specific string identifying the thread. This field is always present.

details Additional information about the thread provided by the target. It is supposed to be human-readable and not interpreted by the frontend. This field is optional.

state Either ‘stopped’ or ‘running’, depending on whether the thread is presently running. This field is always present.

core The value of this field is an integer number of the processor core the thread was last seen on. This field is optional.

27.7.7 GDB/MI Ada Exception Information
Whenever a *stopped record is emitted because the program stopped after hitting an exception catchpoint (see Section 5.1.3 [Set Catchpoints], page 55), GDB provides the name of the exception that was raised via the exception-name field.

27.8 Simple Examples of GDB/MI Interaction
This subsection presents several simple examples of interaction using the GDB/MI interface. In these examples, ‘->’ means that the following line is passed to GDB/MI as input, while ‘<-' means the output received from GDB/MI.

Note the line breaks shown in the examples are here only for readability, they don’t appear in the real output.

Setting a Breakpoint
Setting a breakpoint generates synchronous output which contains detailed information of the breakpoint.

```gdb
-> -break-insert main
<- "done,bkpt={number="1",type="breakpoint",disp="keep", enabled="y",addr=0x08048564,func="main",file="myprog.c", fullname="/home/nickrob/myprog.c",line="68",thread-groups=["i1"], times="0"},
<- (gdb)
```

Program Execution
Program execution generates asynchronous records and MI gives the reason that execution stopped.

```gdb
-> -exec-run
<- "running"
<- (gdb)
<- *stopped,reason="breakpoint-hit",disp="keep",bkptno="1",thread-id="0",
 frame={addr=0x08048564,func="main",
 args={name="argc",value="1"},
 file="myprog.c",fullname="/home/nickrob/myprog.c",line="68"}
<- (gdb)
-> -exec-continue
<- "running"
<- (gdb)
<- *stopped,reason="exited-normally"
<- (gdb)
```
Quitting GDB

Quitting GDB just prints the result class `"exit".

```plaintext
-> (gdb)
< -gdb-exit
< ^exit
```

Please note that `^exit` is printed immediately, but it might take some time for GDB to actually exit. During that time, GDB performs necessary cleanups, including killing programs being debugged or disconnecting from debug hardware, so the frontend should wait till GDB exits and should only forcibly kill GDB if it fails to exit in reasonable time.

A Bad Command

Here’s what happens if you pass a non-existent command:

```plaintext
-> -rubbish
< "error,msg="Undefined MI command: rubbish"
< (gdb)
```

27.9 GDB/MI Command Description Format

The remaining sections describe blocks of commands. Each block of commands is laid out in a fashion similar to this section.

Motivation

The motivation for this collection of commands.

Introduction

A brief introduction to this collection of commands as a whole.

Commands

For each command in the block, the following is described:

Synopsis

```plaintext
-command args...
```

Result

GDB Command

The corresponding GDB CLI command(s), if any.

Example

Example(s) formatted for readability. Some of the described commands have not been implemented yet and these are labeled N.A. (not available).

27.10 GDB/MI Breakpoint Commands

This section documents GDB/MI commands for manipulating breakpoints.

The -break-after Command
Chapter 27: The GDB/MI Interface

Synopsis

`-break-after number count`

The breakpoint number `number` is not in effect until it has been hit `count` times. To see how this is reflected in the output of the `-break-list` command, see the description of the `-break-list` command below.

GDB Command

The corresponding GDB command is `ignore`.

Example

```gdb
(gdb)
-break-insert main
"done,bkpt={number="1",type="breakpoint",disp="keep", enabled="y",addr="0x000100d0",func="main",file="hello.c",
fullname="/home/foo/hello.c",line="5",thread-groups="[i1]",
times="0"}
(gdb)
-break-after 1 3
-"done
(gdb)
-break-list
"done, BreakpointTable={nr_rows="1", nr_cols="6",
hdr=[{width="3",alignment="-1",col_name="number",colhdr="Num"},
{width="14",alignment="-1",col_name="type",colhdr="Type"},
{width="4",alignment="-1",col_name="disp",colhdr="Disp"},
{width="3",alignment="-1",col_name="enabled",colhdr="Enb"},
{width="10",alignment="-1",col_name="addr",colhdr="Address"},
{width="40",alignment="2",col_name="what",colhdr="What"}],
body=[bkpt={number="1",type="breakpoint",disp="keep", enabled="y",
addr="0x000100d0",func="main",file="hello.c",fullname="/home/foo/hello.c",
line="5",thread-groups="[i1]",times="0",ignore="3"}])
(gdb)
```

The `-break-commands` Command

Synopsis

`-break-commands number [ command1 ... commandN ]`

Specifies the CLI commands that should be executed when breakpoint `number` is hit. The parameters `command1` to `commandN` are the commands. If no command is specified, any previously-set commands are cleared. See Section 5.1.7 [Break Commands], page 62. Typical use of this functionality is tracing a program, that is, printing of values of some variables whenever breakpoint is hit and then continuing.

GDB Command

The corresponding GDB command is `commands`.

Example

```gdb
(gdb)
-break-insert main
"done,bkpt={number="1",type="breakpoint",disp="keep",
```
The **-break-condition** Command

**Synopsis**

\[-break-condition number expr\]

Breakpoint **number** will stop the program only if the condition in **expr** is true. The condition becomes part of the `-break-list` output (see the description of the `-break-list` command below).

**GDB Command**

The corresponding GDB command is `condition`.

**Example**

```bash
(gdb)
  -break-condition 1 1
  "done
(gdb)
  -break-list
  "done,BreakpointTable={nr_rows="1",nr_cols="6",hdr=[{width="3",alignment="-1",col_name="number",colhdr="Num"}],
  {width="14",alignment="-1",col_name="type",colhdr="Type"},
  {width="4",alignment="-1",col_name="disp",colhdr="Disp"},
  {width="3",alignment="-1",col_name="enabled",colhdr="Enb"},
  {width="10",alignment="-1",col_name="addr",colhdr="Address"},
  {width="40",alignment="2",col_name="what",colhdr="What"}],
  body=[bkpt={number="1",type="breakpoint",disp="keep",enabled="y",addr="0x000100d0",func="main",file="hello.c",fullname="/home/foo/hello.c",line="5",thread-groups=["i1"],times="0",ignore="3"}]}
(gdb)
```

The **-break-delete** Command

**Synopsis**

\[-break-delete ( breakpoint )+\]

Delete the breakpoint(s) whose number(s) are specified in the argument list. This is obviously reflected in the breakpoint list.

**GDB Command**

The corresponding GDB command is `delete`.

**Example**

```bash
(gdb)
  -break-delete 1
  "done
```
The `-break-disable` Command

**Synopsis**

```
-break-disable ( breakpoint )+
```

Disable the named `breakpoint(s)`. The field `enabled` in the break list is now set to `n` for the named `breakpoint(s)`.

**GDB Command**

The corresponding GDB command is `disable`.

**Example**

```
(gdb)
-break-disable 2
```

The `-break-enable` Command

**Synopsis**

```
-break-enable ( breakpoint )+
```

Enable (previously disabled) `breakpoint(s)`.

**GDB Command**

The corresponding GDB command is `enable`.

**Example**

```
(gdb)
-break-enable 2
```
/*done
(gdb)
-break-list
"done,BreakpointTable={nr_rows="1",nr_cols="6", 
hdr=[[width="3",alignment="-1",col_name="number",colhdr="Num"], 
{width="14",alignment="-1",col_name="type",colhdr="Type"}, 
{width="4",alignment="-1",col_name="disp",colhdr="Disp"}, 
{width="3",alignment="-1",col_name="enabled",colhdr="Enb"}, 
{width="10",alignment="-1",col_name="addr",colhdr="Address"}, 
{width="40",alignment="2",col_name="what",colhdr="What"}], 
body=[bkpt={number="2",type="breakpoint",disp="keep",enabled="y", 
addr="0x000100d0",func="main",file="hello.c",fullname="/home/foo/hello.c", 
line="5",thread-groups=["i1"],times="0"}])
(gdb)

The -break-info Command

Synopsis

-break-info breakpoint

Get information about a single breakpoint.

The result is a table of breakpoints. See Section 27.7.4 [GDB/MI Breakpoint Information], page 468, for details on the format of each breakpoint in the table.

GDB Command

The corresponding GDB command is ‘info break breakpoint’.

Example

N.A.

The -break-insert Command

Synopsis

-break-insert [ -t ] [ -h ] [ -f ] [ -d ] [ -a ] 
[ -c condition ] [ -i ignore-count ] 
[ -p thread-id ] [ location ]

If specified, location, can be one of:

linespec location

A linespec location. See Section 9.2.1 [Linespec Locations], page 102.

explicit location

An explicit location. GDB/MI explicit locations are analogous to the CLI’s explicit locations using the option names listed below. See Section 9.2.2 [Explicit Locations], page 103.

‘--source filename’

The source file name of the location. This option requires the use of either ‘--function’ or ‘--line’.

‘--function function’

The name of a function or method.
'--label label'
The name of a label.

'--line lineoffset'
An absolute or relative line offset from the start of the location.

address location
An address location, *address. See Section 9.2.3 [Address Locations], page 104.

The possible optional parameters of this command are:

' -t' Insert a temporary breakpoint.

' -h' Insert a hardware breakpoint.

' -f' If location cannot be parsed (for example if it refers to unknown files or functions), create a pending breakpoint. Without this flag, GDB will report an error, and won’t create a breakpoint, if location cannot be parsed.

' -d' Create a disabled breakpoint.

' -a' Create a tracepoint. See Chapter 13 [Tracepoints], page 163. When this parameter is used together with ' -h', a fast tracepoint is created.

' -c condition'
Make the breakpoint conditional on condition.

' -i ignore-count'
Initialize the ignore-count.

' -p thread-id'
Restrict the breakpoint to the specified thread-id.

Result
See Section 27.7.4 [GDB/MI Breakpoint Information], page 468, for details on the format of the resulting breakpoint.

Note: this format is open to change.

GDB Command
The corresponding GDB commands are ‘break’, ‘tbreak’, ‘hbreak’, and ‘thbreak’.

Example

(gdb)
-break-insert main
"done,bkpt={number="1",addr="0x0001072c",file="recursive2.c",
fullname="/home/foo/recursive2.c,line="4",thread-groups=["i1"],
times="0"}
(gdb)
-break-insert -t foo
"done,bkpt={number="2",addr="0x00010774",file="recursive2.c",
fullname="/home/foo/recursive2.c,line="11",thread-groups=["i1"],
times="0"}
(gdb)
-break-list
"done,BreakpointTable={nr_rows="2",nr_cols="6",}
The `dprintf-insert` Command

Synopsis

```
dprintf-insert [ -t ] [ -f ] [ -d ]
  [ -c condition ] [ -i ignore-count ]
  [ -p thread-id ] [ location ] [ format ]
  [ argument ]
```

If supplied, `location` may be specified the same way as for the `break-insert` command. See `break-insert`, page 476.

The possible optional parameters of this command are:

`-t` Insert a temporary breakpoint.

`-f` If `location` cannot be parsed (for example, if it refers to unknown files or functions), create a pending breakpoint. Without this flag, GDB will report an error, and won’t create a breakpoint, if `location` cannot be parsed.

`-d` Create a disabled breakpoint.

`-c condition` Make the breakpoint conditional on `condition`.

`-i ignore-count` Set the ignore count of the breakpoint (see Section 5.1.6 [Conditions], page 60) to `ignore-count`.

`-p thread-id` Restrict the breakpoint to the specified `thread-id`.

Result

See Section 27.7.4 [GDB/MI Breakpoint Information], page 468, for details on the format of the resulting breakpoint.

**GDB Command**

The corresponding GDB command is `dprintf`.

```
(gdb)
```
Example

(gdb)
4-dprintf-insert foo "At foo entry\n"
4^done,bkpt={number="1",type="dprintf",disp="keep",enabled="y",
addr="0x000000000040061b",func="foo",file="mi-dprintf.c",
fullname="mi-dprintf.c",line="25",thread-groups=["i1"],
times="0",script={"printf \"At foo entry\n\","continue"},
original-location="foo"}
(gdb)
5-dprintf-insert 26 "arg=%d, g=%d\n" arg g
5^done,bkpt={number="2",type="dprintf",disp="keep",enabled="y",
addr="0x000000000040062a",func="foo",file="mi-dprintf.c",
fullname="mi-dprintf.c",line="26",thread-groups=["i1"],
times="0",script={"printf \"arg=%d, g=%d\n\", arg, g","continue"},
original-location="mi-dprintf.c:26"}
(gdb)

The -break-list Command

Synopsis

-break-list

Displays the list of inserted breakpoints, showing the following fields:

‘Number’ number of the breakpoint

‘Type’ type of the breakpoint: ‘breakpoint’ or ‘watchpoint’

‘Disposition’ should the breakpoint be deleted or disabled when it is hit: ‘keep’ or ‘nokeep’

‘Enabled’ is the breakpoint enabled or no: ‘y’ or ‘n’

‘Address’ memory location at which the breakpoint is set

‘What’ logical location of the breakpoint, expressed by function name, file name, line number

‘Thread-groups’ list of thread groups to which this breakpoint applies

‘Times’ number of times the breakpoint has been hit

If there are no breakpoints or watchpoints, the BreakpointTable body field is an empty list.

GDB Command

The corresponding GDB command is ‘info break’.

Example

(gdb)
-break-list
"done,BreakpointTable={nr_rows="2",nr_cols="6",
hdr={[{width="3",alignment="-1",col_name="number",colhdr="Num"}],
{width="14",alignment="-1",col_name="type",colhdr="Type"},
{width="4",alignment="-1",col_name="disp",colhdr="Disp"},
{width="3",alignment="-1",col_name="enabled",colhdr="Enb"},
Here's an example of the result when there are no breakpoints:

```
(gdb)
-break-list
```

```
^done,wpt={number="2",exp="x"
```

The `-break-passcount` Command

**Synopsis**

```
-break-passcount tracepoint-number passcount
```

Set the passcount for tracepoint `tracepoint-number` to `passcount`. If the breakpoint referred to by `tracepoint-number` is not a tracepoint, error is emitted. This corresponds to CLI command `passcount`

The `-break-watch` Command

**Synopsis**

```
-break-watch [ -a | -r ]
```

Create a watchpoint. With the `-a` option it will create an access watchpoint, i.e., a watchpoint that triggers either on a read from or on a write to the memory location. With the `-r` option, the watchpoint created is a read watchpoint, i.e., it will trigger only when the memory location is accessed for reading. Without either of the options, the watchpoint created is a regular watchpoint, i.e., it will trigger when the memory location is accessed for writing. See Section 5.1.2 [Setting Watchpoints], page 52.

Note that `-break-list` will report a single list of watchpoints and breakpoints inserted.

**GDB Command**

The corresponding GDB commands are `watch`, `awatch`, and `rwatch`.

**Example**

Setting a breakpoint on a variable in the `main` function:

```
(gdb)
-break-watch x
```

```
^done,wpt={number="2",exp="x"
```
(gdb)
-exec-continue
*running
(\begin{verbatim}
  ^running
  \end{verbatim})
(gdb)
*stopped,reason="watchpoint-trigger",wpt={number="2",exp="x"},
  value={old="-268439212",new="55"},
  frame={func="main",args=[],file="recursive2.c",
         fullname="/home/foo/bar/recursive2.c",line="5"}
(gdb)

Setting a watchpoint on a variable local to a function. GDB will stop the program execution twice: first for the variable changing value, then for the watchpoint going out of scope.

(gdb)
-break-watch C
  ^done,wpt={number="5",exp="C"}
(gdb)
-exec-continue
  ^running
  (gdb)
*stopped,reason="watchpoint-scope",wpnum="5",
  frame={func="callee3",args=[{name="strarg",
                               value="0x11940 "A string argument."}],
         file="../../../devo/gdb/testsuite/gdb.mi/basics.c",
         fullname="/home/foo/bar/devo/gdb/testsuite/gdb.mi/basics.c",line="18"}
(gdb)

Listing breakpoints and watchpoints, at different points in the program execution. Note that once the watchpoint goes out of scope, it is deleted.

(gdb)
-break-watch C
  ^done,wpt={number="2",exp="C"}
(gdb)
-break-list
  ^done,BreakpointTable={nr_rows="2",nr_cols="6",
    hdr=[{width="3",alignment="-1",col_name="number",colhdr="Num"},
      {width="14",alignment="-1",col_name="type",colhdr="Type"},
      {width="4",alignment="-1",col_name="disp",colhdr="Disp"},
      {width="3",alignment="-1",col_name="enabled",colhdr="Enb"},
      {width="10",alignment="-1",col_name="addr",colhdr="Address"},
      {width="40",alignment="2",col_name="what",colhdr="What"}],
    body=[{bkpt={number="1",type="breakpoint",disp="keep",enabled="y",
                   addr="0x00010734",func="callee4",
                   file="../../../devo/gdb/testsuite/gdb.mi/basics.c",
                   fullname="/home/foo/devo/gdb/testsuite/gdb.mi/basics.c",line="8",thread-groups=["i1"],
                   times="1"},
      bkpt={number="2",type="watchpoint",disp="keep",
             enabled="y",addr="",what="C",thread-groups=["i1"],times="0"}]}(gdb)
-exec-continue
^running
(gdb)
*stopped,reason="watchpoint-trigger",wpt={number="2",exp="C"},
  value={old="-276895068",new="3"},
  frame={func="callee4",args=[],
  file="/home/foo/bar/devo/gdb/testsuite/gdb.mi/basics.c",
  fullname="/home/foo/bar/devo/gdb/testsuite/gdb.mi/basics.c",line="13"}
(gdb)
-break-list
^done,BreakpointTable={nr_rows="2",nr_cols="6",
  hdr=[{width="3",alignment="-1",col_name="number",colhdr="Num"},
    {width="14",alignment="-1",col_name="type",colhdr="Type"},
    {width="4",alignment="-1",col_name="disp",colhdr="Disp"},
    {width="3",alignment="-1",col_name="enabled",colhdr="Enb"},
    {width="10",alignment="-1",col_name="addr",colhdr="Address"},
    {width="40",alignment="2",col_name="what",colhdr="What"}],
  body=[bkpt={number="1",type="breakpoint",disp="keep",enabled="y",
    addr="0x0010734",func="callee4",
    file="/home/foo/bar/devo/gdb/testsuite/gdb.mi/basics.c",
    fullname="/home/foo/bar/devo/gdb/testsuite/gdb.mi/basics.c",line="8",thread-groups=['i1'],times="1"},
    bkpt={number="2",type="watchpoint",disp="keep",enabled="y",
      addr="",what="C",thread-groups=['i1'],times="-5"}]
(gdb)
-break-list
^done,BreakpointTable={nr_rows="1",nr_cols="6",
  hdr=[{width="3",alignment="-1",col_name="number",colhdr="Num"},
    {width="14",alignment="-1",col_name="type",colhdr="Type"},
    {width="4",alignment="-1",col_name="disp",colhdr="Disp"},
    {width="3",alignment="-1",col_name="enabled",colhdr="Enb"},
    {width="10",alignment="-1",col_name="addr",colhdr="Address"},
    {width="40",alignment="2",col_name="what",colhdr="What"}],
  body=[bkpt={number="1",type="breakpoint",disp="keep",enabled="y",
    addr="0x0010734",func="callee4",
    file="/home/foo/bar/devo/gdb/testsuite/gdb.mi/basics.c",
    fullname="/home/foo/bar/devo/gdb/testsuite/gdb.mi/basics.c",line="18"}]
(gdb)
-break-list
^done,BreakpointTable={nr_rows="1",nr_cols="6",
  hdr=[{width="3",alignment="-1",col_name="number",colhdr="Num"},
    {width="14",alignment="-1",col_name="type",colhdr="Type"},
    {width="4",alignment="-1",col_name="disp",colhdr="Disp"},
    {width="3",alignment="-1",col_name="enabled",colhdr="Enb"},
    {width="10",alignment="-1",col_name="addr",colhdr="Address"},
    {width="40",alignment="2",col_name="what",colhdr="What"}],
  body=[bkpt={number="1",type="breakpoint",disp="keep",enabled="y",
    addr="0x0010734",func="callee4",
    file="/home/foo/bar/devo/gdb/testsuite/gdb.mi/basics.c",
    fullname="/home/foo/bar/devo/gdb/testsuite/gdb.mi/basics.c",line="18",thread-groups=['i1'],times="1"}]
(gdb)

### 27.11 GDB/MI Catchpoint Commands

This section documents GDB/MI commands for manipulating catchpoints.

#### 27.11.1 Shared Library GDB/MI Catchpoints

The -catch-load Command
Chapter 27: The GDB/MI Interface

Synopsis

-catch-load [-t] [-d] regexp

Add a catchpoint for library load events. If the ‘-t’ option is used, the catchpoint is a temporary one (see Section 5.1.1 [Setting Breakpoints], page 46). If the ‘-d’ option is used, the catchpoint is created in a disabled state. The ‘regexp’ argument is a regular expression used to match the name of the loaded library.

GDB Command

The corresponding GDB command is ‘catch load’.

Example

-catch-load -t foo.so
"done,bkpt={number="1",type="catchpoint",disp="del",enabled="y", what="load of library matching foo.so",catch-type="load",times="0"}
(gdb)

The -catch-unload Command

Synopsis

-catch-unload [-t] [-d] regexp

Add a catchpoint for library unload events. If the ‘-t’ option is used, the catchpoint is a temporary one (see Section 5.1.1 [Setting Breakpoints], page 46). If the ‘-d’ option is used, the catchpoint is created in a disabled state. The ‘regexp’ argument is a regular expression used to match the name of the unloaded library.

GDB Command

The corresponding GDB command is ‘catch unload’.

Example

-catch-unload -d bar.so
"done,bkpt={number="2",type="catchpoint",disp="keep",enabled="n", what="load of library matching bar.so",catch-type="unload",times="0"}
(gdb)

27.11.2 Ada Exception GDB/MI Catchpoints

The following GDB/MI commands can be used to create catchpoints that stop the execution when Ada exceptions are being raised.

The -catch-assert Command

Synopsis

-catch-assert [-c condition] [-d] [-t]

Add a catchpoint for failed Ada assertions.

The possible optional parameters for this command are:

‘-c condition’

Make the catchpoint conditional on condition.
‘-d’  Create a disabled catchpoint.

‘-t’  Create a temporary catchpoint.

**GDB Command**

The corresponding GDB command is ‘catch assert’.

**Example**

```
catch-assert
"done,bkptno="5",bkpt={number="5",type="breakpoint",disp="keep",
enabled="y",addr="0x000000000404888",what="failed Ada assertions",
thread-groups=[],times="0",
original-location="__gnat_debug_raise_assert_failure"}
(gdb)
```

The **-catch-exception Command**

**Synopsis**

```
-c condition
-d
-e exception-name
-t
-u
```

Add a catchpoint stopping when Ada exceptions are raised. By default, the command stops the program when any Ada exception gets raised. But it is also possible, by using some of the optional parameters described below, to create more selective catchpoints.

The possible optional parameters for this command are:

‘-c condition’

Make the catchpoint conditional on condition.

‘-d’  Create a disabled catchpoint.

‘-e exception-name’

Only stop when exception-name is raised. This option cannot be used combined with ‘-u’.

‘-t’  Create a temporary catchpoint.

‘-u’  Stop only when an unhandled exception gets raised. This option cannot be used combined with ‘-e’.

**GDB Command**

The corresponding GDB commands are ‘catch exception’ and ‘catch exception unhandled’.

**Example**

```
catch-exception -e Program_Error
"done,bkptno="4",bkpt={number="4",type="breakpoint",disp="keep",
enabled="y",addr="0x000000000404874",what="Program_Error' Ada exception", thread-groups=[],times="0",
original-location="__gnat_debug_raise_exception"}
(gdb)
```
27.12 GDB/MI Program Context

The \texttt{-exec-arguments} Command

\textbf{Synopsis}

\begin{verbatim}
-exec-arguments args
\end{verbatim}

Set the inferior program arguments, to be used in the next \texttt{-exec-run}.

\textbf{GDB Command}

The corresponding \texttt{gdb} command is \texttt{set args}.

\textbf{Example}

\begin{verbatim}
(gdb)
-exec-arguments -v word
^done
(gdb)
\end{verbatim}

The \texttt{-environment-cd} Command

\textbf{Synopsis}

\begin{verbatim}
-environment-cd pathdir
\end{verbatim}

Set \texttt{gdb}'s working directory.

\textbf{GDB Command}

The corresponding \texttt{gdb} command is \texttt{cd}.

\textbf{Example}

\begin{verbatim}
(gdb)
-environment-cd /kwikemart/marge/ezannoni/flathead-dev/devo/gdb
^done
(gdb)
\end{verbatim}

The \texttt{-environment-directory} Command

\textbf{Synopsis}

\begin{verbatim}
-environment-directory [ -r ] [ pathdir ]+
\end{verbatim}

Add directories \texttt{pathdir} to beginning of search path for source files. If the \texttt{-r} option is used, the search path is reset to the default search path. If directories \texttt{pathdir} are supplied in addition to the \texttt{-r} option, the search path is first reset and then addition occurs as normal. Multiple directories may be specified, separated by blanks. Specifying multiple directories in a single command results in the directories added to the beginning of the search path in the same order they were presented in the command. If blanks are needed as part of a directory name, double-quotes should be used around the name. In the command output, the path will show up separated by the system directory-separator character. The directory-separator character must not be used in any directory name. If no directories are specified, the current search path is displayed.
GDB Command

The corresponding GDB command is ‘dir’.

Example

```
(gdb)
-environment-directory /kwikemart/marge/ezannoni/flathead-dev/devo/gdb
"done,source-path="/kwikemart/marge/ezannoni/flathead-dev/devo/gdb:$cdir:$cwd"
(gdb)
-environment-directory ""
"done,source-path="/kwikemart/marge/ezannoni/flathead-dev/devo/gdb:$cdir:$cwd"
(gdb)
-environment-directory -r /home/jjohnstn/src/gdb /usr/src
"done,source-path="/home/jjohnstn/src/gdb:/usr/src:$cdir:$cwd"
(gdb)
-environment-directory -r
"done,source-path="$cdir:$cwd"
(gdb)
```

The -environment-path Command

Synopsis

```
-environment-path [ -r ] [ pathdir ]+
```

Add directories pathdir to beginning of search path for object files. If the ‘-r’ option is used, the search path is reset to the original search path that existed at gdb start-up. If directories pathdir are supplied in addition to the ‘-r’ option, the search path is first reset and then addition occurs as normal. Multiple directories may be specified, separated by blanks. Specifying multiple directories in a single command results in the directories added to the beginning of the search path in the same order they were presented in the command. If blanks are needed as part of a directory name, double-quotes should be used around the name. In the command output, the path will show up separated by the system directory-separator character. The directory-separator character must not be used in any directory name. If no directories are specified, the current path is displayed.

GDB Command

The corresponding GDB command is ‘path’.

Example

```
(gdb)
-environment-path
"done,path="/usr/bin"
(gdb)
-environment-path /kwikemart/marge/ezannoni/flathead-dev/ppc-eabi/gdb /bin
"done,path="/kwikemart/marge/ezannoni/flathead-dev/ppc-eabi/gdb:/bin:/usr/bin"
(gdb)
-environment-path -r /usr/local/bin
"done,path="/usr/local/bin:/usr/bin"
(gdb)
```

The -environment-pwd Command
Synopsis

- `environment-pwd`
  Show the current working directory.

GDB Command

The corresponding GDB command is ‘pwd’.

Example

```
(gdb)
environment-pwd
"done,cwd="/kwikemart/marge/ezannoni/flathead-dev/devo/gdb"
(gdb)
```

27.13 GDB/MI Thread Commands

The -thread-info Command

Synopsis

- `thread-info [ thread-id ]`
  Reports information about either a specific thread, if the `thread-id` parameter is present, or about all threads. When printing information about all threads, also reports the current thread.

GDB Command

The ‘info thread’ command prints the same information about all threads.

Result

The result is a list of threads. The following attributes are defined for a given thread:

- ‘current’ This field exists only for the current thread. It has the value ‘*’.
- ‘id’ The identifier that GDB uses to refer to the thread.
- ‘target-id’ The identifier that the target uses to refer to the thread.
- ‘details’ Extra information about the thread, in a target-specific format. This field is optional.
- ‘name’ The name of the thread. If the user specified a name using the `thread name` command, then this name is given. Otherwise, if GDB can extract the thread name from the target, then that name is given. If GDB cannot find the thread name, then this field is omitted.
- ‘frame’ The stack frame currently executing in the thread.
- ‘state’ The thread’s state. The ‘state’ field may have the following values:
  - `stopped` The thread is stopped. Frame information is available for stopped threads.
running

The thread is running. There's no frame information for running threads.

'core'

If GDB can find the CPU core on which this thread is running, then this field is the core identifier. This field is optional.

Example

```plaintext
-thread-info
"done,threads=[
    {id="2",target-id="Thread 0xb7e14b90 (LWP 21257)",
      frame={level="0",addr="0xffffe410",func="__kernel_vsyscall",
        args=[]},state="running"},
    {id="1",target-id="Thread 0xb7e156b0 (LWP 21254)",
      frame={level="0",addr="0x0804891f",func="foo",
        args=[{name="i",value="10"}],
        file="/tmp/a.c",fullname="/tmp/a.c",line="158"},
      state="running"}],
  current-thread-id="1"
(gdb)
```

The -thread-list-ids Command

Synopsis

-`thread-list-ids`

Produces a list of the currently known GDB thread ids. At the end of the list it also prints the total number of such threads.

This command is retained for historical reasons, the -`thread-info` command should be used instead.

GDB Command

Part of `info threads` supplies the same information.

Example

```plaintext
(gdb)
-thread-list-ids
"done,thread-ids={thread-id="3",thread-id="2",thread-id="1"},
  current-thread-id="1",number-of-threads="3"
(gdb)
```

The -thread-select Command

Synopsis

-`thread-select threadnum`

Make `threadnum` the current thread. It prints the number of the new current thread, and the topmost frame for that thread.

This command is deprecated in favor of explicitly using the `--thread` option to each command.

GDB Command

The corresponding GDB command is `thread`. 
Example

(gdb)
-exec-next
^running
(gdb)
*stopped, reason="end-stepping-range", thread-id="2", line="187",
file="../../../devo/gdb/testsuite/gdb.threads/linux-dp.c"
(gdb)
-thread-list-ids
^done,
thread-ids={thread-id="3", thread-id="2", thread-id="1"},
number-of-threads="3"
(gdb)
-thread-select 3
^done, new-thread-id="3",
frame={level="0", func="vprintf",
args=[{name="format", value="0x8048e9c "%*s%c %d %c\n"},
{name="arg", value="0x2"}], file="vprintf.c", line="31"}
(gdb)

27.14 GDB/MI Ada Tasking Commands

The -ada-task-info Command

Synopsis

-ada-task-info [ task-id ]

Reports information about either a specific Ada task, if the task-id parameter is present, or about all Ada tasks.

GDB Command

The ‘info tasks’ command prints the same information about all Ada tasks (see Section 15.4.9.6 [Ada Tasks], page 210).

Result

The result is a table of Ada tasks. The following columns are defined for each Ada task:

‘current’ This field exists only for the current thread. It has the value ‘*’.

‘id’ The identifier that GDB uses to refer to the Ada task.

‘task-id’ The identifier that the target uses to refer to the Ada task.

‘thread-id’ The identifier of the thread corresponding to the Ada task.

This field should always exist, as Ada tasks are always implemented on top of a thread. But if GDB cannot find this corresponding thread for any reason, the field is omitted.

‘parent-id’ This field exists only when the task was created by another task. In this case, it provides the ID of the parent task.
Debugging with gdb

```
Example

-ada-task-info
  "done, tasks={nr_rows="3", nr_cols="8",
  hdr= [{width="1", alignment="-1", col_name="current", colhdr=""},
        {width="3", alignment="1", col_name="id", colhdr="ID"},
        {width="9", alignment="1", col_name="task-id", colhdr="TID"},
        {width="4", alignment="1", col_name="thread-id", colhdr=""},
        {width="4", alignment="1", col_name="parent-id", colhdr="P-ID"},
        {width="3", alignment="1", col_name="priority", colhdr="Pri"},
        {width="22",alignment="-1",col_name="state",colhdr="State"},
        {width="1",alignment="2",col_name="name",colhdr="Name"}],
  body=[{current="*",id="1",task-id=" 644010",thread-id="1",priority="48",
      state="Child Termination Wait",name="main_task"}]
```

```
(gdb)
```

27.15 GDB/MI Program Execution

These are the asynchronous commands which generate the out-of-band record `*stopped`. Currently GDB only really executes asynchronously with remote targets and this interaction is mimicked in other cases.

The -exec-continue Command

Synopsis

```
-exec-continue [--reverse] [--all|--thread-group N]
```

Resumes the execution of the inferior program, which will continue to execute until it reaches a debugger stop event. If the `--reverse` option is specified, execution resumes in reverse until it reaches a stop event. Stop events may include:

- breakpoints or watchpoints
- signals or exceptions
- the end of the process (or its beginning under `--reverse`)
- the end or beginning of a replay log if one is being used.

In all-stop mode (see Section 5.5.1 [All-Stop Mode], page 76), may resume only one thread, or all threads, depending on the value of the `scheduler-locking` variable. If `--all` is specified, all threads (in all inferiors) will be resumed. The `--all` option is ignored in all-stop mode. If the `--thread-group` options is specified, then all threads in that thread group are resumed.

GDB Command

The corresponding GDB corresponding is `continue`.

`priority`

The base priority of the task.

`state`

The current state of the task. For a detailed description of the possible states, see Section 15.4.9.6 [Ada Tasks], page 210.

`name`

The name of the task.
Example

```bash
-exec-continue
 ^running
 (gdb)
 @Hello world
 *stopped, reason="breakpoint-hit", disp="keep", bkptno="2", frame=
   {func="foo", args=[], file="hello.c", fullname="/home/foo/bar/hello.c", line="13"}
 (gdb)
```

The -exec-finish Command

Synopsis

```
-exec-finish [--reverse]
```

Resumes the execution of the inferior program until the current function is exited. Displays the results returned by the function. If the ‘--reverse’ option is specified, resumes the reverse execution of the inferior program until the point where current function was called.

GDB Command

The corresponding GDB command is ‘finish’.

Example

Function returning void.

```bash
-exec-finish
 ^running
 (gdb)
 @hello from foo
 *stopped, reason="function-finished", frame={func="main", args=[],
   file="hello.c", fullname="/home/foo/bar/hello.c", line="7"}
 (gdb)
```

Function returning other than void. The name of the internal GDB variable storing the result is printed, together with the value itself.

```bash
-exec-finish
 ^running
 (gdb)
 *stopped, reason="function-finished", frame={addr="0x000107b0", func="foo",
   args={[name="a", value="1"], [name="b", value="9"]},
   file="recursive2.c", fullname="/home/foo/bar/recursive2.c", line="14"},
 gdb-result-var="\$1", return-value="0"
 (gdb)
```

The -exec-interrupt Command

Synopsis

```
-exec-interrupt [--all|--thread-group N]
```

Interrupts the background execution of the target. Note how the token associated with the stop message is the one for the execution command that has been interrupted. The token for the interrupt itself only appears in the ‘^done’ output. If the user is trying to interrupt a non-running program, an error message will be printed.
Note that when asynchronous execution is enabled, this command is asynchronous just like other execution commands. That is, first the ‘^done’ response will be printed, and the target stop will be reported after that using the ‘*stopped’ notification.

In non-stop mode, only the context thread is interrupted by default. All threads (in all inferiors) will be interrupted if the ‘--all’ option is specified. If the ‘--thread-group’ option is specified, all threads in that group will be interrupted.

**GDB Command**

The corresponding GDB command is ‘interrupt’.

**Example**

```
(gdb)
  111-exec-continue
  111"running

(gdb)
  222-exec-interrupt
  222"done

(gdb)
  111*stopped,signal-name="SIGINT",signal-meaning="Interrupt",
  frame={addr="0x00010140",func="foo",args=[],file="try.c",
  fullname="/home/foo/bar/try.c",line="13"}

(gdb)

(gdb)
  -exec-interrupt
  "error,msg="mi_cmd_exec_interrupt: Inferior not executing."

(gdb)
```

**The -exec-jump Command**

**Synopsis**

```
-exec-jump location
```

Resumes execution of the inferior program at the location specified by parameter. See Section 9.2 [Specify Location], page 102, for a description of the different forms of location.

**GDB Command**

The corresponding GDB command is ‘jump’.

**Example**

```
-exec-jump foo.c:10
*running,thread-id="all"
"running
```

**The -exec-next Command**

**Synopsis**

```
-exec-next [--reverse]
```

Resumes execution of the inferior program, stopping when the beginning of the next source line is reached.
If the ‘--reverse’ option is specified, resumes reverse execution of the inferior program, stopping at the beginning of the previous source line. If you issue this command on the first line of a function, it will take you back to the caller of that function, to the source line where the function was called.

**GDB Command**
The corresponding GDB command is ‘next’.

**Example**
```
-exec-next
*running
(gdb)
*stopped,reason="end-stepping-range",line="8",file="hello.c"
(gdb)
```

**The -exec-next-instruction Command**

**Synopsis**
```
-exec-next-instruction [--reverse]
```
Executes one machine instruction. If the instruction is a function call, continues until the function returns. If the program stops at an instruction in the middle of a source line, the address will be printed as well.

If the ‘--reverse’ option is specified, resumes reverse execution of the inferior program, stopping at the previous instruction. If the previously executed instruction was a return from another function, it will continue to execute in reverse until the call to that function (from the current stack frame) is reached.

**GDB Command**
The corresponding GDB command is ‘nexti’.

**Example**
```
(gdb)
-exec-next-instruction
*running

(gdb)
*stopped,reason="end-stepping-range",
addr="0x000100d4",line="5",file="hello.c"
(gdb)
```

**The -exec-return Command**

**Synopsis**
```
-exec-return
```
Makes current function return immediately. Doesn’t execute the inferior. Displays the new current frame.

**GDB Command**
The corresponding GDB command is ‘return’.
Example

(gdb)
200-break-insert callee4
200\done,bkpt={number="1",addr="0x00010734",
file=".../.../devo/gdb testsuite/gdb.mi/basics.c",line="8"}
(gdb)
000-exec-run
000\running
(gdb)
000\stopped,reason="breakpoint-hit",disp="keep",bkptno="1",
frame={func="callee4",args=[],
file=".../.../devo/gdb testsuite/gdb.mi/basics.c",
fullname="/home/foo/bar/devo/gdb testsuite/gdb.mi/basics.c",line="8"}
(gdb)
205-break-delete
205\done
(gdb)
111-exec-return
111\done,frame={level="0",func="callee3",
args={[name="strarg",
value="0x11940 "A string argument.""}],
file=".../.../devo/gdb testsuite/gdb.mi/basics.c",
fullname="/home/foo/bar/devo/gdb testsuite/gdb.mi/basics.c",line="18"}
(gdb)

The \texttt{-exec-run} Command

Synopsis

\texttt{-exec-run [ --all | --thread-group N ] [ --start ]}

Starts execution of the inferior from the beginning. The inferior executes until either a breakpoint is encountered or the program exits. In the latter case the output will include an exit code, if the program has exited exceptionally.

When neither the \texttt{--all} nor the \texttt{--thread-group} option is specified, the current inferior is started. If the \texttt{--thread-group} option is specified, it should refer to a thread group of type \texttt{process}, and that thread group will be started. If the \texttt{--all} option is specified, then all inferiors will be started.

Using the \texttt{--start} option instructs the debugger to stop the execution at the start of the inferior’s main subprogram, following the same behavior as the \texttt{start} command (see Section 4.2 \textit{[Starting]}, page 26).

GDB Command

The corresponding GDB command is \texttt{run}.

Examples

(gdb)
-break-insert main
\done,bkpt={number="1",addr="0x0001072c",file="recursive2.c",line="4"}
(gdb)
-exec-run
\running
(gdb)
\stopped,reason="breakpoint-hit",disp="keep",bkptno="1",

\textit{Debugging with GDB}
Program exited normally:

  (gdb)
  -exec-run
  "running
  (gdb)
  x = 55
  *stopped,reason="exited-normally"
  (gdb)

Program exited exceptionally:

  (gdb)
  -exec-run
  "running
  (gdb)
  x = 55
  *stopped,reason="exited",exit-code="01"
  (gdb)

Another way the program can terminate is if it receives a signal such as SIGINT. In this case, GDB/MI displays this:

  (gdb)
  *stopped,reason="exited-signalled",signal-name="SIGINT",
  signal-meaning="Interrupt"

The -exec-step Command

Synopsis

  -exec-step [--reverse]

  Resumes execution of the inferior program, stopping when the beginning of the next source line is reached, if the next source line is not a function call. If it is, stop at the first instruction of the called function. If the ‘--reverse’ option is specified, resumes reverse execution of the inferior program, stopping at the beginning of the previously executed source line.

GDB Command

The corresponding GDB command is ‘step’.

Example

Stepping into a function:

  -exec-step
  "running
  (gdb)
  *stopped,reason="end-stepping-range",
  frame={func="foo",args=[[name="a",value="10"],
  [name="b",value="0"]],file="recursive2.c",
  fullname="/home/foo/bar/recursive2.c",line="11"}
  (gdb)

Regular stepping:
The -exec-step-instruction Command

Synopsis

-exec-step-instruction [--reverse]

Resumes the inferior which executes one machine instruction. If the ‘--reverse’ option is specified, resumes reverse execution of the inferior program, stopping at the previously executed instruction. The output, once GDB has stopped, will vary depending on whether we have stopped in the middle of a source line or not. In the former case, the address at which the program stopped will be printed as well.

GDB Command

The corresponding GDB command is ‘stepi’.

Example

(gdb)
-exec-step-instruction
'running

(gdb)
*stopped,reason="end-stepping-range",line="14",file="recursive2.c"
(gdb)

The -exec-until Command

Synopsis

-exec-until [ location ]

Executes the inferior until the location specified in the argument is reached. If there is no argument, the inferior executes until a source line greater than the current one is reached. The reason for stopping in this case will be ‘location-reached’.

GDB Command

The corresponding GDB command is ‘until’.

Example

(gdb)
Chapter 27: The GDB/MI Interface

27.16 GDB/MI Stack Manipulation Commands

The -enable-frame-filters Command

-gdb allows Python-based frame filters to affect the output of the MI commands relating to stack traces. As there is no way to implement this in a fully backward-compatible way, a front end must request that this functionality be enabled.

Once enabled, this feature cannot be disabled.

Note that if Python support has not been compiled into gdb, this command will still succeed (and do nothing).

The -stack-info-frame Command

Synopsis

-stack-info-frame

Get info on the selected frame.

GDB Command

The corresponding gdb command is ‘info frame’ or ‘frame’ (without arguments).

Example

(gdb)
-stack-info-frame
"done,frame={level="1",addr="0x0001076c",func="callee3",file="../../../devo/gdb/testsuite/gdb.mi/basics.c",fullname="/home/foo/bar/devo/gdb/testsuite/gdb.mi/basics.c",line="17"}"
(gdb)

The -stack-info-depth Command

Synopsis

-stack-info-depth [ max-depth ]

Return the depth of the stack. If the integer argument max-depth is specified, do not count beyond max-depth frames.

GDB Command

There’s no equivalent gdb command.
Example

For a stack with frame levels 0 through 11:

```gdb
(gdb)
-stack-info-depth
"done,depth="12"
(gdb)
-stack-info-depth 4
"done,depth="4"
(gdb)
-stack-info-depth 12
"done,depth="12"
(gdb)
-stack-info-depth 11
"done,depth="11"
(gdb)
-stack-info-depth 13
"done,depth="12"
(gdb)
```

The `-stack-list-arguments` Command

**Synopsis**

```
-stack-list-arguments [ --no-frame-filters ] [ --skip-unavailable ] print-values
[ low-frame high-frame ]
```

Display a list of the arguments for the frames between `low-frame` and `high-frame` (inclusive). If `low-frame` and `high-frame` are not provided, list the arguments for the whole call stack. If the two arguments are equal, show the single frame at the corresponding level. It is an error if `low-frame` is larger than the actual number of frames. On the other hand, `high-frame` may be larger than the actual number of frames, in which case only existing frames will be returned.

If `print-values` is 0 or `--no-values`, print only the names of the variables; if it is 1 or `--all-values`, print also their values; and if it is 2 or `--simple-values`, print the name, type and value for simple data types, and the name and type for arrays, structures and unions. If the option `--no-frame-filters` is supplied, then Python frame filters will not be executed.

If the `--skip-unavailable` option is specified, arguments that are not available are not listed. Partially available arguments are still displayed, however.

Use of this command to obtain arguments in a single frame is deprecated in favor of the `'-stack-list-variables'` command.

**GDB Command**

GDB does not have an equivalent command. gdbtk has a `gdb_get_args` command which partially overlaps with the functionality of `'-stack-list-arguments'`.

Example

```gdb
(gdb)
-stack-list-frames
"done,
stack=[
frame={level="0",addr="0x00010734",func="callee4",
```
The \texttt{-stack-list-frames} Command

**Synopsis**

\texttt{-stack-list-frames [ \texttt{--no-frame-filters \ low-frame \ high-frame} ]}

List the frames currently on the stack. For each frame it displays the following info:

- **level**: The frame number, 0 being the topmost frame, i.e., the innermost function.
- **addr**: The $pc$ value for that frame.
‘func’    Function name.
‘file’    File name of the source file where the function lives.
‘fullname’    The full file name of the source file where the function lives.
‘line’    Line number corresponding to the $pc$.
‘from’    The shared library where this function is defined. This is only given if the frame’s function is not known.

If invoked without arguments, this command prints a backtrace for the whole stack. If given two integer arguments, it shows the frames whose levels are between the two arguments (inclusive). If the two arguments are equal, it shows the single frame at the corresponding level. It is an error if low-frame is larger than the actual number of frames. On the other hand, high-frame may be larger than the actual number of frames, in which case only existing frames will be returned. If the option --no-frame-filters is supplied, then Python frame filters will not be executed.

GDB Command
The corresponding GDB commands are ‘backtrace’ and ‘where’.

Example
Full stack backtrace:

(gdb)
   stack-list-frames
^done

Show frames between low_frame and high_frame:

(gdb)
The \texttt{-stack-list-locals} Command

**Synopsis**

\texttt{-stack-list-locals [ --no-frame-filters ] [ --skip-unavailable ] print-values}

Display the local variable names for the selected frame. If \textit{print-values} is 0 or \texttt{--no-values}, print only the names of the variables; if it is 1 or \texttt{--all-values}, print also their values; and if it is 2 or \texttt{--simple-values}, print the name, type and value for simple data types, and the name and type for arrays, structures and unions. In this last case, a frontend can immediately display the value of simple data types and create variable objects for other data types when the user wishes to explore their values in more detail. If the option \texttt{--no-frame-filters} is supplied, then Python frame filters will not be executed.

If the \texttt{--skip-unavailable} option is specified, local variables that are not available are not listed. Partially available local variables are still displayed, however.

This command is deprecated in favor of the \texttt{'-stack-list-variables'} command.

**GDB Command**

`info locals` in GDB, `gdb_get_locals` in gdbtk.

**Example**

\begin{verbatim}
(gdb)
-stack-list-locals 0
"done,locals=[name="A",name="B",name="C"]
(gdb)
-stack-list-locals --all-values
"done,locals=[{name="A",value="1"},{name="B",value="2"},
{name="C",value="{1, 2, 3}"}]
-stack-list-locals --simple-values
"done,locals=[{name="A",type="int",value="1"},
{name="B",type="int",value="2"},{name="C",type="int [3]"}]
(gdb)
\end{verbatim}

The \texttt{-stack-list-variables} Command
Synopsis

```
-stack-list-variables [ --no-frame-filters ] [ --skip-unavailable ] print-values
```

Display the names of local variables and function arguments for the selected frame. If `print-values` is 0 or `--no-values`, print only the names of the variables; if it is 1 or `--all-values`, print also their values; and if it is 2 or `--simple-values`, print the name, type and value for simple data types, and the name and type for arrays, structures and unions. If the option `--no-frame-filters` is supplied, then Python frame filters will not be executed.

If the `--skip-unavailable` option is specified, local variables and arguments that are not available are not listed. Partially available arguments and local variables are still displayed, however.

Example

```
(gdb)
-stack-list-variables --thread 1 --frame 0 --all-values
"done,variables=[{name="x",value="11"},{name="s",value="{a = 1, b = 2}"}]
```

The `-stack-select-frame` Command

Synopsis

```
-stack-select-frame framenum
```

Change the selected frame. Select a different frame `framenum` on the stack.

This command is deprecated in favor of passing the `--frame` option to every command.

GDB Command

The corresponding `gdb` commands are `frame`, `up`, `down`, `select-frame`, `up-silent`, and `down-silent`.

Example

```
(gdb)
-stack-select-frame 2
"done
```

27.17 GDB/MI Variable Objects

Introduction to Variable Objects

Variable objects are "object-oriented" MI interface for examining and changing values of expressions. Unlike some other MI interfaces that work with expressions, variable objects are specifically designed for simple and efficient presentation in the frontend. A variable object is identified by string name. When a variable object is created, the frontend specifies the expression for that variable object. The expression can be a simple variable, or it can be an arbitrary complex expression, and can even involve CPU registers. After creating a variable object, the frontend can invoke other variable object operations—for example to obtain or change the value of a variable object, or to change display format.

Variable objects have hierarchical tree structure. Any variable object that corresponds to a composite type, such as structure in C, has a number of child variable objects, for example
corresponding to each element of a structure. A child variable object can itself have children, recursively. Recursion ends when we reach leaf variable objects, which always have built-in types. Child variable objects are created only by explicit request, so if a frontend is not interested in the children of a particular variable object, no child will be created.

For a leaf variable object it is possible to obtain its value as a string, or set the value from a string. String value can be also obtained for a non-leaf variable object, but it’s generally a string that only indicates the type of the object, and does not list its contents. Assignment to a non-leaf variable object is not allowed.

A frontend does not need to read the values of all variable objects each time the program stops. Instead, MI provides an update command that lists all variable objects whose values has changed since the last update operation. This considerably reduces the amount of data that must be transferred to the frontend. As noted above, children variable objects are created on demand, and only leaf variable objects have a real value. As result, gdb will read target memory only for leaf variables that frontend has created.

The automatic update is not always desirable. For example, a frontend might want to keep a value of some expression for future reference, and never update it. For another example, fetching memory is relatively slow for embedded targets, so a frontend might want to disable automatic update for the variables that are either not visible on the screen, or “closed”. This is possible using so called “frozen variable objects”. Such variable objects are never implicitly updated.

Variable objects can be either fixed or floating. For the fixed variable object, the expression is parsed when the variable object is created, including associating identifiers to specific variables. The meaning of expression never changes. For a floating variable object the values of variables whose names appear in the expressions are re-evaluated every time in the context of the current frame. Consider this example:

```c
void do_work(...) {
    struct work_state state;
    if (...) do_work(...);
}
```

If a fixed variable object for the `state` variable is created in this function, and we enter the recursive call, the variable object will report the value of `state` in the top-level `do_work` invocation. On the other hand, a floating variable object will report the value of `state` in the current frame.

If an expression specified when creating a fixed variable object refers to a local variable, the variable object becomes bound to the thread and frame in which the variable object is created. When such variable object is updated, GDB makes sure that the thread/frame combination the variable object is bound to still exists, and re-evaluates the variable object in context of that thread/frame.

The following is the complete set of GDB/MI operations defined to access this functionality:

<table>
<thead>
<tr>
<th>Operation</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>-enable-pretty-printing</td>
<td>enable Python-based pretty-printing</td>
</tr>
</tbody>
</table>
-var-create create a variable object
-var-delete delete the variable object and/or its children
-var-set-format set the display format of this variable
-var-show-format show the display format of this variable
-var-info-num-children tells how many children this object has
-var-list-children return a list of the object’s children
-var-info-type show the type of this variable object
-var-info-expression print parent-relative expression that this variable object represents
-var-info-path-expression print full expression that this variable object represents
-var-show-attributes is this variable editable? does it exist here?
-var-evaluate-expression get the value of this variable
-var-assign set the value of this variable
-var-update update the variable and its children
-var-set-frozen set frozenness attribute
-var-set-update-range set range of children to display on update

In the next subsection we describe each operation in detail and suggest how it can be used.

Description And Use of Operations on Variable Objects

The -enable-pretty-printing Command

-enable-pretty-printing

GDB allows Python-based visualizers to affect the output of the MI variable object commands. However, because there was no way to implement this in a fully backward-compatible way, a front end must request that this functionality be enabled.

Once enabled, this feature cannot be disabled.

Note that if Python support has not been compiled into GDB, this command will still succeed (and do nothing).

This feature is currently (as of GDB 7.0) experimental, and may work differently in future versions of GDB.

The -var-create Command

Synopsis

-var-create {name | "-"}

{frame-addr | "+" | "&"} expression

This operation creates a variable object, which allows the monitoring of a variable, the result of an expression, a memory cell or a CPU register.

The name parameter is the string by which the object can be referenced. It must be unique. If '-' is specified, the varobj system will generate a string “varNNNNNNN” automatically. It will be unique provided that one does not specify name of that format. The command fails if a duplicate name is found.
The frame under which the expression should be evaluated can be specified by `frame-addr`. A `*` indicates that the current frame should be used. A `@` indicates that a floating variable object must be created.

`expression` is any expression valid on the current language set (must not begin with a `*`), or one of the following:
- `*addr`, where `addr` is the address of a memory cell
- `*addr-addr` — a memory address range (TBD)
- `$regname` — a CPU register name

A varobj’s contents may be provided by a Python-based pretty-printer. In this case the varobj is known as a dynamic varobj. Dynamic varobjs have slightly different semantics in some cases. If the `-enable.pretty-printing` command is not sent, then GDB will never create a dynamic varobj. This ensures backward compatibility for existing clients.

**Result**

This operation returns attributes of the newly-created varobj. These are:

- `'name'` The name of the varobj.
- `'numchild'` The number of children of the varobj. This number is not necessarily reliable for a dynamic varobj. Instead, you must examine the `has_more` attribute.
- `'value'` The varobj’s scalar value. For a varobj whose type is some sort of aggregate (e.g., a `struct`), or for a dynamic varobj, this value will not be interesting.
- `'type'` The varobj’s type. This is a string representation of the type, as would be printed by the GDB CLI. If `print object` (see Section 10.8 [Print Settings], page 125) is set to on, the actual (derived) type of the object is shown rather than the declared one.
- `'thread-id'` If a variable object is bound to a specific thread, then this is the thread’s identifier.
- `'has_more'` For a dynamic varobj, this indicates whether there appear to be any children available. For a non-dynamic varobj, this will be 0.
- `'dynamic'` This attribute will be present and have the value ‘1’ if the varobj is a dynamic varobj. If the varobj is not a dynamic varobj, then this attribute will not be present.
- `'displayhint'` A dynamic varobj can supply a display hint to the front end. The value comes directly from the Python pretty-printer object’s `display_hint` method. See Section 23.2.2.5 [Pretty Printing API], page 336.

Typical output will look like this:

```
name="name",numchild="N",type="type",thread-id="M",
has_more="has_more"
```
The \texttt{-var-delete} Command

**Synopsis**

\texttt{-var-delete [ -c ] name}

Deletes a previously created variable object and all of its children. With the \texttt{-c} option, just deletes the children.

Returns an error if the object \textit{name} is not found.

The \texttt{-var-set-format} Command

**Synopsis**

\texttt{-var-set-format name format-spec}

Sets the output format for the value of the object \textit{name} to be \textit{format-spec}.

The syntax for the \textit{format-spec} is as follows:

\begin{verbatim}
format-spec \mapsto \{\text{binary} | \text{decimal} | \text{hexadecimal} | \text{octal} | \text{natural}\}
\end{verbatim}

The natural format is the default format chosen automatically based on the variable type (like decimal for an \texttt{int}, hex for pointers, etc.).

For a variable with children, the format is set only on the variable itself, and the children are not affected.

The \texttt{-var-show-format} Command

**Synopsis**

\texttt{-var-show-format name}

Returns the format used to display the value of the object \textit{name}.

\begin{verbatim}
format \mapsto format-spec
\end{verbatim}

The \texttt{-var-info-num-children} Command

**Synopsis**

\texttt{-var-info-num-children name}

Returns the number of children of a variable object \textit{name}:

\begin{verbatim}
numchild=n
\end{verbatim}

Note that this number is not completely reliable for a dynamic varobj. It will return the current number of children, but more children may be available.

The \texttt{-var-list-children} Command

**Synopsis**

\texttt{-var-list-children [print-values] name [from to]}

Return a list of the children of the specified variable object and create variable objects for them, if they do not already exist. With a single argument or if \textit{print-values} has a value of 0 or \texttt{--no-values}, print only the names of the variables; if \textit{print-values} is 1 or
--all-values, also print their values; and if it is 2 or --simple-values print the name and value for simple data types and just the name for arrays, structures and unions.

from and to, if specified, indicate the range of children to report. If from or to is less than zero, the range is reset and all children will be reported. Otherwise, children starting at from (zero-based) and up to and excluding to will be reported.

If a child range is requested, it will only affect the current call to -var-list-children, but not future calls to -var-update. For this, you must instead use -var-set-update-range. The intent of this approach is to enable a front end to implement any update approach it likes; for example, scrolling a view may cause the front end to request more children with -var-list-children, and then the front end could call -var-set-update-range with a different range to ensure that future updates are restricted to just the visible items.

For each child the following results are returned:

name Name of the variable object created for this child.
exp The expression to be shown to the user by the front end to designate this child. For example this may be the name of a structure member. For a dynamic varobj, this value cannot be used to form an expression. There is no way to do this at all with a dynamic varobj.

For C/C++ structures there are several pseudo children returned to designate access qualifiers. For these pseudo children exp is 'public', 'private', or 'protected'. In this case the type and value are not present.

A dynamic varobj will not report the access qualifying pseudo-children, regardless of the language. This information is not available at all with a dynamic varobj.

numchild Number of children this child has. For a dynamic varobj, this will be 0.
type The type of the child. If 'print object' (see Section 10.8 [Print Settings], page 125) is set to on, the actual (derived) type of the object is shown rather than the declared one.
value If values were requested, this is the value.
thread-id If this variable object is associated with a thread, this is the thread id. Otherwise this result is not present.
frozen If the variable object is frozen, this variable will be present with a value of 1.
displayhint A dynamic varobj can supply a display hint to the front end. The value comes directly from the Python pretty-printer object's display_hint method. See Section 23.2.2.5 [Pretty Printing API], page 336.
dynamic This attribute will be present and have the value ‘1’ if the varobj is a dynamic varobj. If the varobj is not a dynamic varobj, then this attribute will not be present.

The result may have its own attributes:
A dynamic varobj can supply a display hint to the front end. The value comes directly from the Python pretty-printer object's \texttt{display\_hint} method. See Section 23.2.2.5 [Pretty Printing API], page 336.

\texttt{has\_more}

This is an integer attribute which is nonzero if there are children remaining after the end of the selected range.

\textbf{Example}

\begin{verbatim}
(gdb)
-var-list-children n
"done,numchild=n,children=[child={name=name,exp=exp,
    numchild=n,type=type},(repeats N times)]
(gdb)
-var-list-children --all-values n
"done,numchild=n,children=[child={name=name,exp=exp,
    numchild=n,value=value,type=type},(repeats N times)]
\end{verbatim}

\textbf{The -var-info-type Command}

\textbf{Synopsis}

\texttt{-var-info-type name}

Returns the type of the specified variable \texttt{name}. The type is returned as a string in the same format as it is output by the GDB CLI:

\begin{verbatim}
type=typename
\end{verbatim}

\textbf{The -var-info-expression Command}

\textbf{Synopsis}

\texttt{-var-info-expression name}

Returns a string that is suitable for presenting this variable object in user interface. The string is generally not valid expression in the current language, and cannot be evaluated.

For example, if \texttt{a} is an array, and variable object \texttt{A} was created for \texttt{a}, then we'll get this output:

\begin{verbatim}
(gdb) -var-info-expression A.1
"done,lang="C",exp="1"
\end{verbatim}

Here, the value of \texttt{lang} is the language name, which can be found in Section 15.4 [Supported Languages], page 191.

Note that the output of the \texttt{-var-list-children} command also includes those expressions, so the \texttt{-var-info-expression} command is of limited use.

\textbf{The -var-info-path-expression Command}

\textbf{Synopsis}

\texttt{-var-info-path-expression name}

Returns an expression that can be evaluated in the current context and will yield the same value that a variable object has. Compare this with the \texttt{-var-info-expression}
command, which result can be used only for UI presentation. Typical use of the \(-\text{var-info-path-expression}\) command is creating a watchpoint from a variable object.

This command is currently not valid for children of a dynamic varobj, and will give an error when invoked on one.

For example, suppose \(C\) is a \(C++\) class, derived from class \(\text{Base}\), and that the \(\text{Base}\) class has a member called \(m\_size\). Assume a variable \(c\) is has the type of \(C\) and a variable object \(C\) was created for variable \(c\). Then, we'll get this output:

\[
\text{(gdb)} \ -\text{var-info-path-expression} \ C.\text{Base.public.m\_size}
\]

\[
\text{^done,path_expr=((Base)c).m\_size)}
\]

The \(-\text{var-show-attributes}\) Command

Synopsis

\[-\text{var-show-attributes} \ name\]

List attributes of the specified variable object \(name\):

\[
\text{status}=\text{attr} \ \{ ( \ , \text{attr} )* \}
\]

where \(\text{attr}\) is \(\{ \{ \text{editable} \ | \ \text{noneditable} \} \ | \ \text{TBD} \}\).

The \(-\text{var-evaluate-expression}\) Command

Synopsis

\[-\text{var-evaluate-expression} \ [-f \ \text{format-spec}] \ name\]

Evaluates the expression that is represented by the specified variable object and returns its value as a string. The format of the string can be specified with the ‘-f’ option. The possible values of this option are the same as for \(-\text{var-set-format}\) (see [\(-\text{var-set-format}\), page 506]. If the ‘-f’ option is not specified, the current display format will be used. The current display format can be changed using the \(-\text{var-set-format}\) command.

\[
\text{value}=\text{value}
\]

Note that one must invoke \(-\text{var-list-children}\) for a variable before the value of a child variable can be evaluated.

The \(-\text{var-assign}\) Command

Synopsis

\[-\text{var-assign} \ name \ \text{expression}\]

Assigns the value of \(\text{expression}\) to the variable object specified by \(name\). The object must be ‘editable’. If the variable’s value is altered by the assign, the variable will show up in any subsequent \(-\text{var-update}\) list.

Example

\[
\text{(gdb)} \ -\text{var-assign} \ \text{var1} \ 3
\]

\[
\text{^done,value="3"}
\]

\[
\text{(gdb)} \ -\text{var-update} \ *
\]

\[
\text{^done,changelist=[{name="var1",in_scope="true",type_changed="false"}]}\]
\]

\[
\text{(gdb)}
\]
The -var-update Command

Synopsis

-\texttt{\textbf{-var-update}} \texttt{\{print-values\} \{name | "*"\}}

Reevaluate the expressions corresponding to the variable object \texttt{name} and all its direct
and indirect children, and return the list of variable objects whose values have changed;
\texttt{name} must be a root variable object. Here, “changed” means that the result of \texttt{-var-evaluate-expression} before and after the \texttt{-var-update} is different. If \texttt{"*"} is used as the
variable object names, all existing variable objects are updated, except for frozen ones (see
\texttt{-var-set-frozen}, page 511). The option \texttt{print-values} determines whether both names and
values, or just names are printed. The possible values of this option are the same as for
\texttt{-var-list-children} (see \texttt{-var-list-children}, page 506). It is recommended to use the
\texttt{"--all-values"} option, to reduce the number of MI commands needed on each program
stop.

With the \texttt{"*"} parameter, if a variable object is bound to a currently running thread, it
will not be updated, without any diagnostic.

If \texttt{-var-set-update-range} was previously used on a varobj, then only the selected range
of children will be reported.

\texttt{-var-update} reports all the changed varobjs in a tuple named \texttt{changelist}.

Each item in the change list is itself a tuple holding:

\begin{itemize}
  \item \texttt{\textbf{name}} \quad The name of the varobj.
  \item \texttt{\textbf{value}} \quad If values were requested for this update, then this field will be present and will
  hold the value of the varobj.
  \item \texttt{\textbf{in\_scope}} \quad This field is a string which may take one of three values:
    \begin{itemize}
      \item \texttt{\textbf{true}} \quad The variable object’s current value is valid.
      \item \texttt{\textbf{false}} \quad The variable object does not currently hold a valid value but it may
        hold one in the future if its associated expression comes back into
        scope.
      \item \texttt{\textbf{invalid}} \quad The variable object no longer holds a valid value. This can oc-
        cur when the executable file being debugged has changed, either
        through recompilation or by using the GDB file command. The
        front end should normally choose to delete these variable objects.
        In the future new values may be added to this list so the front should be prepared
        for this possibility. See Section 27.6 [GDB/MI Development and Front Ends],
        page 463.
    \end{itemize}
  \item \texttt{\textbf{type\_changed}} \quad This is only present if the varobj is still valid. If the type changed, then this
    will be the string \texttt{\textbf{true}}; otherwise it will be \texttt{\textbf{false}}.
    When a varobj’s type changes, its children are also likely to have become in-
    correct. Therefore, the varobj’s children are automatically deleted when this
\end{itemize}
attribute is ‘true’. Also, the varobj’s update range, when set using the -var-set-update-range command, is unset.

‘new_type’
If the varobj’s type changed, then this field will be present and will hold the new type.

‘new_num_children’
For a dynamic varobj, if the number of children changed, or if the type changed, this will be the new number of children.

The ‘numchild’ field in other varobj responses is generally not valid for a dynamic varobj – it will show the number of children that GDB knows about, but because dynamic varobjs lazily instantiate their children, this will not reflect the number of children which may be available.

The ‘new_num_children’ attribute only reports changes to the number of children known by GDB. This is the only way to detect whether an update has removed children (which necessarily can only happen at the end of the update range).

‘displayhint’
The display hint, if any.

‘has_more’
This is an integer value, which will be 1 if there are more children available outside the varobj’s update range.

‘dynamic’
This attribute will be present and have the value ‘1’ if the varobj is a dynamic varobj. If the varobj is not a dynamic varobj, then this attribute will not be present.

‘new_children’
If new children were added to a dynamic varobj within the selected update range (as set by -var-set-update-range), then they will be listed in this attribute.

Example
(gdb)
-var-assign var1 3
"done,value="3"
(gdb)
-var-update --all-values var1
"done,changelist=[{name="var1",value="3",in_scope="true", type_changed="false"}]
(gdb)

The -var-set-frozen Command

Synopsis
-var-set-frozen name flag

Set the frozenness flag on the variable object name. The flag parameter should be either ‘1’ to make the variable frozen or ‘0’ to make it unfrozen. If a variable object is frozen, then neither itself, nor any of its children, are implicitly updated by -var-update of a parent
variable or by \texttt{-var-update *}. Only \texttt{-var-update} of the variable itself will update its value and values of its children. After a variable object is unfrozen, it is implicitly updated by all subsequent \texttt{-var-update} operations. Unfreezing a variable does not update it, only subsequent \texttt{-var-update} does.

Example

\begin{verbatim}
(gdb)
  -var-set-frozen V 1
  "done
(gdb)
\end{verbatim}

The \texttt{-var-set-update-range} command

Synopsis

\texttt{-var-set-update-range name from to}

Set the range of children to be returned by future invocations of \texttt{-var-update}.

\texttt{from} and \texttt{to} indicate the range of children to report. If \texttt{from} or \texttt{to} is less than zero, the range is reset and all children will be reported. Otherwise, children starting at \texttt{from} (zero-based) and up to and excluding \texttt{to} will be reported.

Example

\begin{verbatim}
(gdb)
  -var-set-update-range V 1 2
  "done
\end{verbatim}

The \texttt{-var-set-visualizer} command

Synopsis

\texttt{-var-set-visualizer name visualizer}

Set a visualizer for the variable object \texttt{name}.

\texttt{visualizer} is the visualizer to use. The special value ‘\texttt{None}’ means to disable any visualizer in use.

If not ‘\texttt{None}’, \texttt{visualizer} must be a Python expression. This expression must evaluate to a callable object which accepts a single argument. \texttt{GDB} will call this object with the value of the varobj \texttt{name} as an argument (this is done so that the same Python pretty-printing code can be used for both the CLI and MI). When called, this object must return an object which conforms to the pretty-printing interface (see Section 23.2.2.5 [Pretty Printing API], page 336).

The pre-defined function \texttt{gdb.default_visualizer} may be used to select a visualizer by following the built-in process (see Section 23.2.2.6 [Selecting Pretty-Printers], page 337). This is done automatically when a varobj is created, and so ordinarily is not needed.

This feature is only available if Python support is enabled. The MI command \texttt{-list-features} (see Section 27.25 [GDB/MI Support Commands], page 534) can be used to check this.
Example
Resetting the visualizer:

```plaintext
(gdb)
-var-set-visualizer V None
"done"
```

Reselecting the default (type-based) visualizer:

```plaintext
(gdb)
-var-set-visualizer V gdb.default_visualizer
"done"
```

Suppose `SomeClass` is a visualizer class. A lambda expression can be used to instantiate this class for a varobj:

```plaintext
(gdb)
-var-set-visualizer V "lambda val: SomeClass()"
"done"
```

27.18 GDB/MI Data Manipulation

This section describes the GDB/MI commands that manipulate data: examine memory and registers, evaluate expressions, etc.

For details about what an addressable memory unit is, see [addressable memory unit], page 123.

The `-data-disassemble` Command

Synopsis

```plaintext
-data-disassemble [ -s start-addr -e end-addr ]
| [ -f filename -l linenum [ -n lines ] ]
-- mode
```

Where:

- `start-addr` is the beginning address (or $pc)
- `end-addr` is the end address
- `filename` is the name of the file to disassemble
- `linenum` is the line number to disassemble around
- `lines` is the number of disassembly lines to be produced. If it is -1, the whole function will be disassembled, in case no `end-addr` is specified. If `end-addr` is specified as a non-zero value, and `lines` is lower than the number of disassembly lines between `start-addr` and `end-addr`, only `lines` lines are displayed; if `lines` is higher than the number of lines between `start-addr` and `end-addr`, only the lines up to `end-addr` are displayed.
- `mode` is one of:
  - 0 disassembly only
• 1 mixed source and disassembly (deprecated)
• 2 disassembly with raw opcodes
• 3 mixed source and disassembly with raw opcodes (deprecated)
• 4 mixed source and disassembly
• 5 mixed source and disassembly with raw opcodes

Modes 1 and 3 are deprecated. The output is “source centric” which hasn’t proved useful in practice. See Section 9.6 [Machine Code], page 108, for a discussion of the difference between /m and /s output of the disassemble command.

Result
The result of the -data-disassemble command will be a list named ‘asm_insns’, the contents of this list depend on the mode used with the -data-disassemble command.

For modes 0 and 2 the ‘asm_insns’ list contains tuples with the following fields:

- **address** The address at which this instruction was disassembled.
- **func-name** The name of the function this instruction is within.
- **offset** The decimal offset in bytes from the start of ‘func-name’.
- **inst** The text disassembly for this ‘address’.
- **opcodes** This field is only present for modes 2, 3 and 5. This contains the raw opcode bytes for the ‘inst’ field.

For modes 1, 3, 4 and 5 the ‘asm_insns’ list contains tuples named ‘src_and_asm_line’, each of which has the following fields:

- **line** The line number within ‘file’.
- **file** The file name from the compilation unit. This might be an absolute file name or a relative file name depending on the compile command used.
- **fullname** Absolute file name of ‘file’. It is converted to a canonical form using the source file search path (see Section 9.5 [Specifying Source Directories], page 105) and after resolving all the symbolic links.
  - If the source file is not found this field will contain the path as present in the debug information.
- **line_asm_insn** This is a list of tuples containing the disassembly for ‘line’ in ‘file’. The fields of each tuple are the same as for -data-disassemble in mode 0 and 2, so ‘address’, ‘func-name’, ‘offset’, ‘inst’, and optionally ‘opcodes’.

  Note that whatever included in the ‘inst’ field, is not manipulated directly by GDB/MI, i.e., it is not possible to adjust its format.

GDB Command
The corresponding GDB command is ‘disassemble’. 
Example

Disassemble from the current value of $pc to $pc + 20:

```plaintext
(gdb)
-data-disassemble -s $pc -e "$pc + 20" -- 0
done,
asm_insns=[
  {address="0x000107c0",func-name="main",offset="4", inst="mov 2, %o0"},
  {address="0x000107c4",func-name="main",offset="8", inst="sethi %hi(0x11800), %o2"},
  {address="0x000107c8",func-name="main",offset="12", inst="or %o2, 0x140, %o1\t! 0x11940 <_lib_version+8>"},
  {address="0x000107cc",func-name="main",offset="16", inst="sethi %hi(0x11800), %o2"},
  {address="0x000107d0",func-name="main",offset="20", inst="or %o2, 0x168, %o4\t! 0x11968 <_lib_version+48>"}]
(gdb)
```

Disassemble the whole main function. Line 32 is part of main.

```plaintext
(gdb)
-data-disassemble -f basics.c -l 32 -- 0
done,asm_insns=[
  {address="0x000107bc",func-name="main",offset="0", inst="save %sp, -112, %sp"},
  {address="0x000107c0",func-name="main",offset="4", inst="mov 2, %o0"},
  {address="0x000107c4",func-name="main",offset="8", inst="sethi %hi(0x11800), %o2"},
  [...]
  {address="0x0001081c",func-name="main",offset="96",inst="ret ",
    {address="0x00010820",func-name="main",offset="100",inst="restore "}]
(gdb)
```

Disassemble 3 instructions from the start of main:

```plaintext
(gdb)
-data-disassemble -f basics.c -l 32 -n 3 -- 0
done,asm_insns=[
  {address="0x000107bc",func-name="main",offset="0", inst="save %sp, -112, %sp"},
  {address="0x000107c0",func-name="main",offset="4", inst="mov 2, %o0"},
  {address="0x000107c4",func-name="main",offset="8", inst="sethi %hi(0x11800), %o2"}]
(gdb)
```

Disassemble 3 instructions from the start of main in mixed mode:

```plaintext
(gdb)
-data-disassemble -f basics.c -l 32 -n 3 -- 1
done,asm_insns=[
  src_and_asm_line={line="31",
    file="/absolute/path/to/src/gdb/testsuite/gdb.mi/basics.c",
    fullname="/absolute/path/to/src/gdb/testsuite/gdb.mi/basics.c",
    line_asm_insn=[{address="0x000107bc", func-name="main",offset="0",inst="save %sp, -112, %sp"}],
    src_and_asm_line={line="32",
      file="/absolute/path/to/src/gdb/testsuite/gdb.mi/basics.c",
      fullname="/absolute/path/to/src/gdb/testsuite/gdb.mi/basics.c",
      line_asm_insn=[{address="0x000107c0", func-name="main",offset="4",inst="mov 2, %o0"}],
```
The \texttt{-data-evaluate-expression} Command

\textbf{Synopsis}

\texttt{-data-evaluate-expression} \textit{expr}

Evaluate \textit{expr} as an expression. The expression could contain an inferior function call. The function call will execute synchronously. If the expression contains spaces, it must be enclosed in double quotes.

\textbf{GDB Command}

The corresponding \texttt{GDB} commands are \texttt{print}, \texttt{output}, and \texttt{call}. In \texttt{gdbtk} only, there's a corresponding \texttt{gdb_eval} command.

\textbf{Example}

In the following example, the numbers that precede the commands are the tokens described in Section 27.4 [\texttt{GDB/MI Command Syntax}], page 460. Notice how \texttt{GDB/MI} returns the same tokens in its output.

\begin{verbatim}
211-data-evaluate-expression A
211^done,value="1"
(gdb)
311-data-evaluate-expression &A
311^done,value="0xeffe47e"
(gdb)
411-data-evaluate-expression A+3
411^done,value="4"
(gdb)
511-data-evaluate-expression "A + 3"
511^done,value="4"
(gdb)
\end{verbatim}

The \texttt{-data-list-changed-registers} Command

\textbf{Synopsis}

\texttt{-data-list-changed-registers}

Display a list of the registers that have changed.

\textbf{GDB Command}

\texttt{GDB} doesn't have a direct analog for this command; \texttt{gdbtk} has the corresponding command \texttt{gdb_changed_register_list}.

\textbf{Example}

On a PPC MBX board:

\begin{verbatim}
(gdb)
-exec-continue
^running
\end{verbatim}
The **-data-list-register-names** Command

**Synopsis**

```
-data-list-register-names [ ( regno )* ]
```

Show a list of register names for the current target. If no arguments are given, it shows a list of the names of all the registers. If integer numbers are given as arguments, it will print a list of the names of the registers corresponding to the arguments. To ensure consistency between a register name and its number, the output list may include empty register names.

**GDB Command**

GDB does not have a command which corresponds to `'-data-list-register-names'`. In gdbtk there is a corresponding command `gdb_regnames`.

**Example**

For the PPC MBX board:

```
(gdb)
-data-list-register-names
"done,register-names=["r0","r1","r2","r3","r4","r5","r6","r7","r8","r9","r10","r11","r12","r13","r14","r15","r16","r17","r18","r19","r20","r21","r22","r23","r24","r25","r26","r27","r28","r29","r30","r31","f0","f1","f2","f3","f4","f5","f6","f7","f8","f9","f10","f11","f12","f13","f14","f15","f16","f17","f18","f19","f20","f21","f22","f23","f24","f25","f26","f27","f28","f29","f30","f31","",",",",",",","",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",",","]
(gdb)
-data-list-register-names 1 2 3
"done,register-names=["r1","r2","r3"]
(gdb)
```

The **-data-list-register-values** Command

**Synopsis**

```
-data-list-register-values [ --skip-unavailable ] fmt [ ( regno )* ]
```

Display the registers’ contents. The format according to which the registers’ contents are to be returned is given by `fmt`, followed by an optional list of numbers specifying the registers to display. A missing list of numbers indicates that the contents of all the registers must be returned. The `--skip-unavailable` option indicates that only the available registers are to be returned.

Allowed formats for `fmt` are:
GDB Command

The corresponding GDB commands are ‘info reg’, ‘info all-reg’, and (in gdbtk) ‘gdb_fetch_registers’.

Example

For a PPC MBX board (note: line breaks are for readability only, they don’t appear in the actual output):

```
(gdb)
-data-list-register-values r 64 65
"done,register-values=[{number="64",value="0xfe00a300"},
{number="65",value="0x00029002"}]
(gdb)
-data-list-register-values x
"done,register-values=[{number="0",value="0xfe0043c8"},
{number="1",value="0x3fff88"},{number="2",value="0xffffffff"},
{number="3",value="0x0"},{number="4",value="0xa"},
{number="5",value="0x3fff68"},{number="6",value="0x3fff58"},
{number="7",value="0xfe011e98"},{number="8",value="0x2"},
{number="9",value="0xfa202820"},{number="10",value="0xfa202808"},
{number="11",value="0x1"},{number="12",value="0x0"},
{number="13",value="0x4544"},{number="14",value="0xfffff"},
{number="15",value="0xffffffff"},{number="16",value="0xffffffff"},
{number="17",value="0x4fffffff"},{number="18",value="0xffffffff"},
{number="19",value="0xffffffff"},{number="20",value="0xffffffff"},
{number="21",value="0xffffffff"},{number="22",value="0xffffffff"},
{number="23",value="0xffffffff"},{number="24",value="0xffffffff"},
{number="25",value="0xffffffff"},{number="26",value="0xffffffff"},
{number="27",value="0xffffffff"},{number="28",value="0xffffffff"},
{number="29",value="0x0"},{number="30",value="0x0"},
{number="31",value="0x0"},{number="32",value="0x0"},
{number="33",value="0x0"},{number="34",value="0x0"},
{number="35",value="0x0"},{number="36",value="0x0"},
{number="37",value="0x0"},{number="38",value="0x0"},
{number="39",value="0x0"},{number="40",value="0x0"},
{number="41",value="0x0"},{number="42",value="0x0"},
{number="43",value="0x0"},{number="44",value="0x0"},
{number="45",value="0x0"},{number="46",value="0x0"},
{number="47",value="0x0"},{number="48",value="0x0"},
{number="49",value="0x0"},{number="50",value="0x0"},
{number="51",value="0x0"},{number="52",value="0x0"},
{number="53",value="0x0"},{number="54",value="0x0"},
{number="55",value="0x0"},{number="56",value="0x0"},
{number="57",value="0x0"},{number="58",value="0x0"},
{number="59",value="0x0"},{number="60",value="0x0"},
{number="61",value="0x0"},{number="62",value="0x0"},
```
The \textit{-data-read-memory} Command

This command is deprecated, use \textit{-data-read-memory-bytes} instead.

**Synopsis**

\texttt{-data-read-memory [-o byte-offset] \\
address word-format word-size \\
nr-rows nr-cols [aschar]}

where:

- `address` An expression specifying the address of the first memory word to be read. Complex expressions containing embedded white space should be quoted using the C convention.

- `word-format` The format to be used to print the memory words. The notation is the same as for \texttt{gdb}'s \texttt{print} command (see Section 10.5 [Output Formats], page 120).

- `word-size` The size of each memory word in bytes.

- `nr-rows` The number of rows in the output table.

- `nr-cols` The number of columns in the output table.

- `aschar` If present, indicates that each row should include an ASCII dump. The value of `aschar` is used as a padding character when a byte is not a member of the printable ASCII character set (printable ASCII characters are those whose code is between 32 and 126, inclusively).

- `byte-offset` An offset to add to the `address` before fetching memory.

This command displays memory contents as a table of `nr-rows` by `nr-cols` words, each word being `word-size` bytes. In total, `nr-rows \times nr-cols \times word-size` bytes are read (returned as `total-bytes`). Should less than the requested number of bytes be returned by the target, the missing words are identified using ‘N/A’. The number of bytes read from the target is returned in `nr-bytes` and the starting address used to read memory in `addr`.

The address of the next/previous row or page is available in `next-row` and `prev-row`, `next-page` and `prev-page`.

**GDB Command**

The corresponding \texttt{GDB} command is ‘\texttt{x}’. \texttt{gdbtk} has ‘\texttt{gdb_get_mem}’ memory read command.

**Example**

Read six bytes of memory starting at `bytes+6` but then offset by `-6` bytes. Format as three rows of two columns. One byte per word. Display each word in hex.
The \texttt{-data-read-memory-bytes} Command

**Synopsis**

\texttt{-data-read-memory-bytes [ -o \textit{offset} ] address count}

where:

\texttt{address}  An expression specifying the address of the first addressable memory unit to be read. Complex expressions containing embedded white space should be quoted using the C convention.

\texttt{count} The number of addressable memory units to read. This should be an integer literal.

\texttt{offset} The offset relative to \textit{address} at which to start reading. This should be an integer literal. This option is provided so that a frontend is not required to first evaluate address and then perform address arithmetics itself.

This command attempts to read all accessible memory regions in the specified range. First, all regions marked as unreadable in the memory map (if one is defined) will be skipped.
See Section 10.17 [Memory Region Attributes], page 146. Second, GDB will attempt to read the remaining regions. For each one, if reading full region results in errors, GDB will try to read a subset of the region.

In general, every single memory unit in the region may be readable or not, and the only way to read every readable unit is to try a read at every address, which is not practical. Therefore, GDB will attempt to read all accessible memory units at either beginning or the end of the region, using a binary division scheme. This heuristic works well for reading across a memory map boundary. Note that if a region has a readable range that is neither at the beginning or the end, GDB will not read it.

The result record (see Section 27.7.1 [GDB/MI Result Records], page 464) that is output of the command includes a field named ‘memory’ whose content is a list of tuples. Each tuple represents a successfully read memory block and has the following fields:

- `begin`: The start address of the memory block, as hexadecimal literal.
- `end`: The end address of the memory block, as hexadecimal literal.
- `offset`: The offset of the memory block, as hexadecimal literal, relative to the start address passed to `-data-read-memory-bytes`.
- `contents`: The contents of the memory block, in hex.

**GDB Command**

The corresponding GDB command is ‘x’.

**Example**

```bash
(gdb)
-data-read-memory-bytes &a 10
"done,memory=[{(begin="0xbffff154",offset="0x00000000", end="0xbffff15e", contents="01000000020000000300")}]
```

**The -data-write-memory-bytes Command**

**Synopsis**

```
-data-write-memory-bytes address contents
-data-write-memory-bytes address contents [count]
```

where:

- ‘address’ An expression specifying the address of the first addressable memory unit to be written. Complex expressions containing embedded white space should be quoted using the C convention.

- ‘contents’ The hex-encoded data to write. It is an error if contents does not represent an integral number of addressable memory units.

- ‘count’ Optional argument indicating the number of addressable memory units to be written. If count is greater than contents’ length, GDB will repeatedly write contents until it fills count memory units.
GDB Command
There’s no corresponding GDB command.

Example

```plaintext
(gdb)
-data-write-memory-bytes &a "aabbcddd"
^done
(gdb)
(gdb)
-data-write-memory-bytes &a "aabbcddd" 16e
^done
(gdb)
```

27.19 GDB/MI Tracepoint Commands
The commands defined in this section implement MI support for tracepoints. For detailed introduction, see Chapter 13 [Tracepoints], page 163.

The -trace-find Command

Synopsis

```
-trace-find mode [parameters...]
```

Find a trace frame using criteria defined by mode and parameters. The following table lists permissible modes and their parameters. For details of operation, see Section 13.2.1 [tfind], page 175.

‘none’ No parameters are required. Stops examining trace frames.

‘frame-number’ An integer is required as parameter. Selects tracepoint frame with that index.

‘tracepoint-number’ An integer is required as parameter. Finds next trace frame that corresponds to tracepoint with the specified number.

‘pc’ An address is required as parameter. Finds next trace frame that corresponds to any tracepoint at the specified address.

‘pc-inside-range’ Two addresses are required as parameters. Finds next trace frame that corresponds to a tracepoint at an address inside the specified range. Both bounds are considered to be inside the range.

‘pc-outside-range’ Two addresses are required as parameters. Finds next trace frame that corresponds to a tracepoint at an address outside the specified range. Both bounds are considered to be inside the range.

‘line’ Line specification is required as parameter. See Section 9.2 [Specify Location], page 102. Finds next trace frame that corresponds to a tracepoint at the specified location.
If ‘none’ was passed as mode, the response does not have fields. Otherwise, the response may have the following fields:

‘found’ This field has either ‘0’ or ‘1’ as the value, depending on whether a matching tracepoint was found.

‘traceframe’ The index of the found traceframe. This field is present iff the ‘found’ field has value of ‘1’.

‘tracepoint’ The index of the found tracepoint. This field is present iff the ‘found’ field has value of ‘1’.

‘frame’ The information about the frame corresponding to the found trace frame. This field is present only if a trace frame was found. See Section 27.7.5 [GDB/MI Frame Information], page 470, for description of this field.

**GDB Command**

The corresponding GDB command is ‘tfind’.

\textbf{-trace-define-variable}

**Synopsis**

\texttt{--trace-define-variable name [ value ]}

Create trace variable \texttt{name} if it does not exist. If \texttt{value} is specified, sets the initial value of the specified trace variable to that value. Note that the \texttt{name} should start with the ‘$’ character.

**GDB Command**

The corresponding GDB command is ‘tvariable’.

**The -trace-frame-collected Command**

**Synopsis**

\texttt{--trace-frame-collected}

\texttt{[--var-print-values var_pval]}

\texttt{[--comp-print-values comp_pval]}

\texttt{[--registers-format regformat]}

\texttt{[--memory-contents]}

This command returns the set of collected objects, register names, trace state variable names, memory ranges and computed expressions that have been collected at a particular trace frame. The optional parameters to the command affect the output format in different ways. See the output description table below for more details.

The reported names can be used in the normal manner to create varobjs and inspect the objects themselves. The items returned by this command are categorized so that it is clear which is a variable, which is a register, which is a trace state variable, which is a memory range and which is a computed expression.

For instance, if the actions were
524 Debugging with gdb

collect myVar, myArray[myIndex], myObj.field, myPtr->field, myCount + 2
collect *(int*)0xaf02bef0@40

the object collected in its entirety would be myVar. The object myArray would be partially
collected, because only the element at index myIndex would be collected. The remaining
objects would be computed expressions.

An example output would be:

(gdb)
-trace-frame-collected
done,
xexplicit-variables=[{name="myVar",value="1"}],
xcomputed-expressions=[{name="myArray[myIndex]",value="0"},
{name="myObj.field",value="0"},
{name="myPtr->field",value="1"},
{name="myCount + 2",value="3"},
{name="$tvar1 + 1",value="43970027"}],
registers=[{number="0",value="0x7fe2c6e79ec8"},
{number="1",value="0x0"},
{number="2",value="0x4"},
...
{number="125",value="0x0"}],
tvars=[{name="$tvar1",current="43970026"}],
memory=[{address="0x00000000602264",length="4"},
{address="0x00000000615bc0",length="4"}]
(gdb)

Where:

explicit-variables

The set of objects that have been collected in their entirety (as opposed to
collecting just a few elements of an array or a few struct members). For each
object, its name and value are printed. The --var-print-values option affects
how or whether the value field is output. If var pval is 0, then print only the
names; if it is 1, print also their values; and if it is 2, print the name, type and
value for simple data types, and the name and type for arrays, structures and
unions.

computed-expressions

The set of computed expressions that have been collected at the current trace
frame. The --comp-print-values option affects this set like the --var-print-
values option affects the explicit-variables set. See above.

registers

The registers that have been collected at the current trace frame. For each reg-
ister collected, the name and current value are returned. The value is formatted
according to the --registers-format option. See the -data-list-register-
values command for a list of the allowed formats. The default is ‘x’.

tvars

The trace state variables that have been collected at the current trace frame.
For each trace state variable collected, the name and current value are returned.

memory

The set of memory ranges that have been collected at the current trace frame.
Its content is a list of tuples. Each tuple represents a collected memory range
and has the following fields:
### Chapter 27: The gdb/mi Interface

**address**  The start address of the memory range, as hexadecimal literal.

**length**  The length of the memory range, as decimal literal.

**contents**  The contents of the memory block, in hex. This field is only present if the **--memory-contents** option is specified.

### GDB Command

There is no corresponding GDB command.

### Example

- **-trace-list-variables**

### Synopsis

- **-trace-list-variables**

  Return a table of all defined trace variables. Each element of the table has the following fields:

  - **name**  The name of the trace variable. This field is always present.
  - **initial**  The initial value. This is a 64-bit signed integer. This field is always present.
  - **current**  The value the trace variable has at the moment. This is a 64-bit signed integer. This field is absent iff current value is not defined, for example if the trace was never run, or is presently running.

### GDB Command

The corresponding GDB command is `tvariables`.

### Example

(gdb)

```
-trace-list-variables
```

```
"done,trace-variables={nr_rows="1",nr_cols="3",
hdr=[[width="15",alignment="-1",col_name="name",colhdr="Name"],
 {width="11",alignment="-1",col_name="initial",colhdr="Initial"}],
 {width="11",alignment="-1",col_name="current",colhdr="Current"}],
body=[variable={name="$trace_timestamp",initial="0"}
 {variable={name="$foo",initial="10",current="15"}}]
```

(gdb)

### -trace-save

### Synopsis

- **-trace-save [-r ] filename**

  Saves the collected trace data to `filename`. Without the `-r` option, the data is downloaded from the target and saved in a local file. With the `-r` option the target is asked to perform the save.

### GDB Command

The corresponding GDB command is `tsave`. 
-trace-start

Synopsis

-trace-start

Starts a tracing experiment. The result of this command does not have any fields.

GDB Command

The corresponding GDB command is `tstart`.

-trace-status

Synopsis

-trace-status

Obtains the status of a tracing experiment. The result may include the following fields:

'supported'

May have a value of either ‘0’, when no tracing operations are supported, ‘1’, when all tracing operations are supported, or ‘file’ when examining trace file. In the latter case, examining of trace frame is possible but new tracing experiment cannot be started. This field is always present.

'running'

May have a value of either ‘0’ or ‘1’ depending on whether tracing experiment is in progress on target. This field is present if `supported` field is not ‘0’.

'stop-reason'

Report the reason why the tracing was stopped last time. This field may be absent iff tracing was never stopped on target yet. The value of `request` means the tracing was stopped as result of the -trace-stop command. The value of `overflow` means the tracing buffer is full. The value of `disconnection` means tracing was automatically stopped when GDB has disconnected. The value of `passcount` means tracing was stopped when a tracepoint was passed a maximal number of times for that tracepoint. This field is present if `supported` field is not ‘0’.

'stopping-tracepoint'

The number of tracepoint whose passcount as exceeded. This field is present iff the `stop-reason` field has the value of `passcount`.

'frames'

'frames-created'

The `frames` field is a count of the total number of trace frames in the trace buffer, while `frames-created` is the total created during the run, including ones that were discarded, such as when a circular trace buffer filled up. Both fields are optional.

'buffer-size'

'buffer-free'

These fields tell the current size of the tracing buffer and the remaining space. These fields are optional.
'circular'
The value of the circular trace buffer flag. 1 means that the trace buffer is circular and old trace frames will be discarded if necessary to make room, 0 means that the trace buffer is linear and may fill up.

'disconnected'
The value of the disconnected tracing flag. 1 means that tracing will continue after GDB disconnects, 0 means that the trace run will stop.

'trace-file'
The filename of the trace file being examined. This field is optional, and only present when examining a trace file.

GDB Command
The corresponding GDB command is ‘tstatus’.

-trace-stop

Synopsis

-trace-stop

Stops a tracing experiment. The result of this command has the same fields as -trace-status, except that the 'supported' and 'running' fields are not output.

GDB Command
The corresponding GDB command is ‘tstop’.

27.20 GDB/MI Symbol Query Commands

The -symbol-list-lines Command

Synopsis

-symbol-list-lines filename

Print the list of lines that contain code and their associated program addresses for the given source filename. The entries are sorted in ascending PC order.

GDB Command
There is no corresponding GDB command.

Example

(gdb)
-symbol-list-lines basics.c
"done,lines=[{pc="0x08048554",line="7"},{pc="0x0804855a",line="8"}]
(gdb)

27.21 GDB/MI File Commands

This section describes the GDB/MI commands to specify executable file names and to read in and obtain symbol table information.
The `-file-exec-and-symbols` Command

**Synopsis**

```
-file-exec-and-symbols file
```

Specify the executable file to be debugged. This file is the one from which the symbol table is also read. If no file is specified, the command clears the executable and symbol information. If breakpoints are set when using this command with no arguments, GDB will produce error messages. Otherwise, no output is produced, except a completion notification.

**GDB Command**

The corresponding GDB command is `file`.

**Example**

```
(gdb)
-file-exec-and-symbols /kwikemart/marge/ezannoni/TRUNK/mbx/hello.mbx
^done
(gdb)
```

The `-file-exec-file` Command

**Synopsis**

```
-file-exec-file file
```

Specify the executable file to be debugged. Unlike `-file-exec-and-symbols`, the symbol table is not read from this file. If used without argument, GDB clears the information about the executable file. No output is produced, except a completion notification.

**GDB Command**

The corresponding GDB command is `exec-file`.

**Example**

```
(gdb)
-file-exec-file /kwikemart/marge/ezannoni/TRUNK/mbx/hello.mbx
^done
(gdb)
```

The `-file-list-exec-source-file` Command

**Synopsis**

```
-file-list-exec-source-file
```

List the line number, the current source file, and the absolute path to the current source file for the current executable. The macro information field has a value of `1` or `0` depending on whether or not the file includes preprocessor macro information.

**GDB Command**

The GDB equivalent is `info source`
Example

(gdb)
123-file-list-exec-source-file
123^done, line="1", file="foo.c", fullname="/home/bar/foo.c", macro-info="1"
(gdb)

The -file-list-exec-source-files Command

Synopsis

-file-list-exec-source-files
List the source files for the current executable.

It will always output both the filename and fullname (absolute file name) of a source file.

GDB Command

The GDB equivalent is `info sources`. gdbtk has an analogous command `gdb_listfiles`.

Example

(gdb)
-file-list-exec-source-files
^done, files=[
{file=foo.c,fullname="/home/foo.c"},
{file=/home/bar.c,fullname="/home/bar.c"},
{file=gdb_could_not_find_fullpath.c}]
(gdb)

The -file-symbol-file Command

Synopsis

-file-symbol-file file
Read symbol table info from the specified file argument. When used without arguments, clears GDB’s symbol table info. No output is produced, except for a completion notification.

GDB Command

The corresponding GDB command is `symbol-file`.

Example

(gdb)
-file-symbol-file /kwikemart/marge/ezannoni/TRUNK/mbx/hello.mbx
^done
(gdb)

27.22 GDB/MI Target Manipulation Commands

The -target-attach Command

Synopsis

-target-attach pid | gid | file
Attach to a process *pid* or a file *file* outside of GDB, or a thread group *gid*. If attaching to a thread group, the id previously returned by `-list-thread-groups --available` must be used.

**GDB Command**

The corresponding GDB command is `attach`.

**Example**

```gdb
(gdb)
-target-attach 34
=thread-created,id="1"
*stopped,thread-id="1",frame={addr="0xb7f7e410",func="bar",args=[]}
^done
(gdb)
```

**The -target-detach Command**

**Synopsis**

```
-target-detach [ pid | gid ]
```

Detach from the remote target which normally resumes its execution. If either *pid* or *gid* is specified, detaches from either the specified process, or specified thread group. There's no output.

**GDB Command**

The corresponding GDB command is `detach`.

**Example**

```gdb
(gdb)
-target-detach
^done
(gdb)
```

**The -target-disconnect Command**

**Synopsis**

```
-target-disconnect
```

Disconnect from the remote target. There's no output and the target is generally not resumed.

**GDB Command**

The corresponding GDB command is `disconnect`.

**Example**

```gdb
(gdb)
-target-disconnect
^done
(gdb)
```

**The -target-download Command**
Synopsis
-\texttt{target-download}

Loads the executable onto the remote target. It prints out an update message every half second, which includes the fields:

- \texttt{section} The name of the section.
- \texttt{section-sent} The size of what has been sent so far for that section.
- \texttt{section-size} The size of the section.
- \texttt{total-sent} The total size of what was sent so far (the current and the previous sections).
- \texttt{total-size} The size of the overall executable to download.

Each message is sent as status record (see Section 27.4.2 [GDB/MI Output Syntax], page 461). In addition, it prints the name and size of the sections, as they are downloaded. These messages include the following fields:

- \texttt{section} The name of the section.
- \texttt{section-size} The size of the section.
- \texttt{total-size} The size of the overall executable to download.

At the end, a summary is printed.

GDB Command
The corresponding GDB command is \texttt{load}.

Example
Note: each status message appears on a single line. Here the messages have been broken down so that they can fit onto a page.

(gdb)
-\texttt{target-download}
 +\texttt{download,\{section=".text",section-size="6668",total-size="9880"\}}
 +\texttt{download,\{section=".text",section-sent="512",section-size="6668",total-sent="512",total-size="9880"\}}
 +\texttt{download,\{section=".text",section-sent="1024",section-size="6668",total-sent="1024",total-size="9880"\}}
 +\texttt{download,\{section=".text",section-sent="1536",section-size="6668",total-sent="1536",total-size="9880"\}}
 +\texttt{download,\{section=".text",section-sent="2048",section-size="6668",total-sent="2048",total-size="9880"\}}
 +\texttt{download,\{section=".text",section-sent="2560",section-size="6668",total-sent="2560",total-size="9880"\}}
 +\texttt{download,\{section=".text",section-sent="3072",section-size="6668",total-sent="3072",total-size="9880"\}}
The `target-select` Command

**Synopsis**

```
-target-select type parameters ...
```

Connect GDB to the remote target. This command takes two args:

`type`  The type of target, for instance `remote`, etc.

`parameters`  Device names, host names and the like. See Section 19.2 [Commands for Managing Targets], page 253, for more details.

The output is a connection notification, followed by the address at which the target program is, in the following form:

```
"connected,addr="address",func="function name", args=[arg list]
```
GDB Command
The corresponding GDB command is ‘target’.

Example
(gdb)
   -target-select remote /dev/ttya
   "connected, addr="0xfe00a300", func="??", args=[]
   (gdb)

27.23 GDB/MI File Transfer Commands

The -target-file-put Command

Synopsis
   -target-file-put hostfile targetfile

Copy file hostfile from the host system (the machine running GDB) to targetfile on the target system.

GDB Command
The corresponding GDB command is ‘remote put’.

Example
(gdb)
   -target-file-put localfile remotefile
   "done
   (gdb)

The -target-file-get Command

Synopsis
   -target-file-get targetfile hostfile

Copy file targetfile from the target system to hostfile on the host system.

GDB Command
The corresponding GDB command is ‘remote get’.

Example
(gdb)
   -target-file-get remotefile localfile
   "done
   (gdb)

The -target-file-delete Command

Synopsis
   -target-file-delete targetfile

Delete targetfile from the target system.
GDB Command
The corresponding GDB command is ‘remote delete’.

Example
(gdb)
-target-file-delete remotefile
done
(gdb)

27.24 Ada Exceptions GDB/MI Commands

The -info-ada-exceptions Command

Synopsis
-info-ada-exceptions [ regexp]
List all Ada exceptions defined within the program being debugged. With a regular expression regexp, only those exceptions whose names match regexp are listed.

GDB Command
The corresponding GDB command is ‘info exceptions’.

Result
The result is a table of Ada exceptions. The following columns are defined for each exception:

‘name’ The name of the exception.

‘address’ The address of the exception.

Example
-info-ada-exceptions aint
done,ada-exceptions=[nr_rows="2",nr_cols="2", hdr=[{width="1",alignment="-1",col_name="name",colhdr="Name"}, {width="1",alignment="-1",col_name="address",colhdr="Address"}], body=[{name="constraint_error",address="0x0000000000613da0"}, {name="const.aint_global_e",address="0x0000000000613b00"}]

Catching Ada Exceptions
The commands describing how to ask GDB to stop when a program raises an exception are described at Section 27.11.2 [Ada Exception GDB/MI Catchpoint Commands], page 483.

27.25 GDB/MI Support Commands
Since new commands and features get regularly added to GDB/MI, some commands are available to help front-ends query the debugger about support for these capabilities. Similarly, it is also possible to query GDB about target support of certain features.

The -info-gdb-mi-command Command
Synopsis

```
-info-gdb-mi-command cmd_name
```

Query support for the GDB/MI command named `cmd_name`.

Note that the dash (`-`) starting all GDB/MI commands is technically not part of the command name (see Section 27.4.1 [GDB/MI Input Syntax], page 461), and thus should be omitted in `cmd_name`. However, for ease of use, this command also accepts the form with the leading dash.

**GDB Command**

There is no corresponding GDB command.

**Result**

The result is a tuple. There is currently only one field:

`exists` This field is equal to "true" if the GDB/MI command exists, "false" otherwise.

**Example**

Here is an example where the GDB/MI command does not exist:

```
-info-gdb-mi-command unsupported-command
"done,command={exists="false"}
```

And here is an example where the GDB/MI command is known to the debugger:

```
-info-gdb-mi-command symbol-list-lines
"done,command={exists="true"}
```

**The -list-features Command**

Returns a list of particular features of the MI protocol that this version of gdb implements. A feature can be a command, or a new field in an output of some command, or even an important bugfix. While a frontend can sometimes detect presence of a feature at runtime, it is easier to perform detection at debugger startup.

The command returns a list of strings, with each string naming an available feature. Each returned string is just a name, it does not have any internal structure. The list of possible feature names is given below.

Example output:

```
(gdb) -list-features
"done,result=["feature1","feature2"]
```

The current list of features is:

`frozen-varobjs`
Indicates support for the `-var-set-frozen` command, as well as possible presence of the `frozen` field in the output of `-varobj-create`.

`pending-breakpoints`
Indicates support for the `-f` option to the `-break-insert` command.

`python`
Indicates Python scripting support, Python-based pretty-printing commands, and possible presence of the `display_hint` field in the output of `-var-list-children`
‘thread-info’
Indicates support for the -thread-info command.

‘data-read-memory-bytes’

‘breakpoint-notifications’
Indicates that changes to breakpoints and breakpoints created via the CLI will be announced via async records.

‘ada-task-info’
Indicates support for the -ada-task-info command.

‘language-option’
Indicates that all GDB/MI commands accept the ‘--language’ option (see Section 27.3.1 [Context management], page 458).

‘info-gdb-mi-command’
Indicates support for the -info-gdb-mi-command command.

‘undefined-command-error-code’
Indicates support for the "undefined-command" error code in error result records, produced when trying to execute an undefined GDB/MI command (see Section 27.7.1 [GDB/MI Result Records], page 464).

‘exec-run-start-option’
Indicates that the -exec-run command supports the ‘--start’ option (see Section 27.15 [GDB/MI Program Execution], page 490).

The -list-target-features Command
Returns a list of particular features that are supported by the target. Those features affect the permitted MI commands, but unlike the features reported by the -list-features command, the features depend on which target GDB is using at the moment. Whenever a target can change, due to commands such as -target-select, -target-attach or -exec-run, the list of target features may change, and the frontend should obtain it again. Example output:

(gdb) -list-target-features
"done,result=["async"]"

The current list of features is:

‘async’ Indicates that the target is capable of asynchronous command execution, which means that GDB will accept further commands while the target is running.

‘reverse’ Indicates that the target is capable of reverse execution. See Chapter 6 [Reverse Execution], page 83, for more information.

27.26 Miscellaneous GDB/MI Commands

The -gdb-exit Command
Synopsis
- `gdb-exit`
  Exit GDB immediately.

GDB Command
Approximately corresponds to ‘quit’.

Example
```
(gdb)
-gdb-exit
^exit
```

The -gdb-set Command

Synopsis
- `gdb-set`
  Set an internal GDB variable.

GDB Command
The corresponding GDB command is ‘set’.

Example
```
(gdb)
-gdb-set $foo=3
^done
```

The -gdb-show Command

Synopsis
- `gdb-show`
  Show the current value of a GDB variable.

GDB Command
The corresponding GDB command is ‘show’.

Example
```
(gdb)
-gdb-show annotate
^done,value="0"
```

The -gdb-version Command

Synopsis
- `gdb-version`
  Show version information for GDB. Used mostly in testing.
GDB Command

The GDB equivalent is `show version`. GDB by default shows this information when you start an interactive session.

Example

```
(gdb)
-gdb-version
"GNU gdb 5.2.1"
"Copyright 2000 Free Software Foundation, Inc.
"GDB is free software, covered by the GNU General Public License, and
"you are welcome to change it and/or distribute copies of it under
"certain conditions.
"Type "show copying" to see the conditions.
"There is absolutely no warranty for GDB. Type "show warranty" for
"details.
"This GDB was configured as
""--host=sparc-sun-solaris2.5.1 --target=ppc-eabi".
"done
(gdb)
```

The `-list-thread-groups` Command

Synopsis

```
-list-thread-groups [ --available ] [ --recurse 1 ] [ group ... ]
```

Lists thread groups (see Section 27.3.3 [Thread groups], page 460). When a single thread group is passed as the argument, lists the children of that group. When several thread group are passed, lists information about those thread groups. Without any parameters, lists information about all top-level thread groups.

Normally, thread groups that are being debugged are reported. With the `--available` option, GDB reports thread groups available on the target.

The output of this command may have either a `threads` result or a `groups` result. The `thread` result has a list of tuples as value, with each tuple describing a thread (see Section 27.7.6 [GDB/MI Thread Information], page 470). The `groups` result has a list of tuples as value, each tuple describing a thread group. If top-level groups are requested (that is, no parameter is passed), or when several groups are passed, the output always has a `groups` result. The format of the `group` result is described below.

To reduce the number of roundtrips it’s possible to list thread groups together with their children, by passing the `--recurse` option and the recursion depth. Presently, only recursion depth of 1 is permitted. If this option is present, then every reported thread group will also include its children, either as `group` or `threads` field.

In general, any combination of option and parameters is permitted, with the following caveats:

- When a single thread group is passed, the output will typically be the `threads` result. Because threads may not contain anything, the `recurse` option will be ignored.
- When the `--available` option is passed, limited information may be available. In particular, the list of threads of a process might be inaccessible. Further, specifying specific thread groups might not give any performance advantage over listing all thread
groups. The frontend should assume that ‘-list-thread-groups --available’ is always an expensive operation and cache the results.

The ‘groups’ result is a list of tuples, where each tuple may have the following fields:

- **id**: Identifier of the thread group. This field is always present. The identifier is an opaque string; frontends should not try to convert it to an integer, even though it might look like one.

- **type**: The type of the thread group. At present, only ‘process’ is a valid type.

- **pid**: The target-specific process identifier. This field is only present for thread groups of type ‘process’ and only if the process exists.

- **exit-code**: The exit code of this group’s last exited thread, formatted in octal. This field is only present for thread groups of type ‘process’ and only if the process is not running.

- **num_children**: The number of children this thread group has. This field may be absent for an available thread group.

- **threads**: This field has a list of tuples as value, each tuple describing a thread. It may be present if the ‘--recurse’ option is specified, and it’s actually possible to obtain the threads.

- **cores**: This field is a list of integers, each identifying a core that one thread of the group is running on. This field may be absent if such information is not available.

- **executable**: The name of the executable file that corresponds to this thread group. The field is only present for thread groups of type ‘process’, and only if there is a corresponding executable file.

**Example**

```
gdb
  -list-thread-groups
  "done, groups=[[id="17", type="process", pid="yyy", num_children="2"]]
  -list-thread-groups 17
  "done, threads=[[id="2", target-id="Thread 0xb7e14b90 (LWP 21257)",
                  frame={level="0", addr="0xffffe410", func="_kernel_vsyscall", args=[], state="running"},
                  id="1", target-id="Thread 0xb7e156b0 (LWP 21254)",
                  frame={level="0", addr="0x0804891f", func="foo", args=[{name="i", value="10"}],
                  file="/tmp/a.c", fullname="/tmp/a.c", line="158", state="running"}]]
  -list-thread-groups --available
  "done, groups=[[id="17", type="process", pid="yyy", num_children="2", cores=[1,2]]]
  -list-thread-groups --available --recurse 1
  "done, groups=[[id="17", type="process", pid="yyy", num_children="2", cores=[1,2],
                 threads=[[id="1", target-id="Thread 0xb7e14b90", cores=[1]],
                           {id="2", target-id="Thread 0xb7e14b90", cores=[2]]},...]
  "done, groups=[[id="17", type="process", pid="yyy", num_children="2", cores=[1,2],
                 threads=[[id="1", target-id="Thread 0xb7e14b90", cores=[1]],
                           {id="2", target-id="Thread 0xb7e14b90", cores=[2]]},...]
```

The -info-os Command

Synopsis

    -info-os [ type ]

If no argument is supplied, the command returns a table of available operating-system-specific information types. If one of these types is supplied as an argument type, then the command returns a table of data of that type.

The types of information available depend on the target operating system.

GDB Command

The corresponding GDB command is ‘info os’.

Example

When run on a GNU/Linux system, the output will look something like this:

```plaintext
(gdb)
```

```plaintext
540 Debugging with GDB

The -info-os Command

Synopsis

    -info-os [ type ]

If no argument is supplied, the command returns a table of available operating-system-specific information types. If one of these types is supplied as an argument type, then the command returns a table of data of that type.

The types of information available depend on the target operating system.

GDB Command

The corresponding GDB command is ‘info os’.

Example

When run on a GNU/Linux system, the output will look something like this:

```
gdb
   -info-os
   "done,OSDataTable={nr_rows="10",nr_cols="3",hdr=[{width="10",alignment="-1",col_name="col0",colhdr="Type"},
   {width="10",alignment="-1",col_name="col1",colhdr="Description"},
   {width="10",alignment="-1",col_name="col2",colhdr="Title"}],
   body=[[col0="cpus",col1="Listing of all cpus/cores on the system",col2="CPUs"],
   [col0="files",col1="Listing of all file descriptors",col2="File descriptors"],
   [col0="modules",col1="Listing of all loaded kernel modules",col2="Kernel modules"],
   [col0="msg",col1="Listing of all message queues",col2="Message queues"],
   [col0="processes",col1="Listing of all processes",col2="Processes"],
   [col0="procgroups",col1="Listing of all process groups",col2="Process groups"],
   [col0="semaphores",col1="Listing of all semaphores",col2="Semaphores"],
   [col0="shm",col1="Listing of all shared-memory regions",col2="Shared-memory regions"],
   [col0="sockets",col1="Listing of all internet-domain sockets",col2="Sockets"],
   [col0="threads",col1="Listing of all threads",col2="Threads"]}
   gdb
   -info-os processes
   "done,OSDataTable={nr_rows="190",nr_cols="4",hdr=[{width="10",alignment="-1",col_name="col0",colhdr="pid"},
   {width="10",alignment="-1",col_name="col1",colhdr="user"},
   {width="10",alignment="-1",col_name="col2",colhdr="command"},
   {width="10",alignment="-1",col_name="col3",colhdr="cores"}],
   body=[[col0="1",col1="root",col2="/sbin/init",col3="0"],
   [col0="2",col1="root",col2="[kthread]",col3="1"],
   [col0="3",col1="root",col2="[ksoftirqd/0]",col3="0"],
   ...
   [col0="26446",col1="stan",col2="bash",col3="0"],
   [col0="28152",col1="stan",col2="bash",col3="1"]}
   (gdb)
```
(Note that the MI output here includes a "Title" column that does not appear in command-line info os; this column is useful for MI clients that want to enumerate the types of data, such as in a popup menu, but is needless clutter on the command line, and info os omits it.)

The -add-inferior Command

Synopsis

- add-inferior

Creates a new inferior (see Section 4.9 [Inferiors and Programs], page 33). The created inferior is not associated with any executable. Such association may be established with the `-file-exec-and-symbols' command (see Section 27.21 [GDB/MI File Commands], page 527). The command response has a single field, `inferior', whose value is the identifier of the thread group corresponding to the new inferior.

Example

gdb
    -add-inferior
    "done,inferior="i3"

The -interpreter-exec Command

Synopsis

- interpreter-exec interpreter command

Execute the specified command in the given interpreter.

GDB Command
The corresponding GDB command is `interpreter-exec'.

Example

(gdb)
    -interpreter-exec console "break main"
    "During symbol reading, couldn't parse type; debugger out of date?.
    During symbol reading, bad structure-type format.
    Breakpoint 1 at 0x8074fc6: file ../../src/gdb/main.c, line 743.
    "done
(gdb)

The -inferior-tty-set Command

Synopsis

- inferior-tty-set /dev/pts/1

Set terminal for future runs of the program being debugged.

GDB Command
The corresponding GDB command is `set inferior-tty' /dev/pts/1.
Example

(gdb)
-inferior-tty-set /dev/pts/1
"done
(gdb)

The -inferior-tty-show Command

Synopsis
-inferior-tty-show

Show terminal for future runs of program being debugged.

GDB Command

The corresponding GDB command is ‘show inferior-tty’.

Example

(gdb)
-inferior-tty-set /dev/pts/1
"done
(gdb)
-inferior-tty-show
"done,inferior_tty_terminal="/dev/pts/1"
(gdb)

The -enable-timings Command

Synopsis
-enable-timings [yes | no]

Toggle the printing of the wallclock, user and system times for an MI command as a field in its output. This command is to help frontend developers optimize the performance of their code. No argument is equivalent to ‘yes’.

GDB Command

No equivalent.

Example

(gdb)
-enable-timings
"done
(gdb)
-break-insert main
"done,bkpt={number="1",type="breakpoint",disp="keep",enabled="y",
addr="0x080484ed",func="main",file="myprog.c",
fullname="/home/nickrob/myprog.c",line="73",thread-groups=["i1"],
times="0"},
time={wallclock="0.05185",user="0.00800",system="0.00000"}
(gdb)
-enable-timings no
"done
(gdb)
-exec-run
^running
(gdb)
*stopped,reason="breakpoint-hit",disp="keep",bkptno="1",thread-id="0", frame={addr="0x080484ed",func="main",args=[{name="argc",value="1"}, {name="argv",value="0xbfb60364"}],file="myprog.c", fullname="/home/nickrob/myprog.c",line="73"}
(gdb)
Chapter 28: GDB Annotations

This chapter describes annotations in GDB. Annotations were designed to interface GDB to graphical user interfaces or other similar programs which want to interact with GDB at a relatively high level.

The annotation mechanism has largely been superseded by GDB/MI (see Chapter 27 [GDB/MI], page 457).

### 28.1 What is an Annotation?

Annotations start with a newline character, two `control-z` characters, and the name of the annotation. If there is no additional information associated with this annotation, the name of the annotation is followed immediately by a newline. If there is additional information, the name of the annotation is followed by a space, the additional information, and a newline. The additional information cannot contain newline characters.

Any output not beginning with a newline and two `control-z` characters denotes literal output from GDB. Currently there is no need for GDB to output a newline followed by two `control-z` characters, but if there was such a need, the annotations could be extended with an `escape` annotation which means those three characters as output.

The annotation level, which is specified using the `--annotate` command line option (see Section 2.1.2 [Mode Options], page 13), controls how much information GDB prints together with its prompt, values of expressions, source lines, and other types of output. Level 0 is for no annotations, level 1 is for use when GDB is run as a subprocess of GNU Emacs, level 3 is the maximum annotation suitable for programs that control GDB, and level 2 annotations have been made obsolete (see Section “Limitations of the Annotation Interface” in GDB’s Obsolete Annotations).

`set annotate level`

The GDB command `set annotate` sets the level of annotations to the specified level.

`show annotate`

Show the current annotation level.

This chapter describes level 3 annotations.

A simple example of starting up GDB with annotations is:

```
$ gdb --annotate=3
GNU gdb 6.0
Copyright 2003 Free Software Foundation, Inc.
GDB is free software, covered by the GNU General Public License,
and you are welcome to change it and/or distribute copies of it
under certain conditions.
Type "show copying" to see the conditions.
There is absolutely no warranty for GDB. Type "show warranty"
for details.
This GDB was configured as "i386-pc-linux-gnu"

^Z^Zpre-prompt
(gdb)
^Z^Zprompt
quit
```
Here ‘quit’ is input to GDB; the rest is output from GDB. The three lines beginning ‘^Z’ (where ‘^’ denotes a ‘control-z’ character) are annotations; the rest is output from GDB.

### 28.2 The Server Prefix

If you prefix a command with ‘server’ then it will not affect the command history, nor will it affect GDB’s notion of which command to repeat if RET is pressed on a line by itself. This means that commands can be run behind a user’s back by a front-end in a transparent manner.

The server prefix does not affect the recording of values into the value history; to print a value without recording it into the value history, use the output command instead of the print command.

Using this prefix also disables confirmation requests (see [confirmation requests], page 307).

### 28.3 Annotation for GDB Input

When GDB prompts for input, it annotates this fact so it is possible to know when to send output, when the output from a given command is over, etc.

Different kinds of input each have a different input type. Each input type has three annotations: a pre- annotation, which denotes the beginning of any prompt which is being output, a plain annotation, which denotes the end of the prompt, and then a post- annotation which denotes the end of any echo which may (or may not) be associated with the input. For example, the prompt input type features the following annotations:

```
^Z^Zpre-prompt
^Z^Zprompt
^Z^Zpost-prompt
```

The input types are

- **prompt** When GDB is prompting for a command (the main GDB prompt).
- **commands** When GDB prompts for a set of commands, like in the commands command. The annotations are repeated for each command which is input.
- **overload-choice** When GDB wants the user to select between various overloaded functions.
- **query** When GDB wants the user to confirm a potentially dangerous operation.
- **prompt-for-continue** When GDB is asking the user to press return to continue. Note: Don’t expect this to work well; instead use set height 0 to disable prompting. This is because the counting of lines is buggy in the presence of annotations.
28.4 Errors

`^Z`Zquit

This annotation occurs right before GDB responds to an interrupt.

`^Z`Zerror

This annotation occurs right before GDB responds to an error.

Quit and error annotations indicate that any annotations which GDB was in the middle of may end abruptly. For example, if a `value-history-begin` annotation is followed by a `error`, one cannot expect to receive the matching `value-history-end`. One cannot expect not to receive it either, however; an error annotation does not necessarily mean that GDB is immediately returning all the way to the top level.

A quit or error annotation may be preceded by

`^Z`Zerror-begin

Any output between that and the quit or error annotation is the error message.

Warning messages are not yet annotated.

28.5 Invalidation Notices

The following annotations say that certain pieces of state may have changed.

`^Z`Zframes-invalid

The frames (for example, output from the `backtrace` command) may have changed.

`^Z`Zbreakpoints-invalid

The breakpoints may have changed. For example, the user just added or deleted a breakpoint.

28.6 Running the Program

When the program starts executing due to a GDB command such as `step` or `continue`,

`^Z`Zstarting

is output. When the program stops,

`^Z`Zstopped

is output. Before the `stopped` annotation, a variety of annotations describe how the program stopped.

`^Z`Zexited exit-status

The program exited, and `exit-status` is the exit status (zero for successful exit, otherwise nonzero).

`^Z`Zsignalled

The program exited with a signal. After the `^Z`Zsignalled, the annotation continues:

intro-text
`^Z`Zsignal-name
name
`^Z`Zsignal-name-end
middle-text
`^Z`Zsignal-string
Debugging with GDB

```
string
^Z^Zsignal-string-end
end-text
```

where `name` is the name of the signal, such as SIGILL or SIGSEGV, and `string` is the explanation of the signal, such as Illegal Instruction or Segmentation fault. The arguments `intro-text`, `middle-text`, and `end-text` are for the user's benefit and have no particular format.

```
^Z^Zsignal
The syntax of this annotation is just like signalled, but GDB is just saying that the program received the signal, not that it was terminated with it.
```

```
^Z^Zbreakpoint number
The program hit breakpoint number `number`.
```

```
^Z^Zwatchpoint number
The program hit watchpoint number `number`.
```

28.7 Displaying Source

The following annotation is used instead of displaying source code:

```
^Z^Zsource filename:line:character:middle:addr
```

where `filename` is an absolute file name indicating which source file, `line` is the line number within that file (where 1 is the first line in the file), `character` is the character position within the file (where 0 is the first character in the file) (for most debug formats this will necessarily point to the beginning of a line), `middle` is ‘middle’ if `addr` is in the middle of the line, or ‘beg’ if `addr` is at the beginning of the line, and `addr` is the address in the target program associated with the source which is being displayed. The `addr` is in the form ‘0x’ followed by one or more lowercase hex digits (note that this does not depend on the language).
29 JIT Compilation Interface

This chapter documents GDB’s just-in-time (JIT) compilation interface. A JIT compiler is a program or library that generates native executable code at runtime and executes it, usually in order to achieve good performance while maintaining platform independence.

Programs that use JIT compilation are normally difficult to debug because portions of their code are generated at runtime, instead of being loaded from object files, which is where GDB normally finds the program’s symbols and debug information. In order to debug programs that use JIT compilation, GDB has an interface that allows the program to register in-memory symbol files with GDB at runtime.

If you are using GDB to debug a program that uses this interface, then it should work transparently so long as you have not stripped the binary. If you are developing a JIT compiler, then the interface is documented in the rest of this chapter. At this time, the only known client of this interface is the LLVM JIT.

Broadly speaking, the JIT interface mirrors the dynamic loader interface. The JIT compiler communicates with GDB by writing data into a global variable and calling a function at a well-known symbol. When GDB attaches, it reads a linked list of symbol files from the global variable to find existing code, and puts a breakpoint in the function so that it can find out about additional code.

29.1 JIT Declarations

These are the relevant struct declarations that a C program should include to implement the interface:

```c
typedef enum {
    JIT_NOACTION = 0,
    JIT_REGISTER_FN,
    JIT_UNREGISTER_FN
} jit_actions_t;

struct jit_code_entry {
    struct jit_code_entry *next_entry;
    struct jit_code_entry *prev_entry;
    const char *symfile_addr;
    uint64_t symfile_size;
};

struct jit_descriptor {
    uint32_t version;
    /* This type should be jit_actions_t, but we use uint32_t
     * to be explicit about the bitwidth. */
    uint32_t action_flag;
    struct jit_code_entry *relevant_entry;
    struct jit_code_entry *first_entry;
};

/* GDB puts a breakpoint in this function. */
void __attribute__((noinline)) __jit_debug_register_code() { }
```
/* Make sure to specify the version statically, because the
destructor may check the version before we can set it. */
struct jit_descriptor __jit_debug_descriptor = { 1, 0, 0, 0 };

If the JIT is multi-threaded, then it is important that the JIT synchronize any modifications to this global data properly, which can easily be done by putting a global mutex around modifications to these structures.

29.2 Registering Code

To register code with GDB, the JIT should follow this protocol:

• Generate an object file in memory with symbols and other desired debug information.
  The file must include the virtual addresses of the sections.
• Create a code entry for the file, which gives the start and size of the symbol file.
• Add it to the linked list in the JIT descriptor.
• Point the relevant_entry field of the descriptor at the entry.
• Set action_flag to JIT_REGISTER and call __jit_debug_register_code.

When GDB is attached and the breakpoint fires, GDB uses the relevant_entry pointer so it doesn’t have to walk the list looking for new code. However, the linked list must still be maintained in order to allow GDB to attach to a running process and still find the symbol files.

29.3 Unregistering Code

If code is freed, then the JIT should use the following protocol:

• Remove the code entry corresponding to the code from the linked list.
• Point the relevant_entry field of the descriptor at the code entry.
• Set action_flag to JIT_UNREGISTER and call __jit_debug_register_code.

If the JIT frees or recompiles code without unregistering it, then GDB and the JIT will leak the memory used for the associated symbol files.

29.4 Custom Debug Info

Generating debug information in platform-native file formats (like ELF or COFF) may be an overkill for JIT compilers; especially if all the debug info is used for is displaying a meaningful backtrace. The issue can be resolved by having the JIT writers decide on a debug info format and also provide a reader that parses the debug info generated by the JIT compiler. This section gives a brief overview on writing such a parser. More specific details can be found in the source file ‘gdb/jit-reader.in’, which is also installed as a header at ‘includedir/gdb/jit-reader.h’ for easy inclusion.

The reader is implemented as a shared object (so this functionality is not available on platforms which don’t allow loading shared objects at runtime). Two GDB commands, jit-reader-load and jit-reader-unload are provided, to be used to load and unload the readers from a preconfigured directory. Once loaded, the shared object is used the parse the debug information emitted by the JIT compiler.
29.4.1 Using JIT Debug Info Readers

Readers can be loaded and unloaded using the `jit-reader-load` and `jit-reader-unload` commands.

**jit-reader-load reader**
Load the JIT reader named `reader`, which is a shared object specified as either an absolute or a relative file name. In the latter case, GDB will try to load the reader from a pre-configured directory, usually `libdir/gdb/` on a UNIX system (here `libdir` is the system library directory, often `'/usr/local/lib'`). Only one reader can be active at a time; trying to load a second reader when one is already loaded will result in GDB reporting an error. A new JIT reader can be loaded by first unloading the current one using `jit-reader-unload` and then invoking `jit-reader-load`.

**jit-reader-unload**
Unload the currently loaded JIT reader.

29.4.2 Writing JIT Debug Info Readers

As mentioned, a reader is essentially a shared object conforming to a certain ABI. This ABI is described in `jit-reader.h`.

`jit-reader.h` defines the structures, macros and functions required to write a reader. It is installed (along with GDB), in `includerdir/gdb` where `includerdir` is the system include directory.

Readers need to be released under a GPL compatible license. A reader can be declared as released under such a license by placing the macro `GDB_DECLARE_GPL_COMPATIBLE_READER` in a source file.

The entry point for readers is the symbol `gdb_init_reader`, which is expected to be a function with the prototype

```c
extern struct gdb_reader_funcs *gdb_init_reader (void);
```

`struct gdb_reader_funcs` contains a set of pointers to callback functions. These functions are executed to read the debug info generated by the JIT compiler (`read`), to unwind stack frames (`unwind`) and to create canonical frame IDs (`get_Frame_id`). It also has a callback that is called when the reader is being unloaded (`destroy`). The struct looks like this

```c
struct gdb_reader_funcs
{
    /* Must be set to GDB_READER_INTERFACE_VERSION. */
    int reader_version;

    /* For use by the reader. */
    void *priv_data;

    gdb_read_debug_info *read;
    gdb_unwind_frame *unwind;
    gdb_get_frame_id *get_frame_id;
    gdb_destroy_reader *destroy;
};
```

The callbacks are provided with another set of callbacks by GDB to do their job. For `read`, these callbacks are passed in a `struct gdb_symbol_callbacks` and for `unwind` and
get_frame_id, in a struct gdb_unwind_callbacks. struct gdb_symbol_callbacks has callbacks to create new object files and new symbol tables inside those object files. struct gdb_unwind_callbacks has callbacks to read registers off the current frame and to write out the values of the registers in the previous frame. Both have a callback (target_read) to read bytes off the target’s address space.
30 In-Process Agent

The traditional debugging model is conceptually low-speed, but works fine, because most bugs can be reproduced in debugging-mode execution. However, as multi-core or many-core processors are becoming mainstream, and multi-threaded programs become more and more popular, there should be more and more bugs that only manifest themselves at normal-mode execution, for example, thread races, because debugger’s interference with the program’s timing may conceal the bugs. On the other hand, in some applications, it is not feasible for the debugger to interrupt the program’s execution long enough for the developer to learn anything helpful about its behavior. If the program’s correctness depends on its real-time behavior, delays introduced by a debugger might cause the program to fail, even when the code itself is correct. It is useful to be able to observe the program’s behavior without interrupting it.

Therefore, traditional debugging model is too intrusive to reproduce some bugs. In order to reduce the interference with the program, we can reduce the number of operations performed by debugger. The In-Process Agent, a shared library, is running within the same process with inferior, and is able to perform some debugging operations itself. As a result, debugger is only involved when necessary, and performance of debugging can be improved accordingly. Note that interference with program can be reduced but can’t be removed completely, because the in-process agent will still stop or slow down the program.

The in-process agent can interpret and execute Agent Expressions (see Appendix F [Agent Expressions], page 675) during performing debugging operations. The agent expressions can be used for different purposes, such as collecting data in tracepoints, and condition evaluation in breakpoints.

You can control whether the in-process agent is used as an aid for debugging with the following commands:

```plaintext
set agent on
Causes the in-process agent to perform some operations on behalf of the debugger. Just which operations requested by the user will be done by the in-process agent depends on the its capabilities. For example, if you request to evaluate breakpoint conditions in the in-process agent, and the in-process agent has such capability as well, then breakpoint conditions will be evaluated in the in-process agent.
```

```plaintext
set agent off
Disables execution of debugging operations by the in-process agent. All of the operations will be performed by gdb.
```

```plaintext
show agent
Display the current setting of execution of debugging operations by the in-process agent.
```

30.1 In-Process Agent Protocol

The in-process agent is able to communicate with both gdb and GDBserver (see Chapter 30 [In-Process Agent], page 553). This section documents the protocol used for communications between gdb or GDBserver and the IPA. In general, gdb or GDBserver sends commands
Debugging with gdb

(see Section 30.1.2 [IPA Protocol Commands], page 555) and data to in-process agent, and then in-process agent replies back with the return result of the command, or some other information. The data sent to in-process agent is composed of primitive data types, such as 4-byte or 8-byte type, and composite types, which are called objects (see Section 30.1.1 [IPA Protocol Objects], page 554).

30.1.1 IPA Protocol Objects

The commands sent to and results received from agent may contain some complex data types called objects.

The in-process agent is running on the same machine with gdb or GDBserver, so it doesn’t have to handle as much differences between two ends as remote protocol (see Appendix E [Remote Protocol], page 607) tries to handle. However, there are still some differences of two ends in two processes:

1. word size. On some 64-bit machines, gdb or GDBserver can be compiled as a 64-bit executable, while in-process agent is a 32-bit one.
2. ABI. Some machines may have multiple types of ABI, gdb or GDBserver is compiled with one, and in-process agent is compiled with the other one.

Here are the IPA Protocol Objects:

1. agent expression object. It represents an agent expression (see Appendix F [Agent Expressions], page 675).
2. tracepoint action object. It represents a tracepoint action (see Section 13.1.6 [Tracepoint Action Lists], page 168) to collect registers, memory, static trace data and to evaluate expression.
3. tracepoint object. It represents a tracepoint (see Chapter 13 [Tracepoints], page 163).

The following table describes important attributes of each IPA protocol object:

<table>
<thead>
<tr>
<th>Name</th>
<th>Size</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>agent expression object</td>
<td></td>
<td></td>
</tr>
<tr>
<td>length</td>
<td>4</td>
<td>length of bytes code</td>
</tr>
<tr>
<td>byte code</td>
<td>length</td>
<td>contents of byte code</td>
</tr>
</tbody>
</table>

tracepoint action for collecting memory

<table>
<thead>
<tr>
<th>Name</th>
<th>Size</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>‘M’</td>
<td>1</td>
<td>type of tracepoint action</td>
</tr>
<tr>
<td>addr</td>
<td>8</td>
<td>if basereg is ‘-1’, addr is the address of the lowest byte to collect, otherwise addr is the offset of basereg for memory collecting.</td>
</tr>
<tr>
<td>len</td>
<td>8</td>
<td>length of memory for collecting</td>
</tr>
<tr>
<td>basereg</td>
<td>4</td>
<td>the register number containing the starting memory address for collecting.</td>
</tr>
</tbody>
</table>

tracepoint action for collecting registers

<table>
<thead>
<tr>
<th>Name</th>
<th>Size</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>‘R’</td>
<td>1</td>
<td>type of tracepoint action</td>
</tr>
</tbody>
</table>
tracepoint action for collecting static trace data

'L' 1 type of tracepoint action

tracepoint action for expression evaluation

'X' 1 type of tracepoint action

agent expression length of [agent expression object], page 554

tracepoint object

number 4 number of tracepoint

address 8 address of tracepoint inserted on

type 4 type of tracepoint

enabled 1 enable or disable of tracepoint

step_count 8 step

pass_count 8 pass

numactions 4 number of tracepoint actions

hit count 8 hit count

trace frame usage 8 trace frame usage

compiled_cond 8 compiled condition

orig_size 8 orig size

condition 4 if condition is NULL

otherwise length of [agent expression object], page 554

actions variable numactions number of [tracepoint action object], page 554

30.1.2 IPA Protocol Commands

The spaces in each command are delimiters to ease reading this commands specification. They don’t exist in real commands.

'FastTrace: tracepoint_object gdb_jump_pad_head'

Installs a new fast tracepoint described by tracepoint_object (see [tracepoint object], page 554). The gdb_jump_pad_head, 8-byte long, is the head of jump-pad, which is used to jump to data collection routine in IPA finally.

Replies:

'OK target_address gdb_jump_pad_head fjump_size fjump'

target_address is address of tracepoint in the inferior. The gdb_jump_pad_head is updated head of jump-pad. Both of target_address and gdb_jump_pad_head are 8-byte long. The fjump contains a sequence of instructions jump to jump-pad entry. The fjump_size, 4-byte long, is the size of fjump.

'E NN' for an error
‘close’ Closes the in-process agent. This command is sent when \texttt{gdb} or GDBserver is about to kill inferiors.

‘$\text{qTfSTM}$’ See [qTfSTM], page 649.

‘$\text{qTsSTM}$’ See [qTsSTM], page 649.

‘$\text{qTSTMat}$’ See [qTSTMat], page 650.

‘\texttt{probe\_marker\_at:\ address}$’

Asks in-process agent to probe the marker at \textit{address}.

Replies:

‘$E\ \textit{NN}$’ for an error

‘\texttt{unprobe\_marker\_at:\ address}$’

Asks in-process agent to unprobe the marker at \textit{address}. 
31 Reporting Bugs in GDB

Your bug reports play an essential role in making GDB reliable.

Reporting a bug may help you by bringing a solution to your problem, or it may not. But in any case the principal function of a bug report is to help the entire community by making the next version of GDB work better. Bug reports are your contribution to the maintenance of GDB.

In order for a bug report to serve its purpose, you must include the information that enables us to fix the bug.

31.1 Have You Found a Bug?

If you are not sure whether you have found a bug, here are some guidelines:

- If the debugger gets a fatal signal, for any input whatever, that is a GDB bug. Reliable debuggers never crash.
- If GDB produces an error message for valid input, that is a bug. (Note that if you’re cross debugging, the problem may also be somewhere in the connection to the target.)
- If GDB does not produce an error message for invalid input, that is a bug. However, you should note that your idea of “invalid input” might be our idea of “an extension” or “support for traditional practice”.
- If you are an experienced user of debugging tools, your suggestions for improvement of GDB are welcome in any case.

31.2 How to Report Bugs

A number of companies and individuals offer support for GNU products. If you obtained GDB from a support organization, we recommend you contact that organization first.

You can find contact information for many support companies and individuals in the file ‘etc/SERVICE’ in the GNU Emacs distribution.

In any event, we also recommend that you submit bug reports for GDB. The preferred method is to submit them directly using GDB’s Bugs web page. Alternatively, the e-mail gateway can be used.

Do not send bug reports to ‘info-gdb’, or to ‘help-gdb’, or to any newsgroups. Most users of GDB do not want to receive bug reports. Those that do have arranged to receive ‘bug-gdb’.

The mailing list ‘bug-gdb’ has a newsgroup ‘gnu.gdb.bug’ which serves as a repeater. The mailing list and the newsgroup carry exactly the same messages. Often people think of posting bug reports to the newsgroup instead of mailing them. This appears to work, but it has one problem which can be crucial: a newsgroup posting often lacks a mail path back to the sender. Thus, if we need to ask for more information, we may be unable to reach you. For this reason, it is better to send bug reports to the mailing list.

The fundamental principle of reporting bugs usefully is this: report all the facts. If you are not sure whether to state a fact or leave it out, state it!

Often people omit facts because they think they know what causes the problem and assume that some details do not matter. Thus, you might assume that the name of the
variable you use in an example does not matter. Well, probably it does not, but one cannot be sure. Perhaps the bug is a stray memory reference which happens to fetch from the location where that name is stored in memory; perhaps, if the name were different, the contents of that location would fool the debugger into doing the right thing despite the bug. Play it safe and give a specific, complete example. That is the easiest thing for you to do, and the most helpful.

Keep in mind that the purpose of a bug report is to enable us to fix the bug. It may be that the bug has been reported previously, but neither you nor we can know that unless your bug report is complete and self-contained.

Sometimes people give a few sketchy facts and ask, “Does this ring a bell?” Those bug reports are useless, and we urge everyone to refuse to respond to them except to chide the sender to report bugs properly.

To enable us to fix the bug, you should include all these things:

- The version of `gdb`. `gdb` announces it if you start with no arguments; you can also print it at any time using `show version`. Without this, we will not know whether there is any point in looking for the bug in the current version of `gdb`.

- The type of machine you are using, and the operating system name and version number.

- The details of the `gdb` build-time configuration. `gdb` shows these details if you invoke it with the `--configuration` command-line option, or if you type `show configuration` at `gdb`’s prompt.

- What compiler (and its version) was used to compile `gdb`—e.g. “gcc–2.8.1”.

- What compiler (and its version) was used to compile the program you are debugging—e.g. “gcc–2.8.1”, or “HP92453-01 A.10.32.03 HP C Compiler”. For GCC, you can say `gcc --version` to get this information; for other compilers, see the documentation for those compilers.

- The command arguments you gave the compiler to compile your example and observe the bug. For example, did you use ‘-O’? To guarantee you will not omit something important, list them all. A copy of the Makefile (or the output from `make`) is sufficient. If we were to try to guess the arguments, we would probably guess wrong and then we might not encounter the bug.

- A complete input script, and all necessary source files, that will reproduce the bug.

- A description of what behavior you observe that you believe is incorrect. For example, “It gets a fatal signal.”

Of course, if the bug is that `GDB` gets a fatal signal, then we will certainly notice it. But if the bug is incorrect output, we might not notice unless it is glaringly wrong. You might as well not give us a chance to make a mistake.

Even if the problem you experience is a fatal signal, you should still say so explicitly. Suppose something strange is going on, such as, your copy of `GDB` is out of synch, or you have encountered a bug in the C library on your system. (This has happened!) Your copy might crash and ours would not. If you told us to expect a crash, then when ours fails to crash, we would know that the bug was not happening for us. If you had not told us to expect a crash, then we would not be able to draw any conclusion from our observations.
To collect all this information, you can use a session recording program such as script, which is available on many Unix systems. Just run your GDB session inside script and then include the ‘typescript’ file with your bug report.

Another way to record a GDB session is to run GDB inside Emacs and then save the entire buffer to a file.

- If you wish to suggest changes to the GDB source, send us context diffs. If you even discuss something in the GDB source, refer to it by context, not by line number. The line numbers in our development sources will not match those in your sources. Your line numbers would convey no useful information to us.

Here are some things that are not necessary:

- A description of the envelope of the bug.

  Often people who encounter a bug spend a lot of time investigating which changes to the input file will make the bug go away and which changes will not affect it. This is often time consuming and not very useful, because the way we will find the bug is by running a single example under the debugger with breakpoints, not by pure deduction from a series of examples. We recommend that you save your time for something else.

  Of course, if you can find a simpler example to report instead of the original one, that is a convenience for us. Errors in the output will be easier to spot, running under the debugger will take less time, and so on.

  However, simplification is not vital; if you do not want to do this, report the bug anyway and send us the entire test case you used.

- A patch for the bug.

  A patch for the bug does help us if it is a good one. But do not omit the necessary information, such as the test case, on the assumption that a patch is all we need. We might see problems with your patch and decide to fix the problem another way, or we might not understand it at all.

  Sometimes with a program as complicated as GDB it is very hard to construct an example that will make the program follow a certain path through the code. If you do not send us the example, we will not be able to construct one, so we will not be able to verify that the bug is fixed.

  And if we cannot understand what bug you are trying to fix, or why your patch should be an improvement, we will not install it. A test case will help us to understand.

- A guess about what the bug is or what it depends on.

  Such guesses are usually wrong. Even we cannot guess right about such things without first using the debugger to find the facts.
32 Command Line Editing

This chapter describes the basic features of the GNU command line editing interface.

32.1 Introduction to Line Editing

The following paragraphs describe the notation used to represent keystrokes.

The text \texttt{C-k} is read as ‘Control-K’ and describes the character produced when the \texttt{k} key is pressed while the Control key is depressed.

The text \texttt{M-k} is read as ‘Meta-K’ and describes the character produced when the Meta key (if you have one) is depressed, and the \texttt{k} key is pressed. The Meta key is labeled \texttt{ALT} on many keyboards. On keyboards with two keys labeled \texttt{ALT} (usually to either side of the space bar), the \texttt{ALT} on the left side is generally set to work as a Meta key. The \texttt{ALT} key on the right may also be configured to work as a Meta key or may be configured as some other modifier, such as a Compose key for typing accented characters.

If you do not have a Meta or \texttt{ALT} key, or another key working as a Meta key, the identical keystroke can be generated by typing \texttt{ESC} \texttt{first}, and then typing \texttt{k}. Either process is known as \textit{metafying} the \texttt{k} key.

The text \texttt{M-C-k} is read as ‘Meta-Control-k’ and describes the character produced by \textit{metafying} \texttt{C-k}.

In addition, several keys have their own names. Specifically, \texttt{DEL}, \texttt{ESC}, \texttt{LFD}, \texttt{SPC}, \texttt{RET}, and \texttt{TAB} all stand for themselves when seen in this text, or in an init file (see Section 32.3 [Readline Init File], page 564). If your keyboard lacks a \texttt{LFD} key, typing \texttt{C-j} will produce the desired character. The \texttt{RET} key may be labeled \texttt{Return} or \texttt{Enter} on some keyboards.

32.2 Readline Interaction

Often during an interactive session you type in a long line of text, only to notice that the first word on the line is misspelled. The Readline library gives you a set of commands for manipulating the text as you type it in, allowing you to just fix your typo, and not forcing you to retype the majority of the line. Using these editing commands, you move the cursor to the place that needs correction, and delete or insert the text of the corrections. Then, when you are satisfied with the line, you simply press \texttt{RET}. You do not have to be at the end of the line to press \texttt{RET}; the entire line is accepted regardless of the location of the cursor within the line.

32.2.1 Readline Bare Essentials

In order to enter characters into the line, simply type them. The typed character appears where the cursor was, and then the cursor moves one space to the right. If you mistype a character, you can use your erase character to back up and delete the mistyped character.

Sometimes you may mistype a character, and not notice the error until you have typed several other characters. In that case, you can type \texttt{C-b} to move the cursor to the left, and then correct your mistake. Afterwards, you can move the cursor to the right with \texttt{C-f}.

When you add text in the middle of a line, you will notice that characters to the right of the cursor are ‘pushed over’ to make room for the text that you have inserted. Likewise, when you delete text behind the cursor, characters to the right of the cursor are ‘pulled
back’ to fill in the blank space created by the removal of the text. A list of the bare essentials for editing the text of an input line follows.

**C-b**  Move back one character.

**C-f**  Move forward one character.

**DEL** or **Backspace**

- Delete the character to the left of the cursor.

**C-d**  Delete the character underneath the cursor.

Printing characters

- Insert the character into the line at the cursor.

**C-_** or **C-x C-u**

- Undo the last editing command. You can undo all the way back to an empty line.

(Depending on your configuration, the **Backspace** key be set to delete the character to the left of the cursor and the **DEL** key set to delete the character underneath the cursor, like **C-d**, rather than the character to the left of the cursor.)

### 32.2.2 Readline Movement Commands

The above table describes the most basic keystrokes that you need in order to do editing of the input line. For your convenience, many other commands have been added in addition to **C-b**, **C-f**, **C-d**, and **DEL**. Here are some commands for moving more rapidly about the line.

**C-a**  Move to the start of the line.

**C-e**  Move to the end of the line.

**M-f**  Move forward a word, where a word is composed of letters and digits.

**M-b**  Move backward a word.

**C-l**  Clear the screen, reprinting the current line at the top.

Notice how **C-f** moves forward a character, while **M-f** moves forward a word. It is a loose convention that control keystrokes operate on characters while meta keystrokes operate on words.

### 32.2.3 Readline Killing Commands

**Killing** text means to delete the text from the line, but to save it away for later use, usually by **yanking** (re-inserting) it back into the line. (‘Cut’ and ‘paste’ are more recent jargon for ‘kill’ and ‘yank’.)

If the description for a command says that it ‘kills’ text, then you can be sure that you can get the text back in a different (or the same) place later.

When you use a kill command, the text is saved in a **kill-ring**. Any number of consecutive kills save all of the killed text together, so that when you yank it back, you get it all. The kill ring is not line specific; the text that you killed on a previously typed line is available to be yanked back later, when you are typing another line.

Here is the list of commands for killing text.
**C-k** Kill the text from the current cursor position to the end of the line.

**M-d** Kill from the cursor to the end of the current word, or, if between words, to the end of the next word. Word boundaries are the same as those used by **M-f**.

**M-DEL** Kill from the cursor the start of the current word, or, if between words, to the start of the previous word. Word boundaries are the same as those used by **M-b**.

**C-w** Kill from the cursor to the previous whitespace. This is different than **M-DEL** because the word boundaries differ.

Here is how to yank the text back into the line. Yanking means to copy the most-recently-killed text from the kill buffer.

**C-y** Yank the most recently killed text back into the buffer at the cursor.

**M-y** Rotate the kill-ring, and yank the new top. You can only do this if the prior command is **C-y** or **M-y**.

### 32.2.4 Readline Arguments

You can pass numeric arguments to Readline commands. Sometimes the argument acts as a repeat count, other times it is the *sign* of the argument that is significant. If you pass a negative argument to a command which normally acts in a forward direction, that command will act in a backward direction. For example, to kill text back to the start of the line, you might type `M-- C-k`.

The general way to pass numeric arguments to a command is to type meta digits before the command. If the first `digit` typed is a minus sign (`-`), then the sign of the argument will be negative. Once you have typed one meta digit to get the argument started, you can type the remainder of the digits, and then the command. For example, to give the **C-d** command an argument of 10, you could type `M-1 0 C-d`, which will delete the next ten characters on the input line.

### 32.2.5 Searching for Commands in the History

Readline provides commands for searching through the command history for lines containing a specified string. There are two search modes: *incremental* and *non-incremental*.

Incremental searches begin before the user has finished typing the search string. As each character of the search string is typed, Readline displays the next entry from the history matching the string typed so far. An incremental search requires only as many characters as needed to find the desired history entry. To search backward in the history for a particular string, type `C-r`. Typing `C-s` searches forward through the history. The characters present in the value of the **isearch-terminators** variable are used to terminate an incremental search. If that variable has not been assigned a value, the **ESC** and **C-J** characters will terminate an incremental search. **C-g** will abort an incremental search and restore the original line. When the search is terminated, the history entry containing the search string becomes the current line.

To find other matching entries in the history list, type `C-r` or `C-s` as appropriate. This will search backward or forward in the history for the next entry matching the search string typed so far. Any other key sequence bound to a Readline command will terminate the
search and execute that command. For instance, a `RET` will terminate the search and accept
the line, thereby executing the command from the history list. A movement command will
terminate the search, make the last line found the current line, and begin editing.

Readline remembers the last incremental search string. If two \texttt{C-r}s are typed without
any intervening characters defining a new search string, any remembered search string is
used.

Non-incremental searches read the entire search string before starting to search for
matching history lines. The search string may be typed by the user or be part of the
contents of the current line.

### 32.3 Readline Init File

Although the Readline library comes with a set of Emacs-like keybindings installed by
default, it is possible to use a different set of keybindings. Any user can customize programs
that use Readline by putting commands in an \texttt{inputrc} file, conventionally in his home
directory. The name of this file is taken from the value of the environment variable \texttt{INPUTRC}.
If that variable is unset, the default is `\texttt{~/.inputrc}`. If that file does not exist or cannot
be read, the ultimate default is `\texttt{/etc/inputrc}`.

When a program which uses the Readline library starts up, the init file is read, and the
key bindings are set.

In addition, the `\texttt{C-x C-r}` command re-reads this init file, thus incorporating any changes
that you might have made to it.

#### 32.3.1 Readline Init File Syntax

There are only a few basic constructs allowed in the Readline init file. Blank lines are
ignored. Lines beginning with a `\texttt{#}` are comments. Lines beginning with a `\texttt{$}` indicate
conditional constructs (see Section 32.3.2 [Conditional Init Constructs], page 570). Other
lines denote variable settings and key bindings.

**Variable Settings**

You can modify the run-time behavior of Readline by altering the values of
variables in Readline using the \texttt{set} command within the init file. The syntax
is simple:

\begin{verbatim}
set variable value
\end{verbatim}

Here, for example, is how to change from the default Emacs-like key binding to
use \texttt{vi} line editing commands:

\begin{verbatim}
set editing-mode vi
\end{verbatim}

Variable names and values, where appropriate, are recognized without regard
to case. Unrecognized variable names are ignored.

Boolean variables (those that can be set to on or off) are set to on if the value is
null or empty, on (case-insensitive), or 1. Any other value results in the variable
being set to off.

A great deal of run-time behavior is changeable with the following variables.

**bell-style**

Controls what happens when Readline wants to ring the terminal bell. If set to `\texttt{none}`, Readline never rings the bell. If set to
‘visible’, Readline uses a visible bell if one is available. If set to ‘audible’ (the default), Readline attempts to ring the terminal’s bell.

**bind-tty-special-chars**
If set to ‘on’, Readline attempts to bind the control characters treated specially by the kernel’s terminal driver to their Readline equivalents.

**comment-begin**
The string to insert at the beginning of the line when the `insert-comment` command is executed. The default value is “#”.

**completion-display-width**
The number of screen columns used to display possible matches when performing completion. The value is ignored if it is less than 0 or greater than the terminal screen width. A value of 0 will cause matches to be displayed one per line. The default value is -1.

**completion-ignore-case**
If set to ‘on’, Readline performs filename matching and completion in a case-insensitive fashion. The default value is ‘off’.

**completion-map-case**
If set to ‘on’, and `completion-ignore-case` is enabled, Readline treats hyphens (‘-‘) and underscores (‘_’) as equivalent when performing case-insensitive filename matching and completion.

**completion-prefix-display-length**
The length in characters of the common prefix of a list of possible completions that is displayed without modification. When set to a value greater than zero, common prefixes longer than this value are replaced with an ellipsis when displaying possible completions.

**completion-query-items**
The number of possible completions that determines when the user is asked whether the list of possibilities should be displayed. If the number of possible completions is greater than this value, Readline will ask the user whether or not he wishes to view them; otherwise, they are simply listed. This variable must be set to an integer value greater than or equal to 0. A negative value means Readline should never ask. The default limit is 100.

**convert-meta**
If set to ‘on’, Readline will convert characters with the eighth bit set to an ASCII key sequence by stripping the eighth bit and prefixing an ESC character, converting them to a meta-prefixed key sequence. The default value is ‘on’.

**disable-completion**
If set to ‘On’, Readline will inhibit word completion. Completion characters will be inserted into the line as if they had been mapped to self-insert. The default is ‘off’.
The `editing-mode` variable controls which default set of key bindings is used. By default, Readline starts up in Emacs editing mode, where the keystrokes are most similar to Emacs. This variable can be set to either `emacs` or `vi`.

The `echo-control-characters` variable, when set to `on`, on operating systems that indicate they support it, Readline echoes a character corresponding to a signal generated from the keyboard. The default is `on`.

The `enable-keypad` variable, when set to `on`, Readline will try to enable the application keypad when it is called. Some systems need this to enable the arrow keys. The default is `off`.

The `enable-meta-key` variable, when set to `on`, Readline will try to enable any meta modifier key the terminal claims to support when it is called. On many terminals, the meta key is used to send eight-bit characters. The default is `on`.

The `expand-tilde` variable, if set to `on`, tilde expansion is performed when Readline attempts word completion. The default is `off`.

The `history-preserve-point` variable, if set to `on`, the history code attempts to place the point (the current cursor position) at the same location on each history line retrieved with `previous-history` or `next-history`. The default is `off`.

The `history-size` variable sets the maximum number of history entries saved in the history list. If set to zero, the number of entries in the history list is not limited.

The `horizontal-scroll-mode` variable can be set to either `on` or `off`. Setting it to `on` means that the text of the lines being edited will scroll horizontally on a single screen line when they are longer than the width of the screen, instead of wrapping onto a new screen line. By default, this variable is set to `off`.

The `input-meta` variable, if set to `on`, Readline will enable eight-bit input (it will not clear the eighth bit in the characters it reads), regardless of what the terminal claims it can support. The default value is `off`. The name `meta-flag` is a synonym for this variable.

The `isearch-terminators` variable specifies the string of characters that should terminate an incremental search without subsequently executing the character as a command.
(see Section 32.2.5 [Searching], page 563). If this variable has not been given a value, the characters ESC and C-J will terminate an incremental search.

**keymap**

Sets Readline’s idea of the current keymap for key binding commands. Acceptable keymap names are emacs, emacs-standard, emacs-meta, emacs-ctlx, vi, vi-move, vi-command, and vi-insert. vi is equivalent to vi-command; emacs is equivalent to emacs-standard. The default value is emacs. The value of the editing-mode variable also affects the default keymap.

**mark-directories**

If set to ‘on’, completed directory names have a slash appended. The default is ‘on’.

**mark-modified-lines**

This variable, when set to ‘on’, causes Readline to display an asterisk (‘*’) at the start of history lines which have been modified. This variable is ‘off’ by default.

**mark-symlinked-directories**

If set to ‘on’, completed names which are symbolic links to directories have a slash appended (subject to the value of mark-directories). The default is ‘off’.

**match-hidden-files**

This variable, when set to ‘on’, causes Readline to match files whose names begin with a ‘.’ (hidden files) when performing filename completion. If set to ‘off’, the leading ‘.’ must be supplied by the user in the filename to be completed. This variable is ‘on’ by default.

**menu-complete-display-prefix**

If set to ‘on’, menu completion displays the common prefix of the list of possible completions (which may be empty) before cycling through the list. The default is ‘off’.

**output-meta**

If set to ‘on’, Readline will display characters with the eighth bit set directly rather than as a meta-prefixed escape sequence. The default is ‘off’.

**page-completions**

If set to ‘on’, Readline uses an internal more-like pager to display a screenful of possible completions at a time. This variable is ‘on’ by default.

**print-completions-horizontally**

If set to ‘on’, Readline will display completions with matches sorted horizontally in alphabetical order, rather than down the screen. The default is ‘off’.
revert-all-at-newline
If set to ‘on’, Readline will undo all changes to history lines before returning when accept-line is executed. By default, history lines may be modified and retain individual undo lists across calls to readline. The default is ‘off’.

show-all-if-ambiguous
This alters the default behavior of the completion functions. If set to ‘on’, words which have more than one possible completion cause the matches to be listed immediately instead of ringing the bell. The default value is ‘off’.

show-all-if-unmodified
This alters the default behavior of the completion functions in a fashion similar to show-all-if-ambiguous. If set to ‘on’, words which have more than one possible completion without any possible partial completion (the possible completions don’t share a common prefix) cause the matches to be listed immediately instead of ringing the bell. The default value is ‘off’.

skip-completed-text
If set to ‘on’, this alters the default completion behavior when inserting a single match into the line. It’s only active when performing completion in the middle of a word. If enabled, readline does not insert characters from the completion that match characters after point in the word being completed, so portions of the word following the cursor are not duplicated. For instance, if this is enabled, attempting completion when the cursor is after the ‘e’ in ‘Makefile’ will result in ‘Makefile’ rather than ‘Makefilefile’, assuming there is a single possible completion. The default value is ‘off’.

visible-stats
If set to ‘on’, a character denoting a file’s type is appended to the filename when listing possible completions. The default is ‘off’.

Key Bindings
The syntax for controlling key bindings in the init file is simple. First you need to find the name of the command that you want to change. The following sections contain tables of the command name, the default keybinding, if any, and a short description of what the command does.

Once you know the name of the command, simply place on a line in the init file the name of the key you wish to bind the command to, a colon, and then the name of the command. There can be no space between the key name and the colon – that will be interpreted as part of the key name. The name of the key can be expressed in different ways, depending on what you find most comfortable.

In addition to command names, readline allows keys to be bound to a string that is inserted when the key is pressed (a macro).
keyname: function-name or macro

keyname is the name of a key spelled out in English. For example:

Control-u: universal-argument
Meta-Rubout: backward-kill-word
Control-o: "> output"

In the above example, C-u is bound to the function universal-argument, M-DEL is bound to the function backward-kill-word, and C-o is bound to run the macro expressed on the right hand side (that is, to insert the text "> output’ into the line).

A number of symbolic character names are recognized while processing this key binding syntax: DEL, ESC, ESCAPE, LFD, NEWLINE, RET, RETURN, RUBOUT, SPACE, SPC, and TAB.

"keyseq": function-name or macro

keyseq differs from keyname above in that strings denoting an entire key sequence can be specified, by placing the key sequence in double quotes. Some gnu Emacs style key escapes can be used, as in the following example, but the special character names are not recognized.

"\C-u": universal-argument
"\C-x\C-r": re-read-init-file
"\e[11~": "Function Key 1"

In the above example, C-u is again bound to the function universal-argument (just as it was in the first example), ‘C-x C-r’ is bound to the function re-read-init-file, and ‘ESC [ 11 ~’ is bound to insert the text ‘Function Key 1’.

The following gnu Emacs style escape sequences are available when specifying key sequences:

\C- control prefix
\M- meta prefix
\e an escape character
\ backslash
\" " , a double quotation mark
\’ ’ , a single quote or apostrophe

In addition to the gnu Emacs style escape sequences, a second set of backslash escapes is available:

\a alert (bell)
\b backspace
\d delete
\f form feed
\n newline
570 Debugging with GDB

\r carriage return
\t horizontal tab
\v vertical tab
\nnnn the eight-bit character whose value is the octal value nnn (one to three digits)
\xHH the eight-bit character whose value is the hexadecimal value HH (one or two hex digits)

When entering the text of a macro, single or double quotes must be used to indicate a macro definition. Unquoted text is assumed to be a function name. In the macro body, the backslash escapes described above are expanded. Backslash will quote any other character in the macro text, including ‘”’ and ‘‘’. For example, the following binding will make ‘C-x ‘ insert a single ‘‘ into the line:

"\C-x\": "\"

32.3.2 Conditional Init Constructs

Readline implements a facility similar in spirit to the conditional compilation features of the C preprocessor which allows key bindings and variable settings to be performed as the result of tests. There are four parser directives used.

$if The $if construct allows bindings to be made based on the editing mode, the terminal being used, or the application using Readline. The text of the test extends to the end of the line; no characters are required to isolate it.

mode The mode= form of the $if directive is used to test whether Readline is in emacs or vi mode. This may be used in conjunction with the ‘set keymap’ command, for instance, to set bindings in the emacs-standard and emacs-ctlx keymaps only if Readline is starting out in emacs mode.

term The term= form may be used to include terminal-specific key bindings, perhaps to bind the key sequences output by the terminal’s function keys. The word on the right side of the ‘=’ is tested against both the full name of the terminal and the portion of the terminal name before the first ‘-’. This allows sun to match both sun and sun-cmd, for instance.

application

The application construct is used to include application-specific settings. Each program using the Readline library sets the application name, and you can test for a particular value. This could be used to bind key sequences to functions useful for a specific program. For instance, the following command adds a key sequence that quotes the current or previous word in Bash:

$$if Bash
  # Quote the current or previous word
  "\C-xq": "\eb"\ef"
$$endif
This command, as seen in the previous example, terminates an $if command.

Commands in this branch of the $if directive are executed if the test fails.

This directive takes a single filename as an argument and reads commands and bindings from that file. For example, the following directive reads from ‘/etc/inputrc’:

```
$include /etc/inputrc
```

### 32.3.3 Sample Init File

Here is an example of an inputrc file. This illustrates key binding, variable assignment, and conditional syntax.
# This file controls the behaviour of line input editing for
# programs that use the GNU Readline library. Existing
# programs include FTP, Bash, and GDB.
#
# You can re-read the inputrc file with C-x C-r.
# Lines beginning with '#' are comments.
#
# First, include any systemwide bindings and variable
# assignments from /etc/Inputrc
$include /etc/Inputrc

#
# Set various bindings for emacs mode.

set editing-mode emacs

$if mode=emacs

Meta-Control-h: backward-kill-word Text after the function name is ignored

#
# Arrow keys in keypad mode
#
"\M-OD": backward-char
"\M-OC": forward-char
"\M-OA": previous-history
"\M-OB": next-history
#
# Arrow keys in ANSI mode
#
"\M-[D": backward-char
"\M-[C": forward-char
"\M-[A": previous-history
"\M-[B": next-history
#
# Arrow keys in 8 bit keypad mode
#
"\M-C-OD": backward-char
"\M-C-OC": forward-char
"\M-C-OA": previous-history
"\M-C-OB": next-history
#
# Arrow keys in 8 bit ANSI mode
#
"\M-C-[D": backward-char
"\M-C-[C": forward-char
#"\M-\C-[A": previous-history
#"\M-\C-[B": next-history

C-q: quoted-insert

$endif

# An old-style binding. This happens to be the default.
TAB: complete

# Macros that are convenient for shell interaction
$if Bash
# edit the path
"\C-xp": "PATH=${PATH}\e\C-e\C-a\ef\C-f"
# prepare to type a quoted word --
# insert open and close double quotes
# and move to just after the open quote
"\C-x": "\\"\C-b"
# insert a backslash (testing backslash escapes
# in sequences and macros)
"\C-x\": "\\"
# Quote the current or previous word
"\C-xq": "\eb\ef"
# Add a binding to refresh the line, which is unbound
"\C-xr": redraw-current-line
# Edit variable on current line.
"\M-\C-v": "\C-a\C-k\C-y\M-\C-e\C-a\C-y="
$endif

# use a visible bell if one is available
set bell-style visible

# don’t strip characters to 7 bits when reading
set input-meta on

# allow iso-latin1 characters to be inserted rather
# than converted to prefix-meta sequences
set convert-meta off

# display characters with the eighth bit set directly
# rather than as meta-prefixed characters
set output-meta on

# if there are more than 150 possible completions for
# a word, ask the user if he wants to see all of them
set completion-query-items 150
# For FTP
$if Ftp
"\C-xg": "get \M-?"
"\C-xt": "put \M-?"
"\M-.": yank-last-arg
$endif

## 32.4 Bindable Readline Commands

This section describes Readline commands that may be bound to key sequences. Command names without an accompanying key sequence are unbound by default.

In the following descriptions, `point` refers to the current cursor position, and `mark` refers to a cursor position saved by the `set-mark` command. The text between the point and mark is referred to as the `region`.

### 32.4.1 Commands For Moving

- **beginning-of-line (C-a)**
  Move to the start of the current line.

- **end-of-line (C-e)**
  Move to the end of the line.

- **forward-char (C-f)**
  Move forward a character.

- **backward-char (C-b)**
  Move back a character.

- **forward-word (M-f)**
  Move forward to the end of the next word. Words are composed of letters and digits.

- **backward-word (M-b)**
  Move back to the start of the current or previous word. Words are composed of letters and digits.

- **clear-screen (C-l)**
  Clear the screen and redraw the current line, leaving the current line at the top of the screen.

- **redraw-current-line ()**
  Refresh the current line. By default, this is unbound.

### 32.4.2 Commands For Manipulating The History

- **accept-line (Newline or Return)**
  Accept the line regardless of where the cursor is. If this line is non-empty, it may be added to the history list for future recall with `add_history()`. If this line is a modified history line, the history line is restored to its original state.

- **previous-history (C-p)**
  Move ‘back’ through the history list, fetching the previous command.
next-history (C-n)
    Move ‘forward’ through the history list, fetching the next command.

beginning-of-history (M-<)
    Move to the first line in the history.

derm-of-history (M->)
    Move to the end of the input history, i.e., the line currently being entered.

reverse-search-history (C-r)
    Search backward starting at the current line and moving ‘up’ through the his-
tory as necessary. This is an incremental search.

forward-search-history (C-s)
    Search forward starting at the current line and moving ‘down’ through the the
history as necessary. This is an incremental search.

non-incremental-reverse-search-history (M-p)
    Search backward starting at the current line and moving ‘up’ through the his-
tory as necessary using a non-incremental search for a string supplied by the
user.

non-incremental-forward-search-history (M-n)
    Search forward starting at the current line and moving ‘down’ through the the
history as necessary using a non-incremental search for a string supplied by the
user.

history-search-forward ()
    Search forward through the history for the string of characters between the
start of the current line and the point. This is a non-incremental search. By
default, this command is unbound.

history-search-backward ()
    Search backward through the history for the string of characters between the
start of the current line and the point. This is a non-incremental search. By
default, this command is unbound.

yank-nth-arg (M-C-y)
    Insert the first argument to the previous command (usually the second word
on the previous line) at point. With an argument n, insert the nth word from
the previous command (the words in the previous command begin with word
0). A negative argument inserts the nth word from the end of the previous
command. Once the argument n is computed, the argument is extracted as if
the ‘!n’ history expansion had been specified.

yank-last-arg (M-. or M-_.)
    Insert last argument to the previous command (the last word of the previous
history entry). With a numeric argument, behave exactly like yank-nth-arg.
Successive calls to yank-last-arg move back through the history list, inserting
the last word (or the word specified by the argument to the first call) of each line
in turn. Any numeric argument supplied to these successive calls determines
the direction to move through the history. A negative argument switches the
direction through the history (back or forward). The history expansion facilities are used to extract the last argument, as if the ‘!$’ history expansion had been specified.

### 32.4.3 Commands For Changing Text

**delete-char (C-d)**
Delete the character at point. If point is at the beginning of the line, there are no characters in the line, and the last character typed was not bound to delete-char, then return EOF.

**backward-delete-char (Rubout)**
Delete the character behind the cursor. A numeric argument means to kill the characters instead of deleting them.

**forward-backward-delete-char ()**
Delete the character under the cursor, unless the cursor is at the end of the line, in which case the character behind the cursor is deleted. By default, this is not bound to a key.

**quoted-insert (C-q or C-v)**
Add the next character typed to the line verbatim. This is how to insert key sequences like C-q, for example.

**tab-insert (M-TAB)**
Insert a tab character.

**self-insert (a, b, A, 1, !, ...)**
Insert yourself.

**transpose-chars (C-t)**
Drag the character before the cursor forward over the character at the cursor, moving the cursor forward as well. If the insertion point is at the end of the line, then this transposes the last two characters of the line. Negative arguments have no effect.

**transpose-words (M-t)**
Drag the word before point past the word after point, moving point past that word as well. If the insertion point is at the end of the line, this transposes the last two words on the line.

**upcase-word (M-u)**
Uppercase the current (or following) word. With a negative argument, uppercase the previous word, but do not move the cursor.

**downcase-word (M-l)**
Lowercase the current (or following) word. With a negative argument, lowercase the previous word, but do not move the cursor.

**capitalize-word (M-c)**
Capitalize the current (or following) word. With a negative argument, capitalize the previous word, but do not move the cursor.
overwrite-mode ()
Toggle overwrite mode. With an explicit positive numeric argument, switches to overwrite mode. With an explicit non-positive numeric argument, switches to insert mode. This command affects only emacs mode; vi mode does overwrite differently. Each call to readline() starts in insert mode.

In overwrite mode, characters bound to self-insert replace the text at point rather than pushing the text to the right. Characters bound to backward-delete-char replace the character before point with a space.

By default, this command is unbound.

32.4.4 Killing And Yanking

kill-line (C-k)
Kill the text from point to the end of the line.

backward-kill-line (C-x Rubout)
Kill backward to the beginning of the line.

unix-line-discard (C-u)
Kill backward from the cursor to the beginning of the current line.

kill-whole-line ()
Kill all characters on the current line, no matter where point is. By default, this is unbound.

kill-word (M-d)
Kill from point to the end of the current word, or if between words, to the end of the next word. Word boundaries are the same as forward-word.

backward-kill-word (M-DEL)
Kill the word behind point. Word boundaries are the same as backward-word.

unix-word-rubout (C-w)
Kill the word behind point, using white space as a word boundary. The killed text is saved on the kill-ring.

unix-filename-rubout ()
Kill the word behind point, using white space and the slash character as the word boundaries. The killed text is saved on the kill-ring.

delete-horizontal-space ()
Delete all spaces and tabs around point. By default, this is unbound.

kill-region ()
Kill the text in the current region. By default, this command is unbound.

copy-region-as-kill ()
Copy the text in the region to the kill buffer, so it can be yanked right away. By default, this command is unbound.

copy-backward-word ()
Copy the word before point to the kill buffer. The word boundaries are the same as backward-word. By default, this command is unbound.
copy-forward-word ()
    Copy the word following point to the kill buffer. The word boundaries are the
    same as forward-word. By default, this command is unbound.

yank (C-y)
    Yank the top of the kill ring into the buffer at point.

yank-pop (M-y)
    Rotate the kill-ring, and yank the new top. You can only do this if the prior
    command is yank or yank-pop.

32.4.5 Specifying Numeric Arguments

digit-argument (M-0, M-1, ... M--)
    Add this digit to the argument already accumulating, or start a new argument.  
    M-- starts a negative argument.

universal-argument ()
    This is another way to specify an argument. If this command is followed by one
    or more digits, optionally with a leading minus sign, those digits define the ar-
    gument. If the command is followed by digits, executing universal-argument
    again ends the numeric argument, but is otherwise ignored. As a special case,
    if this command is immediately followed by a character that is neither a digit
    or minus sign, the argument count for the next command is multiplied by four.
    The argument count is initially one, so executing this function the first time
    makes the argument count four, a second time makes the argument count six-
    teen, and so on. By default, this is not bound to a key.

32.4.6 Letting Readline Type For You

complete (TAB)
    Attempt to perform completion on the text before point. The actual completion
    performed is application-specific. The default is filename completion.

possible-completions (M-?)
    List the possible completions of the text before point. When displaying com-
    pletions, Readline sets the number of columns used for display to the value of
    completion-display-width, the value of the environment variable COLUMNS,  
    or the screen width, in that order.

insert-completions (M-*)
    Insert all completions of the text before point that would have been generated
    by possible-completions.

menu-complete ()
    Similar to complete, but replaces the word to be completed with a single match
    from the list of possible completions. Repeated execution of menu-complete
    steps through the list of possible completions, inserting each match in turn. 
    At the end of the list of completions, the bell is rung (subject to the setting
    of bell-style) and the original text is restored. An argument of n moves n
    positions forward in the list of matches; a negative argument may be used to
move backward through the list. This command is intended to be bound to TAB, but is unbound by default.

```
menu-complete-backward ()
   Identical to menu-complete, but moves backward through the list of possible completions, as if menu-complete had been given a negative argument.
```

delete-char-or-list ()
   Deletes the character under the cursor if not at the beginning or end of the line (like delete-char). If at the end of the line, behaves identically to possible-completions. This command is unbound by default.

### 32.4.7 Keyboard Macros

```
start-kbd-macro (C-x ()
   Begin saving the characters typed into the current keyboard macro.

end-kbd-macro (C-x ))
   Stop saving the characters typed into the current keyboard macro and save the definition.

call-last-kbd-macro (C-x e)
   Re-execute the last keyboard macro defined, by making the characters in the macro appear as if typed at the keyboard.
```

### 32.4.8 Some Miscellaneous Commands

```
re-read-init-file (C-x C-r)
   Read in the contents of the inputrc file, and incorporate any bindings or variable assignments found there.

abort (C-g)
   Abort the current editing command and ring the terminal’s bell (subject to the setting of bell-style).

do-uppercase-version (M-a, M-b, M-x, ...)
   If the metafied character x is lowercase, run the command that is bound to the corresponding uppercase character.

prefix-meta (ESC)
   Metafy the next character typed. This is for keyboards without a meta key. Typing ‘ESC f’ is equivalent to typing M-f.

undo (C-_ or C-x C-u)
   Incremental undo, separately remembered for each line.

revert-line (M-r)
   Undo all changes made to this line. This is like executing the undo command enough times to get back to the beginning.

tilde-expand (M-~)
   Perform tilde expansion on the current word.

set-mark (C-@)
   Set the mark to the point. If a numeric argument is supplied, the mark is set to that position.
```
exchange-point-and-mark (C-x C-x)
Swapping the point with the mark. The current cursor position is set to the saved position, and the old cursor position is saved as the mark.

character-search (C-])
A character is read and point is moved to the next occurrence of that character. A negative count searches for previous occurrences.

character-search-backward (M-C-])
A character is read and point is moved to the previous occurrence of that character. A negative count searches for subsequent occurrences.

skip-csi-sequence ()
Read enough characters to consume a multi-key sequence such as those defined for keys like Home and End. Such sequences begin with a Control Sequence Indicator (CSI), usually ESC-]. If this sequence is bound to "\e", keys producing such sequences will have no effect unless explicitly bound to a readline command, instead of inserting stray characters into the editing buffer. This is unbound by default, but usually bound to ESC-[].

insert-comment (M-#)
Without a numeric argument, the value of the comment-begin variable is inserted at the beginning of the current line. If a numeric argument is supplied, this command acts as a toggle: if the characters at the beginning of the line do not match the value of comment-begin, the value is inserted, otherwise the characters in comment-begin are deleted from the beginning of the line. In either case, the line is accepted as if a newline had been typed.

dump-functions ()
Print all of the functions and their key bindings to the Readline output stream. If a numeric argument is supplied, the output is formatted in such a way that it can be made part of an inputrc file. This command is unbound by default.

dump-variables ()
Print all of the settable variables and their values to the Readline output stream. If a numeric argument is supplied, the output is formatted in such a way that it can be made part of an inputrc file. This command is unbound by default.

dump-macros ()
Print all of the Readline key sequences bound to macros and the strings they output. If a numeric argument is supplied, the output is formatted in such a way that it can be made part of an inputrc file. This command is unbound by default.

emacs-editing-mode (C-e)
When in vi command mode, this causes a switch to emacs editing mode.

vi-editing-mode (M-C-j)
When in emacs editing mode, this causes a switch to vi editing mode.
32.5 Readline vi Mode

While the Readline library does not have a full set of vi editing functions, it does contain enough to allow simple editing of the line. The Readline vi mode behaves as specified in the POSIX standard.

In order to switch interactively between emacs and vi editing modes, use the command \texttt{M-C-j} (bound to \texttt{emacs-editing-mode} when in vi mode and to \texttt{vi-editing-mode} in \texttt{emacs} mode). The Readline default is \texttt{emacs} mode.

When you enter a line in vi mode, you are already placed in ‘insertion’ mode, as if you had typed an ‘i’. Pressing \texttt{ESC} switches you into ‘command’ mode, where you can edit the text of the line with the standard vi movement keys, move to previous history lines with ‘k’ and subsequent lines with ‘j’, and so forth.
33 Using History Interactively

This chapter describes how to use the GNU History Library interactively, from a user’s standpoint. It should be considered a user’s guide. For information on using the GNU History Library in your own programs, see Section “Programming with GNU History” in GNU History Library.

33.1 History Expansion

The History library provides a history expansion feature that is similar to the history expansion provided by csh. This section describes the syntax used to manipulate the history information.

History expansions introduce words from the history list into the input stream, making it easy to repeat commands, insert the arguments to a previous command into the current input line, or fix errors in previous commands quickly.

History expansion takes place in two parts. The first is to determine which line from the history list should be used during substitution. The second is to select portions of that line for inclusion into the current one. The line selected from the history is called the event, and the portions of that line that are acted upon are called words. Various modifiers are available to manipulate the selected words. The line is broken into words in the same fashion that Bash does, so that several words surrounded by quotes are considered one word. History expansions are introduced by the appearance of the history expansion character, which is ‘!’ by default.

33.1.1 Event Designators

An event designator is a reference to a command line entry in the history list. Unless the reference is absolute, events are relative to the current position in the history list.

! Start a history substitution, except when followed by a space, tab, the end of the line, or ‘=’.

!n Refer to command line n.

!-n Refer to the command n lines back.

!! Refer to the previous command. This is a synonym for ‘!-1’.

!string Refer to the most recent command preceding the current position in the history list starting with string.

!string[?] Refer to the most recent command preceding the current position in the history list containing string. The trailing ‘?’ may be omitted if the string is followed immediately by a newline.

^string1^string2^ Quick Substitution. Repeat the last command, replacing string1 with string2. Equivalent to !!:s/string1/string2/.

!# The entire command line typed so far.
33.1.2 Word Designators

Word designators are used to select desired words from the event. A ‘:’ separates the event specification from the word designator. It may be omitted if the word designator begins with a ‘~’, ‘$’, ‘*’, ‘-’, or ‘%’. Words are numbered from the beginning of the line, with the first word being denoted by 0 (zero). Words are inserted into the current line separated by single spaces.

For example,

!! designates the preceding command. When you type this, the preceding command is repeated in toto.

!!:$ designates the last argument of the preceding command. This may be shortened to !$.

!fi:2 designates the second argument of the most recent command starting with the letters fi.

Here are the word designators:

0 (zero) The 0th word. For many applications, this is the command word.
n The nth word.
^ The first argument; that is, word 1.
$ The last argument.
% The word matched by the most recent ‘?string?’ search.
-x-y A range of words; ‘-y’ abbreviates ‘0-y’.
* All of the words, except the 0th. This is a synonym for ‘1-$’. It is not an error to use ‘*’ if there is just one word in the event; the empty string is returned in that case.
x* Abbreviates ‘x-$’
x- Abbreviates ‘x-$’ like ‘x*’, but omits the last word.

If a word designator is supplied without an event specification, the previous command is used as the event.

33.1.3 Modifiers

After the optional word designator, you can add a sequence of one or more of the following modifiers, each preceded by a ‘:’.

h Remove a trailing pathname component, leaving only the head.
t Remove all leading pathname components, leaving the tail.
r Remove a trailing suffix of the form ‘.suffix’, leaving the basename.
e Remove all but the trailing suffix.
p Print the new command but do not execute it.
\texttt{\textbackslash s/old/new/}

Substitute \textit{new} for the first occurrence of \textit{old} in the event line. Any delimiter may be used in place of ‘/’. The delimiter may be quoted in \textit{old} and \textit{new} with a single backslash. If ‘&’ appears in \textit{new}, it is replaced by \textit{old}. A single backslash will quote the ‘&’. The final delimiter is optional if it is the last character on the input line.

\texttt{\textbackslash k}

Repeat the previous substitution.

\texttt{\textbackslash g}

Cause changes to be applied over the entire event line. Used in conjunction with ‘\texttt{s}’, as in \texttt{gs/old/new/}, or with ‘\texttt{k}’.

\texttt{\textbackslash G}

Apply the following ‘\texttt{s}’ modifier once to each word in the event.
Appendix A  In Memoriam

The GDB project mourns the loss of the following long-time contributors:

**Fred Fish**  Fred was a long-standing contributor to GDB (1991-2006), and to Free Software in general. Outside of GDB, he was known in the Amiga world for his series of Fish Disks, and the GeekGadget project.

**Michael Snyder**  Michael was one of the Global Maintainers of the GDB project, with contributions recorded as early as 1996, until 2011. In addition to his day to day participation, he was a large driving force behind adding Reverse Debugging to GDB.

Beyond their technical contributions to the project, they were also enjoyable members of the Free Software Community. We will miss them.
Appendix B Formatting Documentation

The GDB 4 release includes an already-formatted reference card, ready for printing with PostScript or Ghostscript, in the ‘gdb’ subdirectory of the main source directory. If you can use PostScript or Ghostscript with your printer, you can print the reference card immediately with ‘refcard.ps’.

The release also includes the source for the reference card. You can format it, using TpX, by typing:

```make
make refcard.dvi
```

The GDB reference card is designed to print in landscape mode on US “letter” size paper; that is, on a sheet 11 inches wide by 8.5 inches high. You will need to specify this form of printing as an option to your DVI output program.

All the documentation for GDB comes as part of the machine-readable distribution. The documentation is written in Texinfo format, which is a documentation system that uses a single source file to produce both on-line information and a printed manual. You can use one of the Info formatting commands to create the on-line version of the documentation and TpX (or texi2roff) to typeset the printed version.

GDB includes an already formatted copy of the on-line Info version of this manual in the ‘gdb’ subdirectory. The main Info file is ‘gdb-7.10.50.20150918-cvs/gdb/gdb.info’, and it refers to subordinate files matching ‘gdb.info*’ in the same directory. If necessary, you can print out these files, or read them with any editor; but they are easier to read using the info subsystem in GNU Emacs or the standalone info program, available as part of the GNU Texinfo distribution.

If you want to format these Info files yourself, you need one of the Info formatting programs, such as texinfo-format-buffer or makeinfo.

If you have makeinfo installed, and are in the top level GDB source directory (‘gdb-7.10.50.20150918-cvs’, in the case of version 7.10.50.20150918-cvs), you can make the Info file by typing:

```make
cd gdb
make gdb.info
```

If you want to typeset and print copies of this manual, you need TpX, a program to print its DVI output files, and ‘texinfo.tex’, the Texinfo definitions file.

TpX is a typesetting program; it does not print files directly, but produces output files called DVI files. To print a typeset document, you need a program to print DVI files. If your system has TpX installed, chances are it has such a program. The precise command to use depends on your system; `lpr -d` is common; another (for PostScript devices) is dvips. The DVI print command may require a file name without any extension or a ‘.dvi’ extension.

TpX also requires a macro definitions file called ‘texinfo.tex’. This file tells TpX how to typeset a document written in Texinfo format. On its own, TpX cannot either read or typeset a Texinfo file. ‘texinfo.tex’ is distributed with GDB and is located in the ‘gdb-version-number/texinfo’ directory.

If you have TpX and a DVI printer program installed, you can typeset and print this manual. First switch to the ‘gdb’ subdirectory of the main source directory (for example, to ‘gdb-7.10.50.20150918-cvs/gdb’) and type:

---

1 In ‘gdb-7.10.50.20150918-cvs/gdb/refcard.ps’ of the version 7.10.50.20150918-cvs release.
make gdb.dvi

Then give ‘gdb.dvi’ to your DVI printing program.
Appendix C Installing GDB

C.1 Requirements for Building GDB

Building GDB requires various tools and packages to be available. Other packages will be used only if they are found.

Tools/Packages Necessary for Building GDB

ISO C90 compiler

GDB is written in ISO C90. It should be buildable with any working C90 compiler, e.g. GCC.

Tools/Packages Optional for Building GDB

Expat

GDB can use the Expat XML parsing library. This library may be included with your operating system distribution; if it is not, you can get the latest version from http://expat.sourceforge.net. The ‘configure’ script will search for this library in several standard locations; if it is installed in an unusual path, you can use the ‘--with-libexpat-prefix’ option to specify its location.

Expat is used for:

• Remote protocol memory maps (see Section E.16 [Memory Map Format], page 670)
• Target descriptions (see Appendix G [Target Descriptions], page 687)
• Remote shared library lists (See Section E.14 [Library List Format], page 669, or alternatively see Section E.15 [Library List Format for SVR4 Targets], page 670)
• MS-Windows shared libraries (see [Shared Libraries], page 241)
• Traceframe info (see Section E.18 [Traceframe Info Format], page 672)
• Branch trace (see Section E.19 [Branch Trace Format], page 672, see Section E.20 [Branch Trace Configuration Format], page 673)

zlib

GDB will use the ‘zlib’ library, if available, to read compressed debug sections. Some linkers, such as GNU gold, are capable of producing binaries with compressed debug sections. If GDB is compiled with ‘zlib’, it will be able to read the debug information in such binaries.

The ‘zlib’ library is likely included with your operating system distribution; if it is not, you can get the latest version from http://zlib.net.

iconv

GDB’s features related to character sets (see Section 10.20 [Character Sets], page 149) require a functioning iconv implementation. If you are on a GNU system, then this is provided by the GNU C Library. Some other systems also provide a working iconv.

If GDB is using the iconv program which is installed in a non-standard place, you will need to tell GDB where to find it. This is done with ‘--with-iconv-bin’ which specifies the directory that contains the iconv program.
On systems without `iconv`, you can install GNU Libiconv. If you have previously installed Libiconv, you can use the `--with-libiconv-prefix` option to configure.

GDB’s top-level `configure` and `Makefile` will arrange to build Libiconv if a directory named `libiconv` appears in the top-most source directory. If Libiconv is built this way, and if the operating system does not provide a suitable `iconv` implementation, then the just-built library will automatically be used by GDB. One easy way to set this up is to download GNU Libiconv, unpack it, and then rename the directory holding the Libiconv source code to `libiconv`.

C.2 Invoking the GDB ‘configure’ Script

GDB comes with a `configure` script that automates the process of preparing GDB for installation; you can then use `make` to build the GDB program.1

The GDB distribution includes all the source code you need for GDB in a single directory, whose name is usually composed by appending the version number to `gdb`.

For example, the GDB version 7.10.50.20150918-cvs distribution is in the `gdb-7.10.50.20150918-cvs` directory. That directory contains:

```
gdb-7.10.50.20150918-cvs/configure (and supporting files)
    script for configuring GDB and all its supporting libraries

gdb-7.10.50.20150918-cvs/gdb
    the source specific to GDB itself

gdb-7.10.50.20150918-cvs/bfd
    source for the Binary File Descriptor library

gdb-7.10.50.20150918-cvs/include
    GNU include files

gdb-7.10.50.20150918-cvs/libiberty
    source for the `-liberty` free software library

gdb-7.10.50.20150918-cvs/opcodes
    source for the library of opcode tables and disassemblers

gdb-7.10.50.20150918-cvs/readline
    source for the GNU command-line interface

gdb-7.10.50.20150918-cvs/glob
    source for the GNU filename pattern-matching subroutine

gdb-7.10.50.20150918-cvs/mmalloc
    source for the GNU memory-mapped malloc package
```

The simplest way to configure and build GDB is to run `configure` from the `gdb-version-number` source directory, which in this example is the `gdb-7.10.50.20150918-cvs` directory.

1 If you have a more recent version of GDB than 7.10.50.20150918-cvs, look at the ‘README’ file in the sources; we may have improved the installation procedures since publishing this manual.
First switch to the ‘gdb-version-number’ source directory if you are not already in it; then run ‘configure’. Pass the identifier for the platform on which GDB will run as an argument.

For example:
```bash
cd gdb-7.10.50.20150918-cvs
./configure host
make
```
where host is an identifier such as ‘sun4’ or ‘decstation’, that identifies the platform where GDB will run. (You can often leave off host; ‘configure’ tries to guess the correct value by examining your system.)

Running ‘configure host’ and then running make builds the ‘bfd’, ‘readline’, ‘mmalloc’, and ‘libiberty’ libraries, then gdb itself. The configured source files, and the binaries, are left in the corresponding source directories.

‘configure’ is a Bourne-shell (/bin/sh) script; if your system does not recognize this automatically when you run a different shell, you may need to run sh on it explicitly:
```bash
sh configure host
```

If you run ‘configure’ from a directory that contains source directories for multiple libraries or programs, such as the ‘gdb-7.10.50.20150918-cvs’ source directory for version 7.10.50.20150918-cvs, ‘configure’ creates configuration files for every directory level underneath (unless you tell it not to, with the ‘--norecursion’ option).

You should run the ‘configure’ script from the top directory in the source tree, the ‘gdb-version-number’ directory. If you run ‘configure’ from one of the subdirectories, you will configure only that subdirectory. That is usually not what you want. In particular, if you run the first ‘configure’ from the ‘gdb’ subdirectory of the ‘gdb-version-number’ directory, you will omit the configuration of ‘bfd’, ‘readline’, and other sibling directories of the ‘gdb’ subdirectory. This leads to build errors about missing include files such as ‘bfd/bfd.h’.

You can install gdb anywhere; it has no hardwired paths. However, you should make sure that the shell on your path (named by the ‘SHELL’ environment variable) is publicly readable. Remember that GDB uses the shell to start your program—some systems refuse to let GDB debug child processes whose programs are not readable.

### C.3 Compiling GDB in Another Directory

If you want to run GDB versions for several host or target machines, you need a different gdb compiled for each combination of host and target. ‘configure’ is designed to make this easy by allowing you to generate each configuration in a separate subdirectory, rather than in the source directory. If your make program handles the ‘VPATH’ feature (GNU make does), running make in each of these directories builds the gdb program specified there.

To build gdb in a separate directory, run ‘configure’ with the ‘--srcdir’ option to specify where to find the source. (You also need to specify a path to find ‘configure’ itself from your working directory. If the path to ‘configure’ would be the same as the argument to ‘--srcdir’, you can leave out the ‘--srcdir’ option; it is assumed.)

For example, with version 7.10.50.20150918-cvs, you can build GDB in a separate directory for a Sun 4 like this:
cd gdb-7.10.50.20150918-cvs
mkdir ../gdb-sun4
cd ../gdb-sun4
../gdb-7.10.50.20150918-cvs/configure sun4
make

When `configure` builds a configuration using a remote source directory, it creates a tree for the binaries with the same structure (and using the same names) as the tree under the source directory. In the example, you’d find the Sun 4 library `libiberty.a` in the directory `gdb-sun4/libiberty`, and GDB itself in `gdb-sun4/gdb`.

Make sure that your path to the `configure` script has just one instance of `gdb` in it. If your path to `configure` looks like `../gdb-7.10.50.20150918-cvs/gdb/configure`, you are configuring only one subdirectory of GDB, not the whole package. This leads to build errors about missing include files such as `bfd/bfd.h`.

One popular reason to build several GDB configurations in separate directories is to configure GDB for cross-compiling (where GDB runs on one machine—the host—while debugging programs that run on another machine—the target). You specify a cross-debugging target by giving the `--target=target` option to `configure`.

When you run `make` to build a program or library, you must run it in a configured directory—whatever directory you were in when you called `configure` (or one of its subdirectories).

The `Makefile` that `configure` generates in each source directory also runs recursively. If you type `make` in a source directory such as `gdb-7.10.50.20150918-cvs` (or in a separate configured directory configured with `--srcdir=dirname/gdb-7.10.50.20150918-cvs`), you will build all the required libraries, and then build GDB.

When you have multiple hosts or targets configured in separate directories, you can run `make` on them in parallel (for example, if they are NFS-mounted on each of the hosts); they will not interfere with each other.

### C.4 Specifying Names for Hosts and Targets

The specifications used for hosts and targets in the `configure` script are based on a three-part naming scheme, but some short predefined aliases are also supported. The full naming scheme encodes three pieces of information in the following pattern:

```
architecture-vendor-os
```

For example, you can use the alias `sun4` as a host argument, or as the value for `target` in a `--target=target` option. The equivalent full name is `sparc-sun-sunos4.1.1`.

The `configure` script accompanying GDB does not provide any query facility to list all supported host and target names or aliases. `configure` calls the Bourne shell script `config.sub` to map abbreviations to full names; you can read the script, if you wish, or you can use it to test your guesses on abbreviations—for example:

```
% sh config.sub i386-linux
i386-pc-linux-gnu
% sh config.sub alpha-linux
alpha-unknown-linux-gnu
% sh config.sub hp9k700
hppa-1.1-hp-hpux
% sh config.sub sun4
sparc-sun-sunos4.1.1
```
% sh config.sub sun3
m68k-sun-sunos4.1.1
% sh config.sub i986v
Invalid configuration ‘i986v’: machine ‘i986v’ not recognized

config.sub is also distributed in the GDB source directory (‘gdb-7.10.50.20150918-cvs’, for version 7.10.50.20150918-cvs).

C.5 ‘configure’ Options

Here is a summary of the ‘configure’ options and arguments that are most often useful for building GDB. ‘configure’ also has several other options not listed here. See Info file ‘configure.info’, node ‘What Configure Does’, for a full explanation of ‘configure’.

```
configure [--help]
[--prefix=dir]
[--exec-prefix=dir]
[--srcdir=dirname]
[--norecursion] [--rm]
[--target=target] host
```

You may introduce options with a single ‘-’ rather than ‘--’ if you prefer; but you may abbreviate option names if you use ‘--’.

--help     Display a quick summary of how to invoke ‘configure’.
--prefix=dir Configure the source to install programs and files under directory ‘dir’.
--exec-prefix=dir Configure the source to install programs under directory ‘dir’.
--srcdir=dirname Warning: using this option requires GNU make, or another make that implements the VPATH feature.
Use this option to make configurations in directories separate from the GDB source directories. Among other things, you can use this to build (or maintain) several configurations simultaneously, in separate directories. ‘configure’ writes configuration-specific files in the current directory, but arranges for them to use the source in the directory dirname. ‘configure’ creates directories under the working directory in parallel to the source directories below dirname.
--norecursion Configure only the directory level where ‘configure’ is executed; do not propagate configuration to subdirectories.
--target=target Configure GDB for cross-debugging programs running on the specified target. Without this option, GDB is configured to debug programs that run on the same machine (host) as GDB itself.
There is no convenient way to generate a list of all available targets.
host ... Configure GDB to run on the specified host.
There is no convenient way to generate a list of all available hosts.
There are many other options available as well, but they are generally needed for special purposes only.

C.6 System-wide configuration and settings

GDB can be configured to have a system-wide init file; this file will be read and executed at startup (see Section 2.1.3 [What GDB does during startup], page 16).

Here is the corresponding configure option:

--with-system-gdbinit=file

Specify that the default location of the system-wide init file is file.

If GDB has been configured with the option ‘--prefix=$prefix’, it may be subject to relocation. Two possible cases:

• If the default location of this init file contains ‘$prefix’, it will be subject to relocation. Suppose that the configure options are ‘--prefix=$prefix --with-system-gdbinit=$prefix/etc/gdbinit’; if GDB is moved from ‘$prefix’ to ‘$install’, the system init file is looked for as ‘$install/etc/gdbinit’ instead of ‘$prefix/etc/gdbinit’.

• By contrast, if the default location does not contain the prefix, it will not be relocated. E.g. if GDB has been configured with ‘--prefix=/usr/local --with-system-gdbinit=/usr/share/gdb/gdbinit’, then GDB will always look for ‘/usr/share/gdb/gdbinit’, wherever GDB is installed.

If the configured location of the system-wide init file (as given by the ‘--with-system-gdbinit’ option at configure time) is in the data-directory (as specified by ‘--with-gdb-datadir’ at configure time) or in one of its subdirectories, then GDB will look for the system-wide init file in the directory specified by the ‘--data-directory’ command-line option. Note that the system-wide init file is only read once, during GDB initialization. If the data-directory is changed after GDB has started with the set data-directory command, the file will not be reread.

C.6.1 Installed System-wide Configuration Scripts

The ‘system-gdbinit’ directory, located inside the data-directory (as specified by ‘--with-gdb-datadir’ at configure time) contains a number of scripts which can be used as system-wide init files. To automatically source those scripts at startup, GDB should be configured with ‘--with-system-gdbinit’. Otherwise, any user should be able to source them by hand as needed.

The following scripts are currently available:

• ‘elinos.py’ This script is useful when debugging a program on an ELinOS target. It takes advantage of the environment variables defined in a standard ELinOS environment in order to determine the location of the system shared libraries, and then sets the ‘solib-absolute-prefix’ and ‘solib-search-path’ variables appropriately.

• ‘wrs-linux.py’ This script is useful when debugging a program on a target running Wind River Linux. It expects the ENV_PREFIX to be set to the host-side sysroot used by the target system.
Appendix D Maintenance Commands

In addition to commands intended for GDB users, GDB includes a number of commands intended for GDB developers, that are not documented elsewhere in this manual. These commands are provided here for reference. (For commands that turn on debugging messages, see Section 22.9 [Debugging Output], page 308.)

```
maint agent [-at location,] expression
maint agent-eval [-at location,] expression
```

Translate the given expression into remote agent bytecodes. This command is useful for debugging the Agent Expression mechanism (see Appendix F [Agent Expressions], page 675). The ‘agent’ version produces an expression useful for data collection, such as by tracepoints, while ‘maint agent-eval’ produces an expression that evaluates directly to a result. For instance, a collection expression for `globa + globb` will include bytecodes to record four bytes of memory at each of the addresses of `globa` and `globb`, while discarding the result of the addition, while an evaluation expression will do the addition and return the sum. If `-at` is given, generate remote agent bytecode for `location`. If not, generate remote agent bytecode for current frame PC address.

```
maint agent-printf format, expr,...
```

Translate the given format string and list of argument expressions into remote agent bytecodes and display them as a disassembled list. This command is useful for debugging the agent version of dynamic printf (see Section 5.1.8 [Dynamic Printf], page 63).

```
maint info breakpoints
```

Using the same format as ‘info breakpoints’, display both the breakpoints you’ve set explicitly, and those GDB is using for internal purposes. Internal breakpoints are shown with negative breakpoint numbers. The type column identifies what kind of breakpoint is shown:

- **breakpoint**: Normal, explicitly set breakpoint.
- **watchpoint**: Normal, explicitly set watchpoint.
- **longjmp**: Internal breakpoint, used to handle correctly stepping through `longjmp` calls.
- **longjmp resume**: Internal breakpoint at the target of a `longjmp`.
- **until**: Temporary internal breakpoint used by the GDB `until` command.
- **finish**: Temporary internal breakpoint used by the GDB `finish` command.
- **shlib events**: Shared library events.

```
maint info btrace
```

Pint information about raw branch tracing data.
**maint btrace packet-history**

Print the raw branch trace packets that are used to compute the execution history for the `record btrace` command. Both the information and the format in which it is printed depend on the btrace recording format.

**bts**

For the BTS recording format, print a list of blocks of sequential code. For each block, the following information is printed:

- **Block number**
  - Newer blocks have higher numbers. The oldest block has number zero.

- **Lowest `PC`**
- **Highest `PC`**

**pt**

For the Intel(R) Processor Trace recording format, print a list of Intel(R) Processor Trace packets. For each packet, the following information is printed:

- **Packet number**
  - Newer packets have higher numbers. The oldest packet has number zero.

- **Trace offset**
  - The packet’s offset in the trace stream.

- **Packet opcode and payload**

**maint btrace clear-packet-history**

Discards the cached packet history printed by the `maint btrace packet-history` command. The history will be computed again when needed.

**maint btrace clear**

Discard the branch trace data. The data will be fetched anew and the branch trace will be recomputed when needed.

This implicitly truncates the branch trace to a single branch trace buffer. When updating branch trace incrementally, the branch trace available to GDB may be bigger than a single branch trace buffer.

**maint set btrace pt skip-pad**

**maint show btrace pt skip-pad**

Control whether GDB will skip PAD packets when computing the packet history.

**set displaced-stepping**

**show displaced-stepping**

Control whether or not GDB will do displaced stepping if the target supports it. Displaced stepping is a way to single-step over breakpoints without removing them from the inferior, by executing an out-of-line copy of the instruction that was originally at the breakpoint location. It is also known as out-of-line single-stepping.

**set displaced-stepping on**

If the target architecture supports it, GDB will use displaced stepping to step over breakpoints.
Appendix D: Maintenance Commands

**set displaced-stepping off**
GDB will not use displaced stepping to step over breakpoints, even if such is supported by the target architecture.

**set displaced-stepping auto**
This is the default mode. GDB will use displaced stepping only if non-stop mode is active (see Section 5.5.2 [Non-Stop Mode], page 77) and the target architecture supports displaced stepping.

**maint check-psymtabs**
Check the consistency of currently expanded psymtabs versus symtabs. Use this to check, for example, whether a symbol is in one but not the other.

**maint check-symtabs**
Check the consistency of currently expanded symtabs.

**maint expand-symtabs [regexp]**
Expand symbol tables. If regexp is specified, only expand symbol tables for file names matching regexp.

**maint set catch-demangler-crashes [on|off]**
**maint show catch-demangler-crashes**
Control whether GDB should attempt to catch crashes in the symbol name demangler. The default is to attempt to catch crashes. If enabled, the first time a crash is caught, a core file is created, the offending symbol is displayed and the user is presented with the option to terminate the current session.

**maint cplus first_component name**
Print the first C++ class/namespace component of name.

**maint cplus namespace**
Print the list of possible C++ namespaces.

**maint deprecate command [replacement]**
**maint undeprecate command**
Deprecate or undeprecate the named command. Deprecated commands cause GDB to issue a warning when you use them. The optional argument replacement says which newer command should be used in favor of the deprecated one; if it is given, GDB will mention the replacement as part of the warning.

**maint dump-me**
Cause a fatal signal in the debugger and force it to dump its core. This is supported only on systems which support aborting a program with the SIGQUIT signal.

**maint internal-error [message-text]**
**maint internal-warning [message-text]**
**maint demangler-warning [message-text]**
Cause GDB to call the internal function internal_error, internal_warning or demangler_warning and hence behave as though an internal problem has been detected. In addition to reporting the internal problem, these functions give the user the opportunity to either quit GDB or (for internal_error and internal_warning) create a core file of the current GDB session.
These commands take an optional parameter `message-text` that is used as the text of the error or warning message.

Here’s an example of using `internal-error`:

```
(gdb) maint internal-error testing, 1, 2
.../maint.c:121: internal-error: testing, 1, 2
A problem internal to GDB has been detected. Further debugging may prove unreliable.
Quit this debugging session? (y or n) n
Create a core file? (y or n) n
(gdb)
```

```
maint set internal-error action [ask|yes|no]
maint show internal-error action
maint set internal-warning action [ask|yes|no]
maint show internal-warning action
maint set demangler-warning action [ask|yes|no]
maint show demangler-warning action
```

When `gdb` reports an internal problem (error or warning) it gives the user the opportunity to both quit `gdb` and create a core file of the current `gdb` session. These commands let you override the default behaviour for each particular `action`, described in the table below.

<table>
<thead>
<tr>
<th>'quit'</th>
<th>You can specify that <code>gdb</code> should always (yes) or never (no) quit. The default is to ask the user what to do.</th>
</tr>
</thead>
<tbody>
<tr>
<td>'corefile'</td>
<td>You can specify that <code>gdb</code> should always (yes) or never (no) create a core file. The default is to ask the user what to do. Note that there is no <code>corefile</code> option for <code>demangler-warning</code>: demangler warnings always create a core file and this cannot be disabled.</td>
</tr>
</tbody>
</table>

```
maint packet text
```

If `gdb` is talking to an inferior via the serial protocol, then this command sends the string `text` to the inferior, and displays the response packet. `gdb` supplies the initial `'$'` character, the terminating `'#'` character, and the checksum.

```
maint print architecture [file]
```

Print the entire architecture configuration. The optional argument `file` names the file where the output goes.

```
maint print c-tdesc
```

Print the current target description (see Appendix G [Target Descriptions], page 687) as a C source file. The created source file can be used in `gdb` when an XML parser is not available to parse the description.

```
maint print dummy-frames
```

Prints the contents of `gdb`’s internal dummy-frame stack.

```
(gdb) b add
... 
(gdb) print add(2,3)
Breakpoint 2, add (a=2, b=3) at ...
58  return (a + b);
The program being debugged stopped while in a function called from `gdb`. 
```
Appendix D: Maintenance Commands

(gdb) maint print dummy-frames
0xa8206d8: id={stack=0xbfffe734,code=0xbfffe73f,!special}, ptd=process 9353
(gdb)

Takes an optional file parameter.

maint print registers [file]
maint print raw-registers [file]
maint print cooked-registers [file]
maint print register-groups [file]
maint print remote-registers [file]
Print GDB's internal register data structures.

The command maint print raw-registers includes the contents of the raw register cache; the command maint print cooked-registers includes the (cooked) value of all registers, including registers which aren’t available on the target nor visible to user; the command maint print register-groups includes the groups that each register is a member of; and the command maint print remote-registers includes the remote target’s register numbers and offsets in the ‘G’ packets.

These commands take an optional parameter, a file name to which to write the information.

maint print reggroups [file]
Print GDB’s internal register group data structures. The optional argument file tells to what file to write the information.

The register groups info looks like this:

(gdb) maint print reggroups
  Group   Type
  general user
  float    user
  all      user
  vector   user
  system   user
  save     internal
  restore  internal

flushregs
This command forces GDB to flush its internal register cache.

maint print objfiles [regexp]
Print a dump of all known object files. If regexp is specified, only print object files whose names match regexp. For each object file, this command prints its name, address in memory, and all of its psymtabs and symtabs.

maint print user-registers
List all currently available user registers. User registers typically provide alternate names for actual hardware registers. They include the four “standard” registers $fp, $pc, $sp, and $ps. See [standard registers], page 142. User registers can be used in expressions in the same way as the canonical register names, but only the latter are listed by the info registers and maint print registers commands.
maint print section-scripts [regexp]
Print a dump of scripts specified in the .debug_gdb_section section. If regexp is specified, only print scripts loaded by object files matching regexp. For each script, this command prints its name as specified in the objfile, and the full path if known. See Section 23.4.2 [dotdebug_gdb_scripts section], page 443.

maint print statistics
This command prints, for each object file in the program, various data about that object file followed by the byte cache (bcache) statistics for the object file. The objfile data includes the number of minimal, partial, full, and stabs symbols, the number of types defined by the objfile, the number of as yet unexpanded psym tables, the number of line tables and string tables, and the amount of memory used by the various tables. The bcache statistics include the counts, sizes, and counts of duplicates of all and unique objects, max, average, and median entry size, total memory used and its overhead and savings, and various measures of the hash table size and chain lengths.

maint print target-stack
A target is an interface between the debugger and a particular kind of file or process. Targets can be stacked in strata, so that more than one target can potentially respond to a request. In particular, memory accesses will walk down the stack of targets until they find a target that is interested in handling that particular address.
This command prints a short description of each layer that was pushed on the target stack, starting from the top layer down to the bottom one.

maint print type expr
Print the type chain for a type specified by expr. The argument can be either a type name or a symbol. If it is a symbol, the type of that symbol is described. The type chain produced by this command is a recursive definition of the data type as stored in GDB’s data structures, including its flags and contained types.

maint set dwarf always-disassemble
maint show dwarf always-disassemble
Control the behavior of info address when using DWARF debugging information.
The default is off, which means that GDB should try to describe a variable’s location in an easily readable format. When on, GDB will instead display the DWARF location expression in an assembly-like format. Note that some locations are too complex for GDB to describe simply; in this case you will always see the disassembly form.
Here is an example of the resulting disassembly:
(gdb) info addr argc
Symbol "argc" is a complex DWARF expression:
1: DW_OP_fbreg 0
For more information on these expressions, see the DWARF standard.

maint set dwarf max-cache-age
maint show dwarf max-cache-age
Control the DWARF compilation unit cache.
In object files with inter-compilation-unit references, such as those produced by the GCC option `-feliminate-dwarf2-dups`, the DWARF reader needs to frequently refer to previously read compilation units. This setting controls how long a compilation unit will remain in the cache if it is not referenced. A higher limit means that cached compilation units will be stored in memory longer, and more total memory will be used. Setting it to zero disables caching, which will slow down GDB startup, but reduce memory consumption.

`maint set profile`
`maint show profile`
Control profiling of GDB.

Profiling will be disabled until you use the `maint set profile` command to enable it. When you enable profiling, the system will begin collecting timing and execution count data; when you disable profiling or exit GDB, the results will be written to a log file. Remember that if you use profiling, GDB will overwrite the profiling log file (often called `gmon.out`). If you have a record of important profiling data in a `gmon.out` file, be sure to move it to a safe location.

Configuring with `--enable-profiling` arranges for GDB to be compiled with the `-pg` compiler option.

`maint set show-debug-regs`
`maint show show-debug-regs`
Control whether to show variables that mirror the hardware debug registers. Use `on` to enable, `off` to disable. If enabled, the debug registers values are shown when GDB inserts or removes a hardware breakpoint or watchpoint, and when the inferior triggers a hardware-assisted breakpoint or watchpoint.

`maint set show-all-tib`
`maint show show-all-tib`
Control whether to show all non zero areas within a 1k block starting at thread local base, when using the `info w32 thread-information-block` command.

`maint set target-async`
`maint show target-async`
This controls whether GDB targets operate in synchronous or asynchronous mode (see Section 5.5.3 [Background Execution], page 78). Normally the default is asynchronous, if it is available; but this can be changed to more easily debug problems occurring only in synchronous mode.

`maint set target-non-stop`
`maint show target-non-stop`
This controls whether GDB targets always operate in non-stop mode even if `set non-stop` is `off` (see Section 5.5.2 [Non-Stop Mode], page 77). The default is `auto`, meaning non-stop mode is enabled if supported by the target.

`maint set target-non-stop auto`
This is the default mode. GDB controls the target in non-stop mode if the target supports it.
maint set target-non-stop on
GDB controls the target in non-stop mode even if the target does not indicate support.

maint set target-non-stop off
GDB does not control the target in non-stop mode even if the target supports it.

maint set per-command
maint show per-command
GDB can display the resources used by each command. This is useful in debugging performance problems.

maint set per-command space [on|off]
maint show per-command space
Enable or disable the printing of the memory used by GDB for each command. If enabled, GDB will display how much memory each command took, following the command’s own output. This can also be requested by invoking GDB with the ‘--statistics’ command-line switch (see Section 2.1.2 [Mode Options], page 13).

maint set per-command time [on|off]
maint show per-command time
Enable or disable the printing of the execution time of GDB for each command. If enabled, GDB will display how much time it took to execute each command, following the command’s own output. Both CPU time and wallclock time are printed. Printing both is useful when trying to determine whether the cost is CPU or, e.g., disk/network latency. Note that the CPU time printed is for GDB only, it does not include the execution time of the inferior because there’s no mechanism currently to compute how much time was spent by GDB and how much time was spent by the program been debugged. This can also be requested by invoking GDB with the ‘--statistics’ command-line switch (see Section 2.1.2 [Mode Options], page 13).

maint set per-command symtab [on|off]
maint show per-command symtab
Enable or disable the printing of basic symbol table statistics for each command. If enabled, GDB will display the following information:

a. number of symbol tables
b. number of primary symbol tables
c. number of blocks in the blockvector

maint space value
An alias for maint set per-command space. A non-zero value enables it, zero disables it.
maint time value
   An alias for maint set per-command time. A non-zero value enables it, zero disables it.

maint translate-address [section] addr
   Find the symbol stored at the location specified by the address addr and an optional section name section. If found, GDB prints the name of the closest symbol and an offset from the symbol’s location to the specified address. This is similar to the info address command (see Chapter 16 [Symbols], page 217), except that this command also allows to find symbols in other sections.
   If section was not specified, the section in which the symbol was found is also printed. For dynamically linked executables, the name of executable or shared library containing the symbol is printed as well.

   The following command is useful for non-interactive invocations of GDB, such as in the test suite.

set watchdog nsec
   Set the maximum number of seconds GDB will wait for the target operation to finish. If this time expires, GDB reports an error and the command is aborted.

show watchdog
   Show the current setting of the target wait timeout.
Appendix E  GDB Remote Serial Protocol

E.1 Overview

There may be occasions when you need to know something about the protocol—for example, if there is only one serial port to your target machine, you might want your program to do something special if it recognizes a packet meant for GDB.

In the examples below, ‘->’ and ‘<-’ are used to indicate transmitted and received data, respectively.

All GDB commands and responses (other than acknowledgments and notifications, see Section E.9 [Notification Packets], page 653) are sent as a packet. A packet is introduced with the character ‘$’, the actual packet-data, and the terminating character ‘#’ followed by a two-digit checksum:

$\text{packet-data}\#\text{checksum}$

The two-digit checksum is computed as the modulo 256 sum of all characters between the leading ‘$’ and the trailing ‘#’ (an eight bit unsigned checksum).

Implementors should note that prior to GDB 5.0 the protocol specification also included an optional two-digit sequence-id:

$\text{sequence-id:packet-data}\#\text{checksum}$

That sequence-id was appended to the acknowledgment. GDB has never output sequence-ids. Stubs that handle packets added since GDB 5.0 must not accept sequence-id.

When either the host or the target machine receives a packet, the first response expected is an acknowledgment: either ‘+’ (to indicate the package was received correctly) or ‘-’ (to request retransmission):

$\text{-> }\text{packet-data}\#\text{checksum}$

$\text{<- }+\text{ checksum}$

The ‘+’/‘-’ acknowledgments can be disabled once a connection is established. See Section E.11 [Packet Acknowledgment], page 656, for details.

The host (GDB) sends commands, and the target (the debugging stub incorporated in your program) sends a response. In the case of step and continue commands, the response is only sent when the operation has completed, and the target has again stopped all threads in all attached processes. This is the default all-stop mode behavior, but the remote protocol also supports GDB’s non-stop execution mode; see Section E.10 [Remote Non-Stop], page 655, for details.

packet-data consists of a sequence of characters with the exception of ‘#’ and ‘$’ (see ‘X’ packet for additional exceptions).

Fields within the packet should be separated using ‘,’ ‘;’ or ‘:’. Except where otherwise noted all numbers are represented in HEX with leading zeros suppressed.

Implementors should note that prior to GDB 5.0, the character ‘;’ could not appear as the third character in a packet (as it would potentially conflict with the sequence-id).

Binary data in most packets is encoded either as two hexadecimal digits per byte of binary data. This allowed the traditional remote protocol to work over connections which were only seven-bit clean. Some packets designed more recently assume an eight-bit clean connection, and use a more efficient encoding to send and receive binary data.
The binary data representation uses 7d (ASCII ‘\{’) as an escape character. Any escaped byte is transmitted as the escape character followed by the original character XORed with 0x20. For example, the byte 0x7d would be transmitted as the two bytes 0x7d 0x5d. The bytes 0x23 (ASCII ‘#’), 0x24 (ASCII ‘$’), and 0x7d (ASCII ‘\{’) must always be escaped. Responses sent by the stub must also escape 0x2a (ASCII ‘*’), so that it is not interpreted as the start of a run-length encoded sequence (described next).

Response data can be run-length encoded to save space. Run-length encoding replaces runs of identical characters with one instance of the repeated character, followed by a ‘*’ and a repeat count. The repeat count is itself sent encoded, to avoid binary characters in data: a value of \( n \) is sent as \( n+29 \). For a repeat count greater or equal to 3, this produces a printable ASCII character, e.g. a space (ASCII code 32) for a repeat count of 3. (This is because run-length encoding starts to win for counts 3 or more.) Thus, for example, ‘0*’ is a run-length encoding of “0000”: the space character after ‘*’ means repeat the leading 0 32 - 29 = 3 more times.

The printable characters ‘#’ and ‘$’ or with a numeric value greater than 126 must not be used. Runs of six repeats (‘#’) or seven repeats (‘$’) can be expanded using a repeat count of only five (‘\*’). For example, ‘00000000’ can be encoded as ‘0*”00’.

The error response returned for some packets includes a two character error number. That number is not well defined.

For any command not supported by the stub, an empty response (‘$\#00’) should be returned. That way it is possible to extend the protocol. A newer gdb can tell if a packet is supported based on that response.

At a minimum, a stub is required to support the ‘g’ and ‘G’ commands for register access, and the ‘m’ and ‘M’ commands for memory access. Stubs that only control single-threaded targets can implement run control with the ‘c’ (continue), and ‘s’ (step) commands. Stubs that support multi-threading targets should support the ‘vCont’ command. All other commands are optional.

E.2 Packets

The following table provides a complete list of all currently defined commands and their corresponding response data. See Section E.13 [File-I/O Remote Protocol Extension], page 657, for details about the File I/O extension of the remote protocol.

Each packet’s description has a template showing the packet’s overall syntax, followed by an explanation of the packet’s meaning. We include spaces in some of the templates for clarity; these are not part of the packet’s syntax. No gdb packet uses spaces to separate its components. For example, a template like ‘foo bar baz’ describes a packet beginning with the three ASCII bytes ‘foo’, followed by a bar, followed directly by a baz. gdb does not transmit a space character between the ‘foo’ and the bar, or between the bar and the baz.

Several packets and replies include a thread-id field to identify a thread. Normally these are positive numbers with a target-specific interpretation, formatted as big-endian hex strings. A thread-id can also be a literal ‘-1’ to indicate all threads, or ‘0’ to pick any thread.

In addition, the remote protocol supports a multiprocess feature in which the thread-id syntax is extended to optionally include both process and thread ID fields, as ‘ppid.tid’.
The *pid* (process) and *tid* (thread) components each have the format described above: a positive number with target-specific interpretation formatted as a big-endian hex string, literal ‘-1’ to indicate all processes or threads (respectively), or ‘0’ to indicate an arbitrary process or thread. Specifying just a process, as ‘ppid’, is equivalent to ‘p-1-tid’. It is an error to specify all processes but a specific thread, such as ‘p-1-tid’. Note that the ‘p’ prefix is *not* used for those packets and replies explicitly documented to include a process ID, rather than a thread-id.

The multiprocess thread-id syntax extensions are only used if both GDB and the stub report support for the ‘multiprocess’ feature using ‘qSupported’. See [multiprocess extensions], page 634, for more information.

Note that all packet forms beginning with an upper- or lower-case letter, other than those described here, are reserved for future use.

Here are the packet descriptions.

‘!’ Enable extended mode. In extended mode, the remote server is made persistent. The ‘R’ packet is used to restart the program being debugged.

Reply:

‘OK’ The remote target both supports and has enabled extended mode.

‘?’ Indicate the reason the target halted. The reply is the same as for step and continue. This packet has a special interpretation when the target is in non-stop mode; see Section E.10 [Remote Non-Stop], page 655.

Reply: See Section E.3 [Stop Reply Packets], page 618, for the reply specifications.

‘A arglen, argnum, arg,...’

Initialized argv[] array passed into program. arglen specifies the number of bytes in the hex encoded byte stream arg. See gdbserver for more details.

Reply:

‘OK’ The arguments were set.

‘E NN’ An error occurred.

‘b baud’ (Don’t use this packet; its behavior is not well-defined.) Change the serial line speed to baud.

JTC: *When does the transport layer state change? When it’s received, or after the ACK is transmitted. In either case, there are problems if the command or the acknowledgment packet is dropped.*

Stan: *If people really wanted to add something like this, and get it working for the first time, they ought to modify ser-unix.c to send some kind of out-of-band message to a specially-setup stub and have the switch happen "in between" packets, so that from remote protocol’s point of view, nothing actually happened.*

‘B addr, mode’

Set *(mode is ‘S’) or clear *(mode is ‘C’)* a breakpoint at addr.

Don’t use this packet. Use the ‘Z’ and ‘z’ packets instead (see [insert breakpoint or watchpoint packet], page 616).
‘bc’  Backward continue. Execute the target system in reverse. No parameter. See Chapter 6 [Reverse Execution], page 83, for more information.

Reply: See Section E.3 [Stop Reply Packets], page 618, for the reply specifications.

‘bs’  Backward single step. Execute one instruction in reverse. No parameter. See Chapter 6 [Reverse Execution], page 83, for more information.

Reply: See Section E.3 [Stop Reply Packets], page 618, for the reply specifications.

‘c [addr]’  Continue at addr, which is the address to resume. If addr is omitted, resume at current address.

This packet is deprecated for multi-threading support. See [vCont packet], page 614.

Reply: See Section E.3 [Stop Reply Packets], page 618, for the reply specifications.

‘C sig;addr’  Continue with signal sig (hex signal number). If ‘;addr’ is omitted, resume at same address.

This packet is deprecated for multi-threading support. See [vCont packet], page 614.

Reply: See Section E.3 [Stop Reply Packets], page 618, for the reply specifications.

‘d’  Toggle debug flag.

Don’t use this packet; instead, define a general set packet (see Section E.4 [General Query Packets], page 621).

‘D’  The first form of the packet is used to detach GDB from the remote system. It is sent to the remote target before GDB disconnects via the detach command.

The second form, including a process ID, is used when multiprocess protocol extensions are enabled (see [multiprocess extensions], page 634), to detach only a specific process. The pid is specified as a big-endian hex string.

Reply:

‘OK’  for success

‘E NN’  for an error

‘F RC,EE,CF;XX’  A reply from GDB to an ‘F’ packet sent by the target. This is part of the File-I/O protocol extension. See Section E.13 [File-I/O Remote Protocol Extension], page 657, for the specification.

‘g’  Read general registers.

Reply:
Each byte of register data is described by two hex digits. The bytes with the register are transmitted in target byte order. The size of each register and their position within the ‘g’ packet are determined by the GDB internal gdbarch functions `DEPRECATED_REGISTER_RAW_SIZE` and `gdbarch_register_name`. The specification of several standard ‘g’ packets is specified below.

When reading registers from a trace frame (see Section 13.2 [Using the Collected Data], page 175), the stub may also return a string of literal ‘x’’s in place of the register data digits, to indicate that the corresponding register has not been collected, thus its value is unavailable. For example, for an architecture with 4 registers of 4 bytes each, the following reply indicates to GDB that registers 0 and 2 have not been collected, while registers 1 and 3 have been collected, and both have zero value:

```
-> g
<- xxxxxxxx00000000xxxxxxxx00000000
```

‘E N N’ for an error.

‘G XX...’ Write general registers. See [read registers packet], page 610, for a description of the XX... data.

Reply:

‘OK’ for success

‘E N N’ for an error

‘H op thread-id’ Set thread for subsequent operations (‘m’, ‘M’, ‘g’, ‘G’, et.al.). Depending on the operation to be performed, op should be ‘c’ for step and continue operations (note that this is deprecated, supporting the ‘vCont’ command is a better option), and ‘g’ for other operations. The thread designator thread-id has the format and interpretation described in [thread-id syntax], page 608.

Reply:

‘OK’ for success

‘E N N’ for an error

‘i [addr[,nnn]]’ Step the remote target by a single clock cycle. If ‘,nnn’ is present, cycle step nnn cycles. If addr is present, cycle step starting at that address.

‘I’ Signal, then cycle step. See [step with signal packet], page 613. See [cycle step packet], page 611.

‘k’ Kill request.

The exact effect of this packet is not specified.

For a bare-metal target, it may power cycle or reset the target system. For that reason, the ‘k’ packet has no reply.

For a single-process target, it may kill that process if possible.
A multiple-process target may choose to kill just one process, or all that are under GDB’s control. For more precise control, use the vKill packet (see \[vKill packet\], page 616).

If the target system immediately closes the connection in response to ‘k’, GDB does not consider the lack of packet acknowledgment to be an error, and assumes the kill was successful.

If connected using target extended-remote, and the target does not close the connection in response to a kill request, GDB probes the target state as if a new connection was opened (see \[? packet\], page 609).

\[m \text{addr, length}\]
Read \(length\) addressable memory units starting at address \(addr\) (see \[addressable memory unit\], page 123). Note that \(addr\) may not be aligned to any particular boundary.

The stub need not use any particular size or alignment when gathering data from memory for the response; even if \(addr\) is word-aligned and \(length\) is a multiple of the word size, the stub is free to use byte accesses, or not. For this reason, this packet may not be suitable for accessing memory-mapped I/O devices.

Reply:

\[XX\ldots\] Memory contents; each byte is transmitted as a two-digit hexadecimal number. The reply may contain fewer addressable memory units than requested if the server was able to read only part of the region of memory.

\[E NN\] \(NN\) is errno

\[M \text{addr, length}:XX\ldots\]
Write \(length\) addressable memory units starting at address \(addr\) (see \[addressable memory unit\], page 123). The data is given by \(XX\ldots\); each byte is transmitted as a two-digit hexadecimal number.

Reply:

\[OK\] for success

\[E NN\] for an error (this includes the case where only part of the data was written).

\[p n\] Read the value of register \(n\); \(n\) is in hex. See \[read registers packet\], page 610, for a description of how the returned register value is encoded.

Reply:

\[XX\ldots\] the register’s value

\[E NN\] for an error

\[\cdot\] Indicating an unrecognized query.

\[p n\ldots=r\ldots\]
Write register \(n\ldots\) with value \(r\ldots\). The register number \(n\) is in hexadecimal, and \(r\ldots\) contains two hex digits for each byte in the register (target byte order).

Reply:
Appendix E: GDB Remote Serial Protocol

- `OK` for success
- `E NN` for an error

- `q name params...`
- `Q name params...`
  General query (`q`) and set (`Q`). These packets are described fully in Section E.4 [General Query Packets], page 621.

- `r`
  Reset the entire system.
  Don’t use this packet; use the ‘R’ packet instead.

- `R XX`
  Restart the program being debugged. The XX, while needed, is ignored. This packet is only available in extended mode (see [extended mode], page 609).
  The ‘R’ packet has no reply.

- `s [addr]`
  Single step, resuming at `addr`. If `addr` is omitted, resume at same address.
  This packet is deprecated for multi-threading support. See [vCont packet], page 614.
  Reply: See Section E.3 [Stop Reply Packets], page 618, for the reply specifications.

- `S sig[;addr]`
  Step with signal. This is analogous to the ‘C’ packet, but requests a single-step, rather than a normal resumption of execution.
  This packet is deprecated for multi-threading support. See [vCont packet], page 614.
  Reply: See Section E.3 [Stop Reply Packets], page 618, for the reply specifications.

- `t addr:PP,MM`
  Search backwards starting at address `addr` for a match with pattern `PP` and mask `MM`, both of which are are 4 byte long. There must be at least 3 digits in `addr`.

- `T thread-id`
  Find out if the thread `thread-id` is alive. See [thread-id syntax], page 608.
  Reply:
  - `OK` thread is still alive
  - `E NN` thread is dead

- `v`
  Packets starting with ‘v’ are identified by a multi-letter name, up to the first ‘;’ or ‘?’ (or the end of the packet).

- `vAttach;pid`
  Attach to a new process with the specified process ID `pid`. The process ID is a hexadecimal integer identifying the process. In all-stop mode, all threads in the attached process are stopped; in non-stop mode, it may be attached without being stopped if that is supported by the target.
  This packet is only available in extended mode (see [extended mode], page 609).
  Reply:
'E nn' for an error

'Any stop packet'
for success in all-stop mode (see Section E.3 [Stop Reply Packets], page 618)

'OK' for success in non-stop mode (see Section E.10 [Remote Non-Stop], page 655)

'vCont[:action[:thread-id]]...

Resume the inferior, specifying different actions for each thread. If an action is specified with no thread-id, then it is applied to any threads that don’t have a specific action specified; if no default action is specified then other threads should remain stopped in all-stop mode and in their current state in non-stop mode. Specifying multiple default actions is an error; specifying no actions is also an error. Thread IDs are specified using the syntax described in [thread-id syntax], page 608.

Currently supported actions are:

'c' Continue.

'C sig' Continue with signal sig. The signal sig should be two hex digits.

's' Step.

'S sig' Step with signal sig. The signal sig should be two hex digits.

't' Stop.

'r start,end'
Step once, and then keep stepping as long as the thread stops at addresses between start (inclusive) and end (exclusive). The remote stub reports a stop reply when either the thread goes out of the range or is stopped due to an unrelated reason, such as hitting a breakpoint. See [range stepping], page 71.

If the range is empty (start == end), then the action becomes equivalent to the ‘s’ action. In other words, single-step once, and report the stop (even if the stepped instruction jumps to start).

(A stop reply may be sent at any point even if the PC is still within the stepping range; for example, it is valid to implement this packet in a degenerate way as a single instruction step operation.)

The optional argument addr normally associated with the ‘c’, ‘C’, ‘s’, and ‘S’ packets is not supported in ‘vCont’.

The ‘t’ action is only relevant in non-stop mode (see Section E.10 [Remote Non-Stop], page 655) and may be ignored by the stub otherwise. A stop reply should be generated for any affected thread not already stopped. When a thread is stopped by means of a ‘t’ action, the corresponding stop reply should indicate that the thread has stopped with signal ‘0’, regardless of whether the target uses some other signal as an implementation detail.

The stub must support ‘vCont’ if it reports support for multiprocess extensions (see [multiprocess extensions], page 634). Note that in this case ‘vCont’ actions
can be specified to apply to all threads in a process by using the `ppid.-1` form of the thread-id.

Reply: See Section E.3 [Stop Reply Packets], page 618, for the reply specifications.

`vCont?` Request a list of actions supported by the `vCont` packet.

Reply:

`vCont[; action... ]`

The `vCont` packet is supported. Each action is a supported command in the `vCont` packet.

`vCont` The `vCont` packet is not supported.

`vFile: operation: parameter...` Perform a file operation on the target system. For details, see Section E.7 [Host I/O Packets], page 651.

`vFlashErase: addr, length` Direct the stub to erase length bytes of flash starting at addr. The region may enclose any number of flash blocks, but its start and end must fall on block boundaries, as indicated by the flash block size appearing in the memory map (see Section E.16 [Memory Map Format], page 670). GDB groups flash memory programming operations together, and sends a `vFlashDone` request after each group; the stub is allowed to delay erase operation until the `vFlashDone` packet is received.

Reply:

`OK` for success
`E NN` for an error

`vFlashWrite: addr: XX...` Direct the stub to write data to flash address addr. The data is passed in binary form using the same encoding as for the `X` packet (see [Binary Data], page 607). The memory ranges specified by `vFlashWrite` packets preceding a `vFlashDone` packet must not overlap, and must appear in order of increasing addresses (although `vFlashErase` packets for higher addresses may already have been received; the ordering is guaranteed only between `vFlashWrite` packets). If a packet writes to an address that was neither erased by a preceding `vFlashErase` packet nor by some other target-specific method, the results are unpredictable.

Reply:

`OK` for success
`E memtype` for `vFlashWrite` addressing non-flash memory
`E NN` for an error

`vFlashDone` Indicate to the stub that flash programming operation is finished. The stub is permitted to delay or batch the effects of a group of `vFlashErase` and
‘vFlashWrite’ packets until a ‘vFlashDone’ packet is received. The contents of the affected regions of flash memory are unpredictable until the ‘vFlashDone’ request is completed.

‘vKill; pid’
Kill the process with the specified process ID pid, which is a hexadecimal integer identifying the process. This packet is used in preference to ‘k’ when multiprocess protocol extensions are supported; see [multiprocess extensions], page 634.
Reply:
‘E nn’ for an error
‘OK’ for success

‘vRun; filename[; argument]...’
Run the program filename, passing it each argument on its command line. The file and arguments are hex-encoded strings. If filename is an empty string, the stub may use a default program (e.g. the last program run). The program is created in the stopped state.
This packet is only available in extended mode (see [extended mode], page 609).
Reply:
‘E nn’ for an error
‘Any stop packet’ for success (see Section E.3 [Stop Reply Packets], page 618)

‘vStopped’
See Section E.9 [Notification Packets], page 653.

‘X addr,length:XX...’
Write data to memory, where the data is transmitted in binary. Memory is specified by its address addr and number of addressable memory units length (see [addressable memory unit], page 123); ‘XX...’ is binary data (see [Binary Data], page 607).
Reply:
‘OK’ for success
‘E NN’ for an error

‘z type,addr,kind’
‘Z type,addr,kind’
Insert (‘Z’) or remove (‘z’) a type breakpoint or watchpoint starting at address address of kind kind.
Each breakpoint and watchpoint packet type is documented separately.
Implementation notes: A remote target shall return an empty string for an unrecognized breakpoint or watchpoint packet type. A remote target shall support either both or neither of a given ‘Ztype...’ and ‘ztype...’ packet pair. To avoid potential problems with duplicate packets, the operations should be implemented in an idempotent way.
Appendix E: GDB Remote Serial Protocol

'z0,addr,kind'

Insert ('Z0') or remove ('z0') a memory breakpoint at address *addr* of type *kind*.

A memory breakpoint is implemented by replacing the instruction at *addr* with a software breakpoint or trap instruction. The *kind* is target-specific and typically indicates the size of the breakpoint in bytes that should be inserted. E.g., the ARM and MIPS can insert either a 2 or 4 byte breakpoint. Some architectures have additional meanings for *kind*; *cond_list* is an optional list of conditional expressions in bytecode form that should be evaluated on the target’s side. These are the conditions that should be taken into consideration when deciding if the breakpoint trigger should be reported back to GDBN.

See also the ‘swbreak’ stop reason (see [swbreak stop reason], page 619) for how to best report a memory breakpoint event to GDB.

The *cond_list* parameter is comprised of a series of expressions, concatenated without separators. Each expression has the following form:

'X len,expr'

*len* is the length of the bytecode expression and *expr* is the actual conditional expression in bytecode form.

The optional *cmd_list* parameter introduces commands that may be run on the target, rather than being reported back to GDB. The parameter starts with a numeric flag *persist*; if the flag is nonzero, then the breakpoint may remain active and the commands continue to be run even when GDB disconnects from the target. Following this flag is a series of expressions concatenated with no separators. Each expression has the following form:

'X len,expr'

*len* is the length of the bytecode expression and *expr* is the actual conditional expression in bytecode form.

see Section E.5 [Architecture-Specific Protocol Details], page 643.

Implementation note: It is possible for a target to copy or move code that contains memory breakpoints (e.g., when implementing overlays). The behavior of this packet, in the presence of such a target, is not defined.

Reply:

'OK'    success
'
' not supported
'E NN' for an error

'z1,addr,kind'

'Z1,addr,kind[;cond_list...]'

Insert ('Z1') or remove ('z1') a hardware breakpoint at address *addr*.

A hardware breakpoint is implemented using a mechanism that is not dependant on being able to modify the target’s memory. The *kind* and *cond_list* have the same meaning as in ‘Z0’ packets.
Implementation note: A hardware breakpoint is not affected by code movement.

Reply:

‘OK’ success
‘?’ not supported
‘E NN’ for an error

‘z2, addr, kind’
‘Z2, addr, kind’
Insert (‘Z2’) or remove (‘z2’) a write watchpoint at addr. The number of bytes to watch is specified by kind.

Reply:

‘OK’ success
‘?’ not supported
‘E NN’ for an error

‘z3, addr, kind’
‘Z3, addr, kind’
Insert (‘Z3’) or remove (‘z3’) a read watchpoint at addr. The number of bytes to watch is specified by kind.

Reply:

‘OK’ success
‘?’ not supported
‘E NN’ for an error

‘z4, addr, kind’
‘Z4, addr, kind’
Insert (‘Z4’) or remove (‘z4’) an access watchpoint at addr. The number of bytes to watch is specified by kind.

Reply:

‘OK’ success
‘?’ not supported
‘E NN’ for an error

E.3 Stop Reply Packets

The ‘C’, ‘c’, ‘S’, ‘s’, ‘vCont’, ‘vAttach’, ‘vRun’, ‘vStopped’, and ‘?’ packets can receive any of the below as a reply. Except for ‘?’ and ‘vStopped’, that reply is only returned when the target halts. In the below the exact meaning of signal number is defined by the header ‘include/gdb/signals.h’ in the GDB source code.

As in the description of request packets, we include spaces in the reply templates for clarity; these are not part of the reply packet’s syntax. No GDB stop reply packet uses spaces to separate its components.
The program received signal number AA (a two-digit hexadecimal number). This is equivalent to a ‘T’ response with no n:r pairs.

The program received signal number AA (a two-digit hexadecimal number). This is equivalent to an ‘S’ response, except that the ‘n:r’ pairs can carry values of important registers and other information directly in the stop reply packet, reducing round-trip latency. Single-step and breakpoint traps are reported this way. Each ‘n:r’ pair is interpreted as follows:

- If \( n \) is a hexadecimal number, it is a register number, and the corresponding \( r \) gives that register’s value. The data \( r \) is a series of bytes in target byte order, with each byte given by a two-digit hex number.
- If \( n \) is ‘thread’, then \( r \) is the thread-id of the stopped thread, as specified in [thread-id syntax], page 608.
- If \( n \) is ‘core’, then \( r \) is the hexadecimal number of the core on which the stop event was detected.
- If \( n \) is a recognized stop reason, it describes a more specific event that stopped the target. The currently defined stop reasons are listed below. The \( aa \) should be ‘05’, the trap signal. At most one stop reason should be present.
- Otherwise, GDB should ignore this ‘n:r’ pair and go on to the next; this allows us to extend the protocol in the future.

The currently defined stop reasons are:

- ‘watch’
- ‘rwatch’
- ‘awatch’ The packet indicates a watchpoint hit, and \( r \) is the data address, in hex.
- ‘library’ The packet indicates that the loaded libraries have changed. GDB should use ‘qXfer:libraries:read’ to fetch a new list of loaded libraries. The \( r \) part is ignored.
- ‘replaylog’ The packet indicates that the target cannot continue replaying logged execution events, because it has reached the end (or the beginning when executing backward) of the log. The value of \( r \) will be either ‘begin’ or ‘end’. See Chapter 6 [Reverse Execution], page 83, for more information.
- ‘swbreak’ The packet indicates a memory breakpoint instruction was executed, irrespective of whether it was GDB that planted the breakpoint or the breakpoint is hardcoded in the program. The \( r \) part must be left empty.

On some architectures, such as x86, at the architecture level, when a breakpoint instruction executes the program counter points at the breakpoint address plus an offset. On such targets, the stub is
responsible for adjusting the PC to point back at the breakpoint address.

This packet should not be sent by default; older GDB versions did not support it. GDB requests it, by supplying an appropriate ‘qSupported’ feature (see [qSupported], page 628). The remote stub must also supply the appropriate ‘qSupported’ feature indicating support.

This packet is required for correct non-stop mode operation.

‘hwbreak’  The packet indicates the target stopped for a hardware breakpoint. The r part must be left empty.

The same remarks about ‘qSupported’ and non-stop mode above apply.

‘fork’  The packet indicates that fork was called, and r is the thread ID of the new child process. Refer to [thread-id syntax], page 608 for the format of the thread-id field. This packet is only applicable to targets that support fork events.

This packet should not be sent by default; older GDB versions did not support it. GDB requests it, by supplying an appropriate ‘qSupported’ feature (see [qSupported], page 628). The remote stub must also supply the appropriate ‘qSupported’ feature indicating support.

‘vfork’  The packet indicates that vfork was called, and r is the thread ID of the new child process. Refer to [thread-id syntax], page 608 for the format of the thread-id field. This packet is only applicable to targets that support vfork events.

This packet should not be sent by default; older GDB versions did not support it. GDB requests it, by supplying an appropriate ‘qSupported’ feature (see [qSupported], page 628). The remote stub must also supply the appropriate ‘qSupported’ feature indicating support.

‘vforkdone’  The packet indicates that a child process created by a vfork has either called exec or terminated, so that the address spaces of the parent and child process are no longer shared. The r part is ignored.

This packet is only applicable to targets that support vforkdone events.

This packet should not be sent by default; older GDB versions did not support it. GDB requests it, by supplying an appropriate ‘qSupported’ feature (see [qSupported], page 628). The remote stub must also supply the appropriate ‘qSupported’ feature indicating support.

‘exec’  The packet indicates that execve was called, and r is the absolute pathname of the file that was executed, in hex. This packet is only applicable to targets that support exec events.
This packet should not be sent by default; older GDB versions did not support it. GDB requests it, by supplying an appropriate 'qSupported' feature (see [qSupported], page 628). The remote stub must also supply the appropriate 'qSupported' feature indicating support.

'W AA'
'W AA ; process:pid'
The process exited, and AA is the exit status. This is only applicable to certain targets.
The second form of the response, including the process ID of the exited process, can be used only when GDB has reported support for multiprocess protocol extensions; see [multiprocess extensions], page 634. The pid is formatted as a big-endian hex string.

'X AA'
'X AA ; process:pid'
The process terminated with signal AA.
The second form of the response, including the process ID of the terminated process, can be used only when GDB has reported support for multiprocess protocol extensions; see [multiprocess extensions], page 634. The pid is formatted as a big-endian hex string.

'O XX...' 'XX...' is hex encoding of ASCII data, to be written as the program’s console output. This can happen at any time while the program is running and the debugger should continue to wait for ‘W’, ‘T’, etc. This reply is not permitted in non-stop mode.

'F call-id,parameter...'
call-id is the identifier which says which host system call should be called. This is just the name of the function. Translation into the correct system call is only applicable as it's defined in GDB. See Section E.13 [File-I/O Remote Protocol Extension], page 657, for a list of implemented system calls.

'parameter...' is a list of parameters as defined for this very system call.
The target replies with this packet when it expects GDB to call a host system call on behalf of the target. GDB replies with an appropriate ‘F’ packet and keeps up waiting for the next reply packet from the target. The latest ‘C’, ‘c’, ‘S’ or ‘s’ action is expected to be continued. See Section E.13 [File-I/O Remote Protocol Extension], page 657, for more details.

E.4 General Query Packets
Packets starting with ‘q’ are general query packets; packets starting with ‘Q’ are general set packets. General query and set packets are a semi-unified form for retrieving and sending information to and from the stub.

The initial letter of a query or set packet is followed by a name indicating what sort of thing the packet applies to. For example, GDB may use a ‘qSymbol’ packet to exchange symbol definitions with the stub. These packet names follow some conventions:
• The name must not contain commas, colons or semicolons.
• Most GDB query and set packets have a leading upper case letter.
• The names of custom vendor packets should use a company prefix, in lower case, followed by a period. For example, packets designed at the Acme Corporation might begin with ‘qacme.foo’ (for querying foos) or ‘Qacme.bar’ (for setting bars).

The name of a query or set packet should be separated from any parameters by a ‘:’; the parameters themselves should be separated by ‘,’ or ‘;’. Stubs must be careful to match the full packet name, and check for a separator or the end of the packet, in case two packet names share a common prefix. New packets should not begin with ‘qC’, ‘qP’, or ‘qL’.

Like the descriptions of the other packets, each description here has a template showing the packet’s overall syntax, followed by an explanation of the packet’s meaning. We include spaces in some of the templates for clarity; these are not part of the packet’s syntax. No GDB packet uses spaces to separate its components.

Here are the currently defined query and set packets:

`QAgent:1`  
`QAgent:0`  
Turn on or off the agent as a helper to perform some debugging operations delegated from GDB (see [Control Agent], page 553).

`QAllow:op:val...`  
Specify which operations GDB expects to request of the target, as a semicolon-separated list of operation name and value pairs. Possible values for op include ‘WriteReg’, ‘WriteMem’, ‘InsertBreak’, ‘InsertTrace’, ‘InsertFastTrace’, and ‘Stop’. val is either 0, indicating that GDB will not request the operation, or 1, indicating that it may. (The target can then use this to set up its own internals optimally, for instance if the debugger never expects to insert breakpoints, it may not need to install its own trap handler.)

`qC`  
Return the current thread ID.

Reply:

`QC thread-id`  
Where thread-id is a thread ID as documented in [thread-id syntax], page 608.

`(anything else)`  
Any other reply implies the old thread ID.

`qCRC:addr,length`  
Compute the CRC checksum of a block of memory using CRC-32 defined in IEEE 802.3. The CRC is computed byte at a time, taking the most significant bit of each byte first. The initial pattern code 0xffffffff is used to ensure leading zeros affect the CRC.

---

1 The ‘qP’ and ‘qL’ packets predate these conventions, and have arguments without any terminator for the packet name; we suspect they are in widespread use in places that are difficult to upgrade. The ‘qC’ packet has no arguments, but some existing stubs (e.g. RedBoot) are known to not check for the end of the packet.
Note: This is the same CRC used in validating separate debug files (see Section 18.3 [Debugging Information in Separate Files], page 246). However the algorithm is slightly different. When validating separate debug files, the CRC is computed taking the least significant bit of each byte first, and the final result is inverted to detect trailing zeros.

Reply:

‘E NN’  An error (such as memory fault)
‘C crc32’  The specified memory region’s checksum is crc32.

QDisableRandomization: value

Some target operating systems will randomize the virtual address space of the inferior process as a security feature, but provide a feature to disable such randomization, e.g. to allow for a more deterministic debugging experience. On such systems, this packet with a value of 1 directs the target to disable address space randomization for processes subsequently started via ‘vRun’ packets, while a packet with a value of 0 tells the target to enable address space randomization. This packet is only available in extended mode (see [extended mode], page 609).

Reply:

‘OK’  The request succeeded.
‘E nn’  An error occurred. The error number nn is given as hex digits.
‘’  An empty reply indicates that ‘QDisableRandomization’ is not supported by the stub.

This packet is not probed by default; the remote stub must request it, by supplying an appropriate ‘qSupported’ response (see [qSupported], page 628). This should only be done on targets that actually support disabling address space randomization.

qfThreadInfo
qsThreadInfo

Obtain a list of all active thread IDs from the target (OS). Since there may be too many active threads to fit into one reply packet, this query works iteratively: it may require more than one query/reply sequence to obtain the entire list of threads. The first query of the sequence will be the ‘qfThreadInfo’ query; subsequent queries in the sequence will be the ‘qsThreadInfo’ query.

NOTE: This packet replaces the ‘qL’ query (see below).

Reply:

‘m thread-id’
A single thread ID

‘m thread-id,thread-id...’
a comma-separated list of thread IDs

‘L’  (lower case letter ‘L’) denotes end of list.

In response to each query, the target will reply with a list of one or more thread IDs, separated by commas. gdb will respond to each reply with a request for
more thread ids (using the ‘qs’ form of the query), until the target responds
with ‘1’ (lower-case ell, for last). Refer to [thread-id syntax], page 608, for the
format of the thread-id fields.

Note: GDB will send the qfThreadInfo query during the initial connection with
the remote target, and the very first thread ID mentioned in the reply will be
stopped by GDB in a subsequent message. Therefore, the stub should ensure that
the first thread ID in the qfThreadInfo reply is suitable for being stopped by
GDB.

‘qGetTLSAddr: thread-id, offset, lm’
Fetch the address associated with thread local storage specified by thread-id,
offset, and lm.

thread-id is the thread ID associated with the thread for which to fetch the
TLS address. See [thread-id syntax], page 608.

offset is the (big endian, hex encoded) offset associated with the thread local
variable. (This offset is obtained from the debug information associated with
the variable.)

lm is the (big endian, hex encoded) OS/ABI-specific encoding of the load mod-
ule associated with the thread local storage. For example, a GNU/Linux system
will pass the link map address of the shared object associated with the thread
local storage under consideration. Other operating environments may choose to
represent the load module differently, so the precise meaning of this parameter
will vary.

Reply:
‘XX...’ Hex encoded (big endian) bytes representing the address of the
thread local storage requested.

‘E nn’ An error occurred. The error number nn is given as hex digits.

‘’ An empty reply indicates that ‘qGetTLSAddr’ is not supported by
the stub.

‘qGetTIBAddr: thread-id’
Fetch address of the Windows OS specific Thread Information Block.

thread-id is the thread ID associated with the thread.

Reply:
‘XX...’ Hex encoded (big endian) bytes representing the linear address of
the thread information block.

‘E nn’ An error occurred. This means that either the thread was not found,
or the address could not be retrieved.

‘’ An empty reply indicates that ‘qGetTIBAddr’ is not supported by
the stub.

‘qL startflag threadcount nextthread’
Obtain thread information from RTOS. Where: startflag (one hex digit) is one
to indicate the first query and zero to indicate a subsequent query; threadcount
Appendix E: GDB Remote Serial Protocol

(two hex digits) is the maximum number of threads the response packet can contain; and nextthread (eight hex digits), for subsequent queries (startflag is zero), is returned in the response as argthread.

Don’t use this packet; use the ‘qfThreadInfo’ query instead (see above).

Reply:

‘qM count done argthread thread...
Where: count (two hex digits) is the number of threads being returned; done (one hex digit) is zero to indicate more threads and one indicates no further threads; argthreadid (eight hex digits) is nextthread from the request packet; thread... is a sequence of thread IDs, threadid (eight hex digits), from the target. See remote.c:parse_threadlist_response().

‘qOffsets’
Get section offsets that the target used when relocating the downloaded image.
Reply:

‘Text=xxx;Data=yyy[;Bss=zzz]’
Relocate the Text section by xxx from its original address. Relocate the Data section by yyy from its original address. If the object file format provides segment information (e.g. ELF ‘PT_LOAD’ program headers), GDB will relocate entire segments by the supplied offsets.

Note: while a Bss offset may be included in the response, GDB ignores this and instead applies the Data offset to the Bss section.

‘TextSeg=xxx[;DataSeg=yyy]’
Relocate the first segment of the object file, which conventionally contains program code, to a starting address of xxx. If ‘DataSeg’ is specified, relocate the second segment, which conventionally contains modifiable data, to a starting address of yyy. GDB will report an error if the object file does not contain segment information, or does not contain at least as many segments as mentioned in the reply. Extra segments are kept at fixed offsets relative to the last relocated segment.

‘qP mode thread-id’
Returns information on thread-id. Where: mode is a hex encoded 32 bit mode; thread-id is a thread ID (see [thread-id syntax], page 608).

Don’t use this packet; use the ‘qThreadExtraInfo’ query instead (see below).
Reply: see remote.c:remote_unpack_thread_info_response().

‘QNonStop:1’
‘QNonStop:0’
Enter non-stop (‘QNonStop:1’) or all-stop (‘QNonStop:0’) mode. See Section E.10 [Remote Non-Stop], page 655, for more information.

Reply:

‘OK’ The request succeeded.
‘E nn’  An error occurred. The error number nn is given as hex digits.

‘’  An empty reply indicates that ‘QNonStop’ is not supported by the stub.

This packet is not probed by default; the remote stub must request it, by supplying an appropriate ‘qSupported’ response (see [qSupported], page 628). Use of this packet is controlled by the set non-stop command; see Section 5.5.2 [Non-Stop Mode], page 77.

‘QPassSignals: signal [;signal]...’
Each listed signal should be passed directly to the inferior process. Signals are numbered identically to continue packets and stop replies (see Section E.3 [Stop Reply Packets], page 618). Each signal list item should be strictly greater than the previous item. These signals do not need to stop the inferior, or be reported to GDB. All other signals should be reported to GDB. Multiple ‘QPassSignals’ packets do not combine; any earlier ‘QPassSignals’ list is completely replaced by the new list. This packet improves performance when using ‘handle signal nostop noprint pass’.

Reply:
‘OK’  The request succeeded.

‘E nn’  An error occurred. The error number nn is given as hex digits.

‘’  An empty reply indicates that ‘QPassSignals’ is not supported by the stub.

Use of this packet is controlled by the set remote pass-signals command (see Section 20.4 [Remote Configuration], page 264). This packet is not probed by default; the remote stub must request it, by supplying an appropriate ‘qSupported’ response (see [qSupported], page 628).

‘QProgramSignals: signal [;signal]...’
Each listed signal may be delivered to the inferior process. Others should be silently discarded.

In some cases, the remote stub may need to decide whether to deliver a signal to the program or not without GDB involvement. One example of that is while detaching — the program’s threads may have stopped for signals that haven’t yet had a chance of being reported to GDB, and so the remote stub can use the signal list specified by this packet to know whether to deliver or ignore those pending signals.

This does not influence whether to deliver a signal as requested by a resumption packet (see [vCont packet], page 614).

Signals are numbered identically to continue packets and stop replies (see Section E.3 [Stop Reply Packets], page 618). Each signal list item should be strictly greater than the previous item. Multiple ‘QProgramSignals’ packets do not combine; any earlier ‘QProgramSignals’ list is completely replaced by the new list.

Reply:
Appendix E: GDB Remote Serial Protocol

‘OK’ The request succeeded.

‘E nn’ An error occurred. The error number nn is given as hex digits.

‘’ An empty reply indicates that ‘QProgramSignals’ is not supported by the stub.

Use of this packet is controlled by the set remote program-signals command (see Section 20.4 [Remote Configuration], page 264). This packet is not probed by default; the remote stub must request it, by supplying an appropriate ‘qSupported’ response (see [qSupported], page 628).

‘qRcmd,command’

Command (hex encoded) is passed to the local interpreter for execution. Invalid commands should be reported using the output string. Before the final result packet, the target may also respond with a number of intermediate ‘OUTPUT’ console output packets. Implementors should note that providing access to a stub’s interpreter may have security implications.

Reply:

‘OK’ A command response with no output.

‘OUTPUT’ A command response with the hex encoded output string OUTPUT.

‘E nn’ Indicate a badly formed request.

‘’ An empty reply indicates that ‘qRcmd’ is not recognized.

(Note that the qRcmd packet’s name is separated from the command by a ‘,’ not a ‘:’, contrary to the naming conventions above. Please don’t use this packet as a model for new packets.)

‘qSearch:memory:address;length;search-pattern’

Search length bytes at address for search-pattern. Both address and length are encoded in hex; search-pattern is a sequence of bytes, also hex encoded.

Reply:

‘0’ The pattern was not found.

‘1,address’ The pattern was found at address.

‘E nn’ A badly formed request or an error was encountered while searching memory.

‘’ An empty reply indicates that ‘qSearch:memory’ is not recognized.

‘QStartNoAckMode’

Request that the remote stub disable the normal ‘+’/’-’ protocol acknowledgments (see Section E.11 [Packet Acknowledgment], page 656).

Reply:

‘OK’ The stub has switched to no-acknowledgment mode. GDB acknowledges this reponse, but neither the stub nor GDB shall send or expect further ‘+’/’-’ acknowledgments in the current connection.
An empty reply indicates that the stub does not support no-acknowledgment mode.

```
qSupported [:gdbfeature [:gdbfeature] ... ]
```

Tell the remote stub about features supported by GDB, and query the stub for features it supports. This packet allows GDB and the remote stub to take advantage of each others’ features. ‘qSupported’ also consolidates multiple feature probes at startup, to improve GDB performance—a single larger packet performs better than multiple smaller probe packets on high-latency links. Some features may enable behavior which must not be on by default, e.g. because it would confuse older clients or stubs. Other features may describe packets which could be automatically probed for, but are not. These features must be reported before GDB will use them. This “default unsupported” behavior is not appropriate for all packets, but it helps to keep the initial connection time under control with new versions of GDB which support increasing numbers of packets.

Reply:

```
stubfeature [:stubfeature] ...`
```

The stub supports or does not support each returned stubfeature, depending on the form of each stubfeature (see below for the possible forms).

```
```

An empty reply indicates that ‘qSupported’ is not recognized, or that no features needed to be reported to GDB.

The allowed forms for each feature (either a gdbfeature in the ‘qSupported’ packet, or a stubfeature in the response) are:

```
name=value
```

The remote protocol feature name is supported, and associated with the specified value. The format of value depends on the feature, but it must not include a semicolon.

```
name+
```

The remote protocol feature name is supported, and does not need an associated value.

```
name-
```

The remote protocol feature name is not supported.

```
name?
```

The remote protocol feature name may be supported, and GDB should auto-detect support in some other way when it is needed. This form will not be used for gdbfeature notifications, but may be used for stubfeature responses.

Whenever the stub receives a ‘qSupported’ request, the supplied set of GDB features should override any previous request. This allows GDB to put the stub in a known state, even if the stub had previously been communicating with a different version of GDB.

The following values of gdbfeature (for the packet sent by GDB) are defined:

```
multiprocess
```

This feature indicates whether GDB supports multiprocess extensions to the remote protocol. GDB does not use such extensions
unless the stub also reports that it supports them by including `multiprocess+' in its `qSupported' reply. See [multiprocess extensions], page 634, for details.

`xmlRegisters'
This feature indicates that GDB supports the XML target description. If the stub sees `xmlRegisters=' with target specific strings separated by a comma, it will report register description.

`qRelocInsn'
This feature indicates whether GDB supports the `qRelocInsn' packet (see Section E.6 [Relocate instruction reply packet], page 644).

`swbreak'
This feature indicates whether GDB supports the swbreak stop reason in stop replies. See [swbreak stop reason], page 619, for details.

`hwbreak'
This feature indicates whether GDB supports the hwbreak stop reason in stop replies. See [swbreak stop reason], page 619, for details.

`fork-events'
This feature indicates whether GDB supports fork event extensions to the remote protocol. GDB does not use such extensions unless the stub also reports that it supports them by including `fork-events+' in its `qSupported' reply.

`vfork-events'
This feature indicates whether GDB supports vfork event extensions to the remote protocol. GDB does not use such extensions unless the stub also reports that it supports them by including `vfork-events+' in its `qSupported' reply.

`exec-events'
This feature indicates whether GDB supports exec event extensions to the remote protocol. GDB does not use such extensions unless the stub also reports that it supports them by including `exec-events+' in its `qSupported' reply.

`vContSupported'
This feature indicates whether GDB wants to know the supported actions in the reply to `vCont?' packet.

Stubs should ignore any unknown values for `gdbfeature`. Any GDB which sends a `qSupported' packet supports receiving packets of unlimited length (earlier versions of GDB may reject overly long responses). Additional values for `gdbfeature` may be defined in the future to let the stub take advantage of new features in GDB, e.g. incompatible improvements in the remote protocol—the `multiprocess' feature is an example of such a feature. The stub’s reply should be independent of the `gdbfeature` entries sent by GDB; first GDB describes all the features it supports, and then the stub replies with all the features it supports. Similarly, GDB will silently ignore unrecognized stub feature responses, as long as each response uses one of the standard forms.
Some features are flags. A stub which supports a flag feature should respond with a ‘+’ form response. Other features require values, and the stub should respond with an ‘=’ form response.

Each feature has a default value, which GDB will use if `qSupported` is not available or if the feature is not mentioned in the `qSupported` response. The default values are fixed; a stub is free to omit any feature responses that match the defaults.

Not all features can be probed, but for those which can, the probing mechanism is useful: in some cases, a stub’s internal architecture may not allow the protocol layer to know some information about the underlying target in advance. This is especially common in stubs which may be configured for multiple targets.

These are the currently defined stub features and their properties:

<table>
<thead>
<tr>
<th>Feature Name</th>
<th>Value Required</th>
<th>Default</th>
<th>Probe Allowed</th>
</tr>
</thead>
<tbody>
<tr>
<td>'PacketSize'</td>
<td>Yes</td>
<td>‘-’</td>
<td>No</td>
</tr>
<tr>
<td>'qXfer:auxv:read'</td>
<td>No</td>
<td>‘-’</td>
<td>Yes</td>
</tr>
<tr>
<td>'qXfer:btrace:read'</td>
<td>No</td>
<td>‘-’</td>
<td>Yes</td>
</tr>
<tr>
<td>'qXfer:btrace-conf:read'</td>
<td>No</td>
<td>‘-’</td>
<td>Yes</td>
</tr>
<tr>
<td>'qXfer:exec-file:read'</td>
<td>No</td>
<td>‘-’</td>
<td>Yes</td>
</tr>
<tr>
<td>'qXfer:features:read'</td>
<td>No</td>
<td>‘-’</td>
<td>Yes</td>
</tr>
<tr>
<td>'qXfer:libraries:read'</td>
<td>No</td>
<td>‘-’</td>
<td>Yes</td>
</tr>
<tr>
<td>'qXfer:libraries-svr4:read'</td>
<td>No</td>
<td>‘-’</td>
<td>Yes</td>
</tr>
<tr>
<td>'augmented-libraries-svr4-read'</td>
<td>No</td>
<td>‘-’</td>
<td>No</td>
</tr>
<tr>
<td>'qXfer:memory-map:read'</td>
<td>No</td>
<td>‘-’</td>
<td>Yes</td>
</tr>
<tr>
<td>'qXfer:sdata:read'</td>
<td>No</td>
<td>‘-’</td>
<td>Yes</td>
</tr>
<tr>
<td>'qXfer:spu:read'</td>
<td>No</td>
<td>‘-’</td>
<td>Yes</td>
</tr>
<tr>
<td>'qXfer:spu:write'</td>
<td>No</td>
<td>‘-’</td>
<td>Yes</td>
</tr>
<tr>
<td>'qXfer:siginfo:read'</td>
<td>No</td>
<td>‘-’</td>
<td>Yes</td>
</tr>
<tr>
<td>'qXfer:siginfo:write'</td>
<td>No</td>
<td>‘-’</td>
<td>Yes</td>
</tr>
<tr>
<td>Feature</td>
<td>Default</td>
<td>Other Values</td>
<td>Notes</td>
</tr>
<tr>
<td>----------------------------------------------</td>
<td>---------</td>
<td>--------------</td>
<td>-------</td>
</tr>
<tr>
<td><code>qXfer:threads:read</code></td>
<td>No</td>
<td>‘-‘, Yes</td>
<td></td>
</tr>
<tr>
<td><code>qXfer:traceframe-info:read</code></td>
<td>No</td>
<td>‘-‘, Yes</td>
<td></td>
</tr>
<tr>
<td><code>qXfer:uib:read</code></td>
<td>No</td>
<td>‘-‘, Yes</td>
<td></td>
</tr>
<tr>
<td><code>qXfer:fdpic:read</code></td>
<td>No</td>
<td>‘-‘, Yes</td>
<td></td>
</tr>
<tr>
<td><code>Qbtrace:off</code></td>
<td>Yes</td>
<td>‘-‘, Yes</td>
<td></td>
</tr>
<tr>
<td><code>Qbtrace:bts</code></td>
<td>Yes</td>
<td>‘-‘, Yes</td>
<td></td>
</tr>
<tr>
<td><code>Qbtrace:pt</code></td>
<td>Yes</td>
<td>‘-‘, Yes</td>
<td></td>
</tr>
<tr>
<td><code>Qbtrace-conf:bts:size</code></td>
<td>Yes</td>
<td>‘-‘, Yes</td>
<td></td>
</tr>
<tr>
<td><code>Qbtrace-conf:pt:size</code></td>
<td>Yes</td>
<td>‘-‘, Yes</td>
<td></td>
</tr>
<tr>
<td><code>QNonStop</code></td>
<td>No</td>
<td>‘-‘, Yes</td>
<td></td>
</tr>
<tr>
<td><code>QPassSignals</code></td>
<td>No</td>
<td>‘-‘, Yes</td>
<td></td>
</tr>
<tr>
<td><code>QStartNoAckMode</code></td>
<td>No</td>
<td>‘-‘, Yes</td>
<td></td>
</tr>
<tr>
<td><code>multiprocess</code></td>
<td>No</td>
<td>‘-‘, No</td>
<td></td>
</tr>
<tr>
<td><code>ConditionalBreakpoints</code></td>
<td>No</td>
<td>‘-‘, No</td>
<td></td>
</tr>
<tr>
<td><code>ConditionalTracepoints</code></td>
<td>No</td>
<td>‘-‘, No</td>
<td></td>
</tr>
<tr>
<td><code>ReverseContinue</code></td>
<td>No</td>
<td>‘-‘, No</td>
<td></td>
</tr>
<tr>
<td><code>ReverseStep</code></td>
<td>No</td>
<td>‘-‘, No</td>
<td></td>
</tr>
<tr>
<td><code>TracepointSource</code></td>
<td>No</td>
<td>‘-‘, No</td>
<td></td>
</tr>
<tr>
<td><code>QAgent</code></td>
<td>No</td>
<td>‘-‘, No</td>
<td></td>
</tr>
<tr>
<td><code>QAllow</code></td>
<td>No</td>
<td>‘-‘, No</td>
<td></td>
</tr>
<tr>
<td><code>QDisableRandomization</code></td>
<td>No</td>
<td>‘-‘, No</td>
<td></td>
</tr>
<tr>
<td><code>EnableDisableTracepoints</code></td>
<td>No</td>
<td>‘-‘, No</td>
<td></td>
</tr>
<tr>
<td><code>QTBuffer:size</code></td>
<td>No</td>
<td>‘-‘, No</td>
<td></td>
</tr>
</tbody>
</table>
‘tracenz’  No  ‘-’  No
‘BreakpointCommands’  No  ‘-’  No
‘swbreak’  No  ‘-’  No
‘hwbreak’  No  ‘-’  No
‘fork-events’  No  ‘-’  No
‘vfork-events’  No  ‘-’  No
‘exec-events’  No  ‘-’  No

These are the currently defined stub features, in more detail:

‘PacketSize=bytes’
  The remote stub can accept packets up to at least bytes in length. gdb will send packets up to this size for bulk transfers, and will never send larger packets. This is a limit on the data characters in the packet, including the frame and checksum. There is no trailing NUL byte in a remote protocol packet; if the stub stores packets in a NUL-terminated format, it should allow an extra byte in its buffer for the NUL. If this stub feature is not supported, gdb guesses based on the size of the ‘g’ packet response.

‘qXfer:auxv:read’
  The remote stub understands the ‘qXfer:auxv:read’ packet (see [qXfer auxiliary vector read], page 637).

‘qXfer:btrace:read’
  The remote stub understands the ‘qXfer:btrace:read’ packet (see [qXfer btrace read], page 637).

‘qXfer:btrace-conf:read’
  The remote stub understands the ‘qXfer:btrace-conf:read’ packet (see [qXfer btrace-conf read], page 638).

‘qXfer:exec-file:read’
  The remote stub understands the ‘qXfer:exec-file:read’ packet (see [qXfer executable filename read], page 638).

‘qXfer:features:read’
  The remote stub understands the ‘qXfer:features:read’ packet (see [qXfer target description read], page 638).

‘qXfer:libraries:read’
  The remote stub understands the ‘qXfer:libraries:read’ packet (see [qXfer library list read], page 638).
Appendix E: GDB Remote Serial Protocol

The remote stub understands the ‘qXfer:libraries-svr4:read’ packet (see [qXfer svr4 library list read], page 639).

The remote stub understands the augmented form of the ‘qXfer:libraries-svr4:read’ packet (see [qXfer svr4 library list read], page 639).

The remote stub understands the ‘qXfer:memory-map:read’ packet (see [qXfer memory map read], page 639).

The remote stub understands the ‘qXfer:sdata:read’ packet (see [qXfer sdata read], page 639).

The remote stub understands the ‘qXfer:spu:read’ packet (see [qXfer spu read], page 640).

The remote stub understands the ‘qXfer:spu:write’ packet (see [qXfer spu write], page 641).

The remote stub understands the ‘qXfer:threads:read’ packet (see [qXfer threads read], page 640).

The remote stub understands the ‘qXfer:traceframe-info:read’ packet (see [qXfer traceframe info read], page 640).

The remote stub understands the ‘qXfer:uib:read’ packet (see [qXfer unwind info block], page 640).

The remote stub understands the ‘qXfer:fdpic:read’ packet (see [qXfer fdpic loadmap read], page 640).

The remote stub understands the ‘QNonStop’ packet (see [QNonStop], page 625).
`QPassSignals`

The remote stub understands the `QPassSignals` packet (see [QPassSignals], page 626).

`QStartNoAckMode`

The remote stub understands the `QStartNoAckMode` packet and prefers to operate in no-acknowledgment mode. See Section E.11 [Packet Acknowledgment], page 656.

`multiprocess`

The remote stub understands the multiprocess extensions to the remote protocol syntax. The multiprocess extensions affect the syntax of thread IDs in both packets and replies (see [thread-id syntax], page 608), and add process IDs to the `D` packet and `W` and `X` replies. Note that reporting this feature indicates support for the syntactic extensions only, not that the stub necessarily supports debugging of more than one process at a time. The stub must not use multiprocess extensions in packet replies unless gdb has also indicated it supports them in its `qSupported` request.

`qXfer:osdata:read`

The remote stub understands the `qXfer:osdata:read` packet (see [qXfer osdata read], page 641).

`ConditionalBreakpoints`

The target accepts and implements evaluation of conditional expressions defined for breakpoints. The target will only report breakpoint triggers when such conditions are true (see Section 5.1.6 [Break Conditions], page 60).

`ConditionalTracepoints`

The remote stub accepts and implements conditional expressions defined for tracepoints (see Section 13.1.4 [Tracepoint Conditions], page 167).

`ReverseContinue`

The remote stub accepts and implements the reverse continue packet (see [bc], page 609).

`ReverseStep`

The remote stub accepts and implements the reverse step packet (see [bs], page 610).

`TracepointSource`

The remote stub understands the `QTDPsrc` packet that supplies the source form of tracepoint definitions.

`QAgent`

The remote stub understands the `QAgent` packet.

`QAllow`

The remote stub understands the `QAllow` packet.

`QDisableRandomization`

The remote stub understands the `QDisableRandomization` packet.
‘StaticTracepoint’
The remote stub supports static tracepoints.

‘InstallInTrace’
The remote stub supports installing tracepoint in tracing.

‘EnableDisableTracepoints’
The remote stub supports the ‘QTEnable’ (see [QTEnable], page 647) and ‘QTDisable’ (see [QTDisable], page 647) packets that allow tracepoints to be enabled and disabled while a trace experiment is running.

‘QTBuffer:size’
The remote stub supports the ‘QTBuffer:size’ (see [QTBuffer-size], page 650) packet that allows to change the size of the trace buffer.

‘tracenz’ The remote stub supports the ‘tracenz’ bytecode for collecting strings. See Section F.2 [Bytecode Descriptions], page 677 for details about the bytecode.

‘BreakpointCommands’
The remote stub supports running a breakpoint’s command list itself, rather than reporting the hit to GDB.

‘Qbtrace:off’
The remote stub understands the ‘Qbtrace:off’ packet.

‘Qbtrace:bts’
The remote stub understands the ‘Qbtrace:bts’ packet.

‘Qbtrace:pt’
The remote stub understands the ‘Qbtrace:pt’ packet.

‘Qbtrace-conf:bts:size’
The remote stub understands the ‘Qbtrace-conf:bts:size’ packet.

‘Qbtrace-conf:pt:size’
The remote stub understands the ‘Qbtrace-conf:pt:size’ packet.

‘swbreak’ The remote stub reports the ‘swbreak’ stop reason for memory breakpoints.

‘hwbreak’ The remote stub reports the ‘hwbreak’ stop reason for hardware breakpoints.

‘fork-events’
The remote stub reports the ‘fork’ stop reason for fork events.

‘vfork-events’
The remote stub reports the ‘vfork’ stop reason for vfork events and vforkdone events.

‘exec-events’
The remote stub reports the ‘exec’ stop reason for exec events.
‘vContSupported’
The remote stub reports the supported actions in the reply to ‘vCont?’ packet.

‘qSymbol::’
Notify the target that GDB is prepared to serve symbol lookup requests. Accept requests from the target for the values of symbols.
Reply:
‘OK’ The target does not need to look up any (more) symbols.

‘qSymbol:sym_name’
The target requests the value of symbol sym_name (hex encoded). GDB may provide the value by using the ‘qSymbol:sym_value:sym_name’ message, described below.

‘qSymbol:sym_value:sym_name’
Set the value of sym_name to sym_value.

sym_name (hex encoded) is the name of a symbol whose value the target has previously requested.
sym_value (hex) is the value for symbol sym_name. If GDB cannot supply a value for sym_name, then this field will be empty.
Reply:
‘OK’ The target does not need to look up any (more) symbols.

‘qSymbol:sym_name’
The target requests the value of a new symbol sym_name (hex encoded). GDB will continue to supply the values of symbols (if available), until the target ceases to request them.

‘qTBuffer’
‘QTBuffer’
‘QTDisconnected’
‘QTDP’
‘QTDPsrc’
‘QTDV’
‘qTfP’
‘qTfV’
‘QTFrame’
‘qTMinFTPILen’
See Section E.6 [Tracepoint Packets], page 644.

‘qThreadExtraInfo,thread-id’
Obtain from the target OS a printable string description of thread attributes for the thread thread-id; see [thread-id syntax], page 608, for the forms of thread-id. This string may contain anything that the target OS thinks is interesting for GDB to tell the user about the thread. The string is displayed in GDB’s info threads display. Some examples of possible thread extra info strings are ‘Runnable’, or ‘Blocked on Mutex’.
Reply:
‘XX...’ Where ‘XX...’ is a hex encoding of ASCII data, comprising the printable string containing the extra information about the thread’s attributes.

(Note that the qThreadExtraInfo packet’s name is separated from the command by a ‘,’ not a ‘:’, contrary to the naming conventions above. Please don’t use this packet as a model for new packets.)

‘QTNotes’
‘qTP’
‘QTSave’
‘qTsP’
‘qTsV’
‘QTStart’
‘QTStop’
‘QTDdisable’
‘QTinit’
‘QTrro’
‘qTStatus’
‘qT’
‘qTfSTM’
‘qTsSTM’
‘qTSTMat’ See Section E.6 [Tracepoint Packets], page 644.

‘qXfer:object:read:annex:offset,length’
Read uninterpreted bytes from the target’s special data area identified by the keyword object. Request length bytes starting at offset bytes into the data. The content and encoding of annex is specific to object; it can supply additional details about what data to access.

Here are the specific requests of this form defined so far. All ‘qXfer:object:read:...’ requests use the same reply formats, listed below.

‘qXfer:auxv:read::offset,length’
Access the target’s auxiliary vector. See Section 10.16 [OS Information], page 143. Note annex must be empty.

This packet is not probed by default; the remote stub must request it, by supplying an appropriate ‘qSupported’ response (see [qSupported], page 628).

‘qXfer:btrace:read:annex:offset,length’
Return a description of the current branch trace. See Section E.19 [Branch Trace Format], page 672. The annex part of the generic ‘qXfer’ packet may have one of the following values:

all Returns all available branch trace.
new Returns all available branch trace if the branch trace changed since the last read request.
delta Returns the new branch trace since the last read request. Adds a new block to the end of the trace that
begins at zero and ends at the source location of the first branch in the trace buffer. This extra block is used to stitch traces together.

If the trace buffer overflowed, returns an error indicating the overflow.

This packet is not probed by default; the remote stub must request it by supplying an appropriate `qSupported` response (see [qSupported], page 628).

`qXfer:btrace-conf:read::offset,length`

Return a description of the current branch trace configuration. See Section E.20 [Branch Trace Configuration Format], page 673.

This packet is not probed by default; the remote stub must request it by supplying an appropriate `qSupported` response (see [qSupported], page 628).

`qXfer:exec-file:read:annex:offset,length`

Return the full absolute name of the file that was executed to create a process running on the remote system. The annex specifies the numeric process ID of the process to query, encoded as a hexadecimal number. If the annex part is empty the remote stub should return the filename corresponding to the currently executing process.

This packet is not probed by default; the remote stub must request it, by supplying an appropriate `qSupported` response (see [qSupported], page 628).

`qXfer:features:read:annex:offset,length`

Access the target description. See Appendix G [Target Descriptions], page 687. The annex specifies which XML document to access. The main description is always loaded from the `target.xml` annex.

This packet is not probed by default; the remote stub must request it, by supplying an appropriate `qSupported` response (see [qSupported], page 628).

`qXfer:libraries:read:annex:offset,length`

Access the target's list of loaded libraries. See Section E.14 [Library List Format], page 669. The annex part of the generic `qXfer` packet must be empty (see [qXfer read], page 637).

Targets which maintain a list of libraries in the program’s memory do not need to implement this packet; it is designed for platforms where the operating system manages the list of loaded libraries.

This packet is not probed by default; the remote stub must request it, by supplying an appropriate `qSupported` response (see [qSupported], page 628).
‘qXfer:libraries-svr4:read:annex:offset,length’

Access the target’s list of loaded libraries when the target is an SVR4 platform. See Section E.15 [Library List Format for SVR4 Targets], page 670. The annex part of the generic ‘qXfer’ packet must be empty unless the remote stub indicated it supports the augmented form of this packet by supplying an appropriate ‘qSupported’ response (see [qXfer read], page 637, [qSupported], page 628).

This packet is optional for better performance on SVR4 targets. GDB uses memory read packets to read the SVR4 library list otherwise.

This packet is not probed by default; the remote stub must request it, by supplying an appropriate ‘qSupported’ response (see [qSupported], page 628).

If the remote stub indicates it supports the augmented form of this packet then the annex part of the generic ‘qXfer’ packet may contain a semicolon-separated list of ‘name=value’ arguments. The currently supported arguments are:

**start=address**

A hexadecimal number specifying the address of the ‘struct link_map’ to start reading the library list from. If unset or zero then the first ‘struct link_map’ in the library list will be chosen as the starting point.

**prev=address**

A hexadecimal number specifying the address of the ‘struct link_map’ immediately preceding the ‘struct link_map’ specified by the ‘start’ argument. If unset or zero then the remote stub will expect that no ‘struct link_map’ exists prior to the starting point.

Arguments that are not understood by the remote stub will be silently ignored.

‘qXfer:memory-map:read::offset,length’

Access the target’s memory-map. See Section E.16 [Memory Map Format], page 670. The annex part of the generic ‘qXfer’ packet must be empty (see [qXfer read], page 637).

This packet is not probed by default; the remote stub must request it, by supplying an appropriate ‘qSupported’ response (see [qSupported], page 628).

‘qXfer:sdata:read::offset,length’

Read contents of the extra collected static tracepoint marker information. The annex part of the generic ‘qXfer’ packet must be empty (see [qXfer read], page 637). See Section 13.1.6 [Tracepoint Action Lists], page 168.
This packet is not probed by default; the remote stub must request it, by supplying an appropriate ‘qSupported’ response (see \[qSupported\], page 628).

‘qXfer:signal:read::offset,length’
Read contents of the extra signal information on the target system. The annex part of the generic ‘qXfer’ packet must be empty (see \[qXfer read\], page 637).
This packet is not probed by default; the remote stub must request it, by supplying an appropriate ‘qSupported’ response (see \[qSupported\], page 628).

‘qXfer:spu:read:annex:offset,length’
Read contents of an spufs file on the target system. The annex specifies which file to read; it must be of the form ‘id/name’, where id specifies an SPU context ID in the target process, and name identifies the spufs file in that context to be accessed.
This packet is not probed by default; the remote stub must request it, by supplying an appropriate ‘qSupported’ response (see \[qSupported\], page 628).

‘qXfer:threads:read::offset,length’
Access the list of threads on target. See Section E.17 [Thread List Format], page 671. The annex part of the generic ‘qXfer’ packet must be empty (see \[qXfer read\], page 637).
This packet is not probed by default; the remote stub must request it, by supplying an appropriate ‘qSupported’ response (see \[qSupported\], page 628).

‘qXfer:traceframe-info:read::offset,length’
Return a description of the current traceframe’s contents. See Section E.18 [Traceframe Info Format], page 672. The annex part of the generic ‘qXfer’ packet must be empty (see \[qXfer read\], page 637).
This packet is not probed by default; the remote stub must request it, by supplying an appropriate ‘qSupported’ response (see \[qSupported\], page 628).

‘qXfer:uib:read:pc:offset,length’
Return the unwind information block for pc. This packet is used on OpenVMS/ia64 to ask the kernel unwind information.
This packet is not probed by default.

‘qXfer:fdpic:read:annex:offset,length’
Read contents of loadmaps on the target system. The annex, either ‘exec’ or ‘interp’, specifies which loadmap, executable loadmap or interpreter loadmap to read.
This packet is not probed by default; the remote stub must request it, by supplying an appropriate ‘qSupported’ response (see \[qSupported\], page 628).
Appendix E: GDB Remote Serial Protocol

'qXfer:osdata:read::offset,length'
Access the target’s operating system information. See Appendix H [Operating System Information], page 697.

Reply:

'm data'  Data data (see [Binary Data], page 607) has been read from the target. There may be more data at a higher address (although it is permitted to return ‘m’ even for the last valid block of data, as long as at least one byte of data was read). It is possible for data to have fewer bytes than the length in the request.

'l data'  Data data (see [Binary Data], page 607) has been read from the target. There is no more data to be read. It is possible for data to have fewer bytes than the length in the request.

'l'  The offset in the request is at the end of the data. There is no more data to be read.

'E00'  The request was malformed, or annex was invalid.

'Enn'  The offset was invalid, or there was an error encountered reading the data. The nn part is a hex-encoded errno value.

'' An empty reply indicates the object string was not recognized by the stub, or that the object does not support reading.

'qXfer:object:write:annex:offset:data...'  Write uninterpreted bytes into the target’s special data area identified by the keyword object, starting at offset bytes into the data. The binary-encoded data (see [Binary Data], page 607) to be written is given by data... The content and encoding of annex is specific to object; it can supply additional details about what data to access.

Here are the specific requests of this form defined so far. All 'qXfer:object:write:...' requests use the same reply formats, listed below.

'qXfer:siginfo:write::offset:data...'  Write data to the extra signal information on the target system. The annex part of the generic ‘qXfer’ packet must be empty (see [qXfer write], page 641).

This packet is not probed by default; the remote stub must request it, by supplying an appropriate ‘qSupported’ response (see [qSupported], page 628).

'qXfer:spu:write:annex:offset:data...'  Write data to an spufs file on the target system. The annex specifies which file to write; it must be of the form ‘id/name’, where id specifies an SPU context ID in the target process, and name identifies the spufs file in that context to be accessed.

This packet is not probed by default; the remote stub must request it, by supplying an appropriate ‘qSupported’ response (see [qSupported], page 628).
Reply:

‘nn’  \(nn\) (hex encoded) is the number of bytes written. This may be fewer bytes than supplied in the request.

‘E00’  The request was malformed, or annex was invalid.

‘E nn’  The offset was invalid, or there was an error encountered writing the data. The \(nn\) part is a hex-encoded errno value.

‘’  An empty reply indicates the object string was not recognized by the stub, or that the object does not support writing.

‘qXfer:object:operation:...’  Requests of this form may be added in the future. When a stub does not recognize the object keyword, or its support for object does not recognize the operation keyword, the stub must respond with an empty packet.

‘qAttached:pid’  Return an indication of whether the remote server attached to an existing process or created a new process. When the multiprocess protocol extensions are supported (see [multiprocess extensions], page 634), \(pid\) is an integer in hexadecimal format identifying the target process. Otherwise, \(gdb\) will omit the \(pid\) field and the query packet will be simplified as ‘qAttached’.

This query is used, for example, to know whether the remote process should be detached or killed when a \(gdb\) session is ended with the quit command.

Reply:

‘1’  The remote server attached to an existing process.

‘0’  The remote server created a new process.

‘E NN’  A badly formed request or an error was encountered.

‘Qbtrace:bts’  Enable branch tracing for the current thread using Branch Trace Store.

Reply:

‘OK’  Branch tracing has been enabled.

‘E.errtext’  A badly formed request or an error was encountered.

‘Qbtrace:pt’  Enable branch tracing for the current thread using Intel(R) Processor Trace.

Reply:

‘OK’  Branch tracing has been enabled.

‘E.errtext’  A badly formed request or an error was encountered.

‘Qbtrace:off’  Disable branch tracing for the current thread.

Reply:
Appendix E: GDB Remote Serial Protocol

‘OK’ Branch tracing has been disabled.
‘E.errtext’
A badly formed request or an error was encountered.

‘Qbtrace-conf:bts:size=value’
Set the requested ring buffer size for new threads that use the btrace recording method in bts format.
Reply:
‘OK’ The ring buffer size has been set.
‘E.errtext’
A badly formed request or an error was encountered.

‘Qbtrace-conf:pt:size=value’
Set the requested ring buffer size for new threads that use the btrace recording method in pt format.
Reply:
‘OK’ The ring buffer size has been set.
‘E.errtext’
A badly formed request or an error was encountered.

E.5 Architecture-Specific Protocol Details
This section describes how the remote protocol is applied to specific target architectures. Also see Section G.4 [Standard Target Features], page 692, for details of XML target descriptions for each architecture.

E.5.1 ARM-specific Protocol Details

E.5.1.1 ARM Breakpoint Kinds
These breakpoint kinds are defined for the ‘Z0’ and ‘Z1’ packets.
2 16-bit Thumb mode breakpoint.
3 32-bit Thumb mode (Thumb-2) breakpoint.
4 32-bit ARM mode breakpoint.

E.5.2 MIPS-specific Protocol Details

E.5.2.1 MIPS Register Packet Format
The following g/G packets have previously been defined. In the below, some thirty-two bit registers are transferred as sixty-four bits. Those registers should be zero/sign extended (which?) to fill the space allocated. Register bytes are transferred in target byte order. The two nibbles within a register byte are transferred most-significant – least-significant.

MIPS32 All registers are transferred as thirty-two bit quantities in the order: 32 general-purpose; sr; lo; hi; bad; cause; pc; 32 floating-point registers; fsr; fir; fp.
MIPS64 All registers are transferred as sixty-four bit quantities (including thirty-two bit registers such as sr). The ordering is the same as MIPS32.
E.5.2.2 MIPS Breakpoint Kinds

These breakpoint kinds are defined for the ‘Z0’ and ‘Z1’ packets.

2 16-bit MIPS16 mode breakpoint.
3 16-bit microMIPS mode breakpoint.
4 32-bit standard MIPS mode breakpoint.
5 32-bit microMIPS mode breakpoint.

E.6 Tracepoint Packets

Here we describe the packets GDB uses to implement tracepoints (see Chapter 13 [Tracepoints], page 163).

‘QTDP:n:addr:ena:step:pass[:Fflen][:Xlen,bytes][-]’

Create a new tracepoint, number n, at addr. If ena is ‘E’, then the tracepoint is enabled; if it is ‘D’, then the tracepoint is disabled. The step gives the tracepoint’s step count, and pass gives its pass count. If an ‘F’ is present, then the tracepoint is to be a fast tracepoint, and the flen is the number of bytes that the target should copy elsewhere to make room for the tracepoint. If an ‘X’ is present, it introduces a tracepoint condition, which consists of a hexadecimal length, followed by a comma and hex-encoded bytes, in a manner similar to action encodings as described below. If the trailing ‘-’ is present, further ‘QTDP’ packets will follow to specify this tracepoint’s actions.

Replies:

‘OK’ The packet was understood and carried out.
‘qRelocInsn’

See Section E.6 [Relocate instruction reply packet], page 644.

’’ The packet was not recognized.

‘QTDP:-n:addr:[S]action...[-]’

Define actions to be taken when a tracepoint is hit. The n and addr must be the same as in the initial ‘QTDP’ packet for this tracepoint. This packet may only be sent immediately after another ‘QTDP’ packet that ended with a ‘-’. If the trailing ‘-’ is present, further ‘QTDP’ packets will follow, specifying more actions for this tracepoint.

In the series of action packets for a given tracepoint, at most one can have an ‘S’ before its first action. If such a packet is sent, it and the following packets define “while-stepping” actions. Any prior packets define ordinary actions — that is, those taken when the tracepoint is first hit. If no action packet has an ‘S’, then all the packets in the series specify ordinary tracepoint actions.

The ‘action...’ portion of the packet is a series of actions, concatenated without separators. Each action has one of the following forms:

‘R mask’ Collect the registers whose bits are set in mask, a hexadecimal number whose i’th bit is set if register number i should be collected. (The least significant bit is numbered zero.) Note that mask may be any number of digits long; it may not fit in a 32-bit word.
Appendix E: GDB Remote Serial Protocol

`M basereg,offset,len`

Collect len bytes of memory starting at the address in register number basereg, plus offset. If basereg is ‘-1’, then the range has a fixed address: offset is the address of the lowest byte to collect. The basereg, offset, and len parameters are all unsigned hexadecimal values (the ‘-1’ value for basereg is a special case).

`X len,expr`

Evaluate expr, whose length is len, and collect memory as it directs. The agent expression expr is as described in Appendix F [Agent Expressions], page 675. Each byte of the expression is encoded as a two-digit hex number in the packet; len is the number of bytes in the expression (and thus one-half the number of hex digits in the packet).

Any number of actions may be packed together in a single ‘QTDP’ packet, as long as the packet does not exceed the maximum packet length (400 bytes, for many stubs). There may be only one ‘R’ action per tracepoint, and it must precede any ‘M’ or ‘X’ actions. Any registers referred to by ‘M’ and ‘X’ actions must be collected by a preceding ‘R’ action. (The “while-stepping” actions are treated as if they were attached to a separate tracepoint, as far as these restrictions are concerned.)

Replies:

‘OK’ The packet was understood and carried out.

‘qRelocInsn’ See Section E.6 [Relocate instruction reply packet], page 644.

‘’ The packet was not recognized.

`QTDPsrc:n:addr:type:start:slen:bytes`

Specify a source string of tracepoint n at address addr. This is useful to get accurate reproduction of the tracepoints originally downloaded at the beginning of the trace run. The type is the name of the tracepoint part, such as ‘cond’ for the tracepoint’s conditional expression (see below for a list of types), while bytes is the string, encoded in hexadecimal.

start is the offset of the bytes within the overall source string, while slen is the total length of the source string. This is intended for handling source strings that are longer than will fit in a single packet.

The available string types are ‘at’ for the location, ‘cond’ for the conditional, and ‘cmd’ for an action command. GDB sends a separate packet for each command in the action list, in the same order in which the commands are stored in the list.

The target does not need to do anything with source strings except report them back as part of the replies to the ‘qTfP’/‘qTsP’ query packets.

Although this packet is optional, and GDB will only send it if the target replies with ‘TracepointSource’ See Section E.4 [General Query Packets], page 621, it makes both disconnected tracing and trace files much easier to use. Otherwise
the user must be careful that the tracepoints in effect while looking at trace frames are identical to the ones in effect during the trace run; even a small discrepancy could cause `tdump' not to work, or a particular trace frame not be found.

`QTDV:n:value:builtin:name'

Create a new trace state variable, number n, with an initial value of value, which is a 64-bit signed integer. Both n and value are encoded as hexadecimal values. GDB has the option of not using this packet for initial values of zero; the target should simply create the trace state variables as they are mentioned in expressions. The value builtin should be 1 (one) if the trace state variable is builtin and 0 (zero) if it is not builtin. GDB only sets builtin to 1 if a previous `qTfV' or `qTsV' packet had it set. The contents of name is the hex-encoded name (without the leading `$') of the trace state variable.

`QTFrame:n'

Select the n’th tracepoint frame from the buffer, and use the register and memory contents recorded there to answer subsequent request packets from GDB. A successful reply from the stub indicates that the stub has found the requested frame. The response is a series of parts, concatenated without separators, describing the frame we selected. Each part has one of the following forms:

`F f'  The selected frame is number n in the trace frame buffer; f is a hexadecimal number. If f is ‘-1', then there was no frame matching the criteria in the request packet.

`T t'  The selected trace frame records a hit of tracepoint number t; t is a hexadecimal number.

`QTFrame:pc:addr'

Like `QTFrame:n', but select the first tracepoint frame after the currently selected frame whose PC is addr; addr is a hexadecimal number.

`QTFrame:tdp:t'

Like `QTFrame:n', but select the first tracepoint frame after the currently selected frame that is a hit of tracepoint t; t is a hexadecimal number.

`QTFrame:range:start:end'

Like `QTFrame:n', but select the first tracepoint frame after the currently selected frame whose PC is between start (inclusive) and end (inclusive); start and end are hexadecimal numbers.

`QTFrame:outside:start:end'

Like `QTFrame:range:start:end', but select the first frame outside the given range of addresses (exclusive).

`qTMinFTPILen'

This packet requests the minimum length of instruction at which a fast tracepoint (see Section 13.1 [Set Tracepoints], page 163) may be placed. For instance, on the 32-bit x86 architecture, it is possible to use a 4-byte jump, but it depends on the target system being able to create trampolines in the first 64K of
memory, which might or might not be possible for that system. So the reply to this packet will be 4 if it is able to arrange for that.

Replies:

‘0’ The minimum instruction length is currently unknown.

‘length’ The minimum instruction length is length, where length is a hexadecimal number greater or equal to 1. A reply of 1 means that a fast tracepoint may be placed on any instruction regardless of size.

‘E’ An error has occurred.

‘’ An empty reply indicates that the request is not supported by the stub.

‘QTStart’ Begin the tracepoint experiment. Begin collecting data from tracepoint hits in the trace frame buffer. This packet supports the ‘qRelocInsn’ reply (see Section E.6 [Relocate instruction reply packet], page 644).

‘QTStop’ End the tracepoint experiment. Stop collecting trace frames.

‘QTEnable:n:addr’ Enable tracepoint n at address addr in a started tracepoint experiment. If the tracepoint was previously disabled, then collection of data from it will resume.

‘QTDisable:n:addr’ Disable tracepoint n at address addr in a started tracepoint experiment. No more data will be collected from the tracepoint unless ‘QTEnable:n:addr’ is subsequently issued.

‘QTinit’ Clear the table of tracepoints, and empty the trace frame buffer.

‘QTo:start1,end1:start2,end2:...’ Establish the given ranges of memory as “transparent”. The stub will answer requests for these ranges from memory’s current contents, if they were not collected as part of the tracepoint hit.

GDB uses this to mark read-only regions of memory, like those containing program code. Since these areas never change, they should still have the same contents they did when the tracepoint was hit, so there’s no reason for the stub to refuse to provide their contents.

‘QTDisconnected:value’ Set the choice to what to do with the tracing run when GDB disconnects from the target. A value of 1 directs the target to continue the tracing run, while 0 tells the target to stop tracing if GDB is no longer in the picture.

‘qTStatus’ Ask the stub if there is a trace experiment running right now.
The reply has the form:

‘T[running]:[field]...’

running is a single digit 1 if the trace is presently running, or 0 if not. It is followed by semicolon-separated optional fields that an agent may use to report additional status.
If the trace is not running, the agent may report any of several explanations as one of the optional fields:

`tnotrun:0`
No trace has been run yet.

`tstop[:text]:0`
The trace was stopped by a user-originated stop command. The optional text field is a user-supplied string supplied as part of the stop command (for instance, an explanation of why the trace was stopped manually). It is hex-encoded.

`tfull:0`
The trace stopped because the trace buffer filled up.

`tdisconnected:0`
The trace stopped because GDB disconnected from the target.

`tpasscount:tpnum`
The trace stopped because tracepoint tpnum exceeded its pass count.

`terror:text:tpnum`
The trace stopped because tracepoint tpnum had an error. The string text is available to describe the nature of the error (for instance, a divide by zero in the condition expression); it is hex-encoded.

`tunknown:0`
The trace stopped for some other reason.

Additional optional fields supply statistical and other information. Although not required, they are extremely useful for users monitoring the progress of a trace run. If a trace has stopped, and these numbers are reported, they must reflect the state of the just-stopped trace.

`tframes:n`
The number of trace frames in the buffer.

`tcreated:n`
The total number of trace frames created during the run. This may be larger than the trace frame count, if the buffer is circular.

`tsize:n`
The total size of the trace buffer, in bytes.

`tfree:n`
The number of bytes still unused in the buffer.

`circular:n`
The value of the circular trace buffer flag. 1 means that the trace buffer is circular and old trace frames will be discarded if necessary to make room, 0 means that the trace buffer is linear and may fill up.

`disconn:n`
The value of the disconnected tracing flag. 1 means that tracing will continue after GDB disconnects, 0 means that the trace run will stop.
Appendix E: GDB Remote Serial Protocol

`qTP: tp:addr`
Ask the stub for the current state of tracepoint number tp at address addr.
Replies:

`Vhits: usage`
The tracepoint has been hit hits times so far during the trace run, and accounts for usage in the trace buffer. Note that while-stepping steps are not counted as separate hits, but the steps’ space consumption is added into the usage number.

`qTV: var`
Ask the stub for the value of the trace state variable number var.
Replies:

`Vvalue`
The value of the variable is value. This will be the current value of the variable if the user is examining a running target, or a saved value if the variable was collected in the trace frame that the user is looking at. Note that multiple requests may result in different reply values, such as when requesting values while the program is running.

`U`
The value of the variable is unknown. This would occur, for example, if the user is examining a trace frame in which the requested variable was not collected.

`qTfP`, `qTsP`
These packets request data about tracepoints that are being used by the target. GDB sends `qTfP` to get the first piece of data, and multiple `qTsP` to get additional pieces. Replies to these packets generally take the form of the QTDP packets that define tracepoints. (FIXME add detailed syntax)

`qTfV`, `qTsV`
These packets request data about trace state variables that are on the target. GDB sends `qTfV` to get the first vari of data, and multiple `qTsV` to get additional variables. Replies to these packets follow the syntax of the QTVDV packets that define trace state variables.

`qTfSTM`, `qTsSTM`
These packets request data about static tracepoint markers that exist in the target program. GDB sends `qTfSTM` to get the first piece of data, and multiple `qTsSTM` to get additional pieces. Replies to these packets take the following form:
Reply:

`m address:id:extra`
A single marker

`m address:id:extra,address:id:extra...`
a comma-separated list of markers

`L` (lower case letter ‘L’) denotes end of list.

`E nn` An error occurred. The error number nn is given as hex digits.
An empty reply indicates that the request is not supported by the stub.

The *address* is encoded in hex; *id* and *extra* are strings encoded in hex.

In response to each query, the target will reply with a list of one or more markers, separated by commas. GDB will respond to each reply with a request for more markers (using the ‘qs’ form of the query), until the target responds with ‘l’ (lower-case ell, for last).

`qTSTMat:address`

This packet requests data about static tracepoint markers in the target program at *address*. Replies to this packet follow the syntax of the ‘qTfSTM’ and qTsSTM packets that list static tracepoint markers.

`QTSave:filename`

This packet directs the target to save trace data to the file name *filename* in the target’s filesystem. The *filename* is encoded as a hex string; the interpretation of the file name (relative vs absolute, wild cards, etc) is up to the target.

`qTBuffer:offset,len`

Return up to *len* bytes of the current contents of trace buffer, starting at *offset*. The trace buffer is treated as if it were a contiguous collection of traceframes, as per the trace file format. The reply consists as many hex-encoded bytes as the target can deliver in a packet; it is not an error to return fewer than were asked for. A reply consisting of just ‘l’ indicates that no bytes are available.

`qTBuffer:circular:value`

This packet directs the target to use a circular trace buffer if *value* is 1, or a linear buffer if the value is 0.

`qTBuffer:size:size`

This packet directs the target to make the trace buffer be of size *size* if possible. A value of ‘-1’ tells the target to use whatever size it prefers.

`QTNotes:[type: text];[type: text]...’`

This packet adds optional textual notes to the trace run. Allowable types include *user*, *notes*, and *tstop*, the *text* fields are arbitrary strings, hex-encoded.

### E.6.1 Relocate instruction reply packet

When installing fast tracepoints in memory, the target may need to relocate the instruction currently at the tracepoint address to a different address in memory. For most instructions, a simple copy is enough, but, for example, call instructions that implicitly push the return address on the stack, and relative branches or other PC-relative instructions require offset adjustment, so that the effect of executing the instruction at a different address is the same as if it had executed in the original location.

In response to several of the tracepoint packets, the target may also respond with a number of intermediate ‘qRelocInsn’ request packets before the final result packet, to have GDB handle this relocation operation. If a packet supports this mechanism, its documentation will explicitly say so. See for example the above descriptions for the ‘QTStart’ and ‘QTDp’ packets. The format of the request is:
'qRelocInsn:from;to'
This requests GDB to copy instruction at address from to address to, possibly adjusted so that executing the instruction at to has the same effect as executing it at from. GDB writes the adjusted instruction to target memory starting at to.

Replies:

'qRelocInsn:adjusted_size'
Informs the stub the relocation is complete. The adjusted_size is the length in bytes of resulting relocated instruction sequence.

'E NN' A badly formed request was detected, or an error was encountered while relocating the instruction.

E.7 Host I/O Packets
The Host I/O packets allow GDB to perform I/O operations on the far side of a remote link. For example, Host I/O is used to upload and download files to a remote target with its own filesystem. Host I/O uses the same constant values and data structure layout as the target-initiated File-I/O protocol. However, the Host I/O packets are structured differently. The target-initiated protocol relies on target memory to store parameters and buffers. Host I/O requests are initiated by GDB, and the target’s memory is not involved. See Section E.13 [File-I/O Remote Protocol Extension], page 657, for more details on the target-initiated protocol.

The Host I/O request packets all encode a single operation along with its arguments. They have this format:

'vFile:operation: parameter...'
operation is the name of the particular request; the target should compare the entire packet name up to the second colon when checking for a supported operation. The format of parameter depends on the operation. Numbers are always passed in hexadecimal. Negative numbers have an explicit minus sign (i.e. two’s complement is not used). Strings (e.g. filenames) are encoded as a series of hexadecimal bytes. The last argument to a system call may be a buffer of escaped binary data (see [Binary Data], page 607).

The valid responses to Host I/O packets are:

'F result [, errno] [:attachment]'
result is the integer value returned by this operation, usually non-negative for success and -1 for errors. If an error has occured, errno will be included in the result specifying a value defined by the File-I/O protocol (see [Errno Values], page 667). For operations which return data, attachment supplies the data as a binary buffer. Binary buffers in response packets are escaped in the normal way (see [Binary Data], page 607). See the individual packet documentation for the interpretation of result and attachment.

An empty response indicates that this operation is not recognized.

These are the supported Host I/O operations:
'vFile:open: filename, flags, mode'
Open a file at filename and return a file descriptor for it, or return -1 if an error
occurs. The filename is a string, flags is an integer indicating a mask of open
flags (see [Open Flags], page 667), and mode is an integer indicating a mask
of mode bits to use if the file is created (see [mode_t Values], page 667). See
[open], page 660, for details of the open flags and mode values.

'vFile:close: fd'
Close the open file corresponding to fd and return 0, or -1 if an error occurs.

'vFile:pread: fd, count, offset'
Read data from the open file corresponding to fd. Up to count bytes will be
read from the file, starting at offset relative to the start of the file. The target
may read fewer bytes; common reasons include packet size limits and an end-
of-file condition. The number of bytes read is returned. Zero should only be
returned for a successful read at the end of the file, or if count was zero.
The data read should be returned as a binary attachment on success. If zero
bytes were read, the response should include an empty binary attachment (i.e.
a trailing semicolon). The return value is the number of target bytes read; the
binary attachment may be longer if some characters were escaped.

'vFile:pwrite: fd, offset, data'
Write data (a binary buffer) to the open file corresponding to fd. Start the
write at offset from the start of the file. Unlike many write system calls,
there is no separate count argument; the length of data in the packet is used.
'vFile:write' returns the number of bytes written, which may be shorter than
the length of data, or -1 if an error occurred.

'vFile:fstat: fd'
Get information about the open file corresponding to fd. On success the infor-
mation is returned as a binary attachment and the return value is the size of
this attachment in bytes. If an error occurs the return value is -1. The format
of the returned binary attachment is as described in [struct stat], page 666.

'vFile:unlink: filename'
Delete the file at filename on the target. Return 0, or -1 if an error occurs. The
filename is a string.

'vFile:readlink: filename'
Read value of symbolic link filename on the target. Return the number of bytes
read, or -1 if an error occurs.
The data read should be returned as a binary attachment on success. If zero
bytes were read, the response should include an empty binary attachment (i.e.
a trailing semicolon). The return value is the number of target bytes read; the
binary attachment may be longer if some characters were escaped.

'vFile:setfs: pid'
Select the filesystem on which vFile operations with filename arguments will
operate. This is required for GDB to be able to access files on remote targets
where the remote stub does not share a common filesystem with the inferior(s).
If \( \text{pid} \) is nonzero, select the filesystem as seen by process \( \text{pid} \). If \( \text{pid} \) is zero, select the filesystem as seen by the remote stub. Return 0 on success, or -1 if an error occurs. If \texttt{vFile:setfs} indicates success, the selected filesystem remains selected until the next successful \texttt{vFile:setfs} operation.

### E.8 Interrupts

When a program on the remote target is running, GDB may attempt to interrupt it by sending a ‘Ctrl-C’, \texttt{BREAK} or a \texttt{BREAK} followed by \( \text{g} \), control of which is specified via GDB’s ‘interrupt-sequence’.

The precise meaning of \texttt{BREAK} is defined by the transport mechanism and may, in fact, be undefined. GDB does not currently define a \texttt{BREAK} mechanism for any of the network interfaces except for TCP, in which case GDB sends the \texttt{telnet} \texttt{BREAK} sequence.

‘Ctrl-C’, on the other hand, is defined and implemented for all transport mechanisms. It is represented by sending the single byte \texttt{0x03} without any of the usual packet overhead described in the Overview section (see Section E.1 [Overview], page 607). When a \texttt{0x03} byte is transmitted as part of a packet, it is considered to be packet data and does not represent an interrupt. E.g., an ‘X’ packet (see [X packet], page 616), used for binary downloads, may include an unescaped \texttt{0x03} as part of its packet.

\texttt{BREAK} followed by \( \text{g} \) is also known as Magic SysRq g. When Linux kernel receives this sequence from serial port, it stops execution and connects to gdb.

Stubs are not required to recognize these interrupt mechanisms and the precise meaning associated with receipt of the interrupt is implementation defined. If the target supports debugging of multiple threads and/or processes, it should attempt to interrupt all currently-executing threads and processes. If the stub is successful at interrupting the running program, it should send one of the stop reply packets (see Section E.3 [Stop Reply Packets], page 618) to GDB as a result of successfully stopping the program in all-stop mode, and a stop reply for each stopped thread in non-stop mode. Interrupts received while the program is stopped are discarded.

### E.9 Notification Packets

The GDB remote serial protocol includes \textit{notifications}, packets that require no acknowledgment. Both the GDB and the stub may send notifications (although the only notifications defined at present are sent by the stub). Notifications carry information without incurring the round-trip latency of an acknowledgment, and so are useful for low-impact communications where occasional packet loss is not a problem.

A notification packet has the form ‘\% data # checksum’, where \texttt{data} is the content of the notification, and \texttt{checksum} is a checksum of \texttt{data}, computed and formatted as for ordinary GDB packets. A notification’s \texttt{data} never contains ‘$’, ‘\%' or ‘#’ characters. Upon receiving a notification, the recipient sends no ‘+’ or ‘-’ to acknowledge the notification’s receipt or to report its corruption.

Every notification’s \texttt{data} begins with a name, which contains no colon characters, followed by a colon character.

Recipients should silently ignore corrupted notifications and notifications they do not understand. Recipients should restart timeout periods on receipt of a well-formed notification, whether or not they understand it.
Senders should only send the notifications described here when this protocol description specifies that they are permitted. In the future, we may extend the protocol to permit existing notifications in new contexts; this rule helps older senders avoid confusing newer recipients.

(Older versions of GDB ignore bytes received until they see the ‘$’ byte that begins an ordinary packet, so new stubs may transmit notifications without fear of confusing older clients. There are no notifications defined for GDB to send at the moment, but we assume that most older stubs would ignore them, as well.)

Each notification is comprised of three parts:

`name:event`
The notification packet is sent by the side that initiates the exchange (currently, only the stub does that), with event carrying the specific information about the notification, and name specifying the name of the notification.

`ack`
The acknowledge sent by the other side, usually GDB, to acknowledge the exchange and request the event.

The purpose of an asynchronous notification mechanism is to report to GDB that something interesting happened in the remote stub.

The remote stub may send notification name:event at any time, but GDB acknowledges the notification when appropriate. The notification event is pending before GDB acknowledges. Only one notification at a time may be pending; if additional events occur before GDB has acknowledged the previous notification, they must be queued by the stub for later synchronous transmission in response to ack packets from GDB. Because the notification mechanism is unreliable, the stub is permitted to resend a notification if it believes GDB may not have received it.

Specifically, notifications may appear when GDB is not otherwise reading input from the stub, or when GDB is expecting to read a normal synchronous response or a ‘+’/’−’ acknowledgment to a packet it has sent. Notification packets are distinct from any other communication from the stub so there is no ambiguity.

After receiving a notification, GDB shall acknowledge it by sending a ack packet as a regular, synchronous request to the stub. Such acknowledgment is not required to happen immediately, as GDB is permitted to send other, unrelated packets to the stub first, which the stub should process normally.

Upon receiving a ack packet, if the stub has other queued events to report to GDB, it shall respond by sending a normal event. GDB shall then send another ack packet to solicit further responses; again, it is permitted to send other, unrelated packets as well which the stub should process normally.

If the stub receives a ack packet and there are no additional event to report, the stub shall return an ‘OK’ response. At this point, GDB has finished processing a notification and the stub has completed sending any queued events. GDB won’t accept any new notifications until the final ‘OK’ is received. If further notification events occur, the stub shall send a new notification, GDB shall accept the notification, and the process shall be repeated.

The process of asynchronous notification can be illustrated by the following example:

```
<-%%Stop:T0505:98e7ffbf;04:4ce6ffbf;08:b1b6e54c;thread:p7526.7526;core:0;
```

...
The following notifications are defined:

<table>
<thead>
<tr>
<th>Notification</th>
<th>Ack</th>
<th>Event</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stop</td>
<td>vStopped</td>
<td>reply. The reply has the form of a stop reply, as described in Section E.3 [Stop Reply Packets], page 618. Refer to Section E.10 [Remote Non-Stop], page 655, for information on how these notifications are acknowledged by GDB.</td>
<td>Report an asynchronous stop event in non-stop mode.</td>
</tr>
</tbody>
</table>

### E.10 Remote Protocol Support for Non-Stop Mode

GDB’s remote protocol supports non-stop debugging of multi-threaded programs, as described in Section 5.5.2 [Non-Stop Mode], page 77. If the stub supports non-stop mode, it should report that to GDB by including ‘QNonStop+’ in its ‘qSupported’ response (see [qSupported], page 628).

GDB typically sends a ‘QNonStop’ packet only when establishing a new connection with the stub. Entering non-stop mode does not alter the state of any currently-running threads, but targets must stop all threads in any already-attached processes when entering all-stop mode. GDB uses the ‘?’ packet as necessary to probe the target state after a mode change.

In non-stop mode, when an attached process encounters an event that would otherwise be reported with a stop reply, it uses the asynchronous notification mechanism (see Section E.9 [Notification Packets], page 653) to inform GDB. In contrast to all-stop mode, where all threads in all processes are stopped when a stop reply is sent, in non-stop mode only the thread reporting the stop event is stopped. That is, when reporting a ‘S’ or ‘T’ response to indicate completion of a step operation, hitting a breakpoint, or a fault, only the affected thread is stopped; any other still-running threads continue to run. When reporting a ‘W’ or ‘X’ response, all running threads belonging to other attached processes continue to run.

In non-stop mode, the target shall respond to the ‘?’ packet as follows. First, any incomplete stop reply notification/’vStopped’ sequence in progress is abandoned. The target must begin a new sequence reporting stop events for all stopped threads, whether or not it has previously reported those events to GDB. The first stop reply is sent as a synchronous reply to the ‘?’ packet, and subsequent stop replies are sent as responses to ‘vStopped’ packets using the mechanism described above. The target must not send asynchronous stop reply notifications until the sequence is complete. If all threads are running when the target receives the ‘?’ packet, or if the target is not attached to any process, it shall respond ‘OK’.

If the stub supports non-stop mode, it should also support the ‘swbreak’ stop reason if software breakpoints are supported, and the ‘hwbreak’ stop reason if hardware breakpoints
are supported (see [swbreak stop reason], page 619). This is because given the asynchronous nature of non-stop mode, between the time a thread hits a breakpoint and the time the event is finally processed by GDB, the breakpoint may have already been removed from the target. Due to this, GDB needs to be able to tell whether a trap stop was caused by a delayed breakpoint event, which should be ignored, as opposed to a random trap signal, which should be reported to the user. Note the ‘swbreak’ feature implies that the target is responsible for adjusting the PC when a software breakpoint triggers, if necessary, such as on the x86 architecture.

E.11 Packet Acknowledgment

By default, when either the host or the target machine receives a packet, the first response expected is an acknowledgment: either ‘+’ (to indicate the package was received correctly) or ‘-’ (to request retransmission). This mechanism allows the GDB remote protocol to operate over unreliable transport mechanisms, such as a serial line.

In cases where the transport mechanism is itself reliable (such as a pipe or TCP connection), the ‘+/−’ acknowledgments are redundant. It may be desirable to disable them in that case to reduce communication overhead, or for other reasons. This can be accomplished by means of the ‘QStartNoAckMode’ packet; see [QStartNoAckMode], page 627.

When in no-acknowledgment mode, neither the stub nor GDB shall send or expect ‘+/−’ protocol acknowledgments. The packet and response format still includes the normal checksum, as described in Section E.1 [Overview], page 607, but the checksum may be ignored by the receiver.

If the stub supports ‘QStartNoAckMode’ and prefers to operate in no-acknowledgment mode, it should report that to GDB by including ‘QStartNoAckMode+’ in its response to ‘qSupported’; see [qSupported], page 628. If GDB also supports ‘QStartNoAckMode’ and it has not been disabled via the set remote noack-packet off command (see Section 20.4 [Remote Configuration], page 264), GDB may then send a ‘QStartNoAckMode’ packet to the stub. Only then may the stub actually turn off packet acknowledgments. GDB sends a final ‘+’ acknowledgment of the stub’s ‘OK’ response, which can be safely ignored by the stub.

Note that set remote noack-packet command only affects negotiation between GDB and the stub when subsequent connections are made; it does not affect the protocol acknowledgment state for any current connection. Since ‘+/−’ acknowledgments are enabled by default when a new connection is established, there is also no protocol request to re-enable the acknowledgments for the current connection, once disabled.

E.12 Examples

Example sequence of a target being re-started. Notice how the restart does not get any direct output:

```
-> R00
<- +
  target restarts
-> ?
<- +
<- T001:1234123412341234
-> +
```

Example sequence of a target being stepped by a single instruction:
E.13 File-I/O Remote Protocol Extension

E.13.1 File-I/O Overview

The File I/O remote protocol extension (short: File-I/O) allows the target to use the host’s file system and console I/O to perform various system calls. System calls on the target system are translated into a remote protocol packet to the host system, which then performs the needed actions and returns a response packet to the target system. This simulates file system operations even on targets that lack file systems.

The protocol is defined to be independent of both the host and target systems. It uses its own internal representation of datatypes and values. Both GDB and the target’s GDB stub are responsible for translating the system-dependent value representations into the internal protocol representations when data is transmitted.

The communication is synchronous. A system call is possible only when GDB is waiting for a response from the ‘C’, ‘c’, ‘S’ or ‘s’ packets. While GDB handles the request for a system call, the target is stopped to allow deterministic access to the target’s memory. Therefore File-I/O is not interruptible by target signals. On the other hand, it is possible to interrupt File-I/O by a user interrupt (‘Ctrl-C’) within GDB.

The target’s request to perform a host system call does not finish the latest ‘C’, ‘c’, ‘S’ or ‘s’ action. That means, after finishing the system call, the target returns to continuing the previous activity (continue, step). No additional continue or step request from GDB is required.

```
(gdb) continue
<- target requests 'system call X'
target is stopped, GDB executes system call
-> GDB returns result
... target continues, GDB returns to wait for the target
<- target hits breakpoint and sends a Txx packet
```

The protocol only supports I/O on the console and to regular files on the host file system. Character or block special devices, pipes, named pipes, sockets or any other communication method on the host system are not supported by this protocol.

File I/O is not supported in non-stop mode.

E.13.2 Protocol Basics

The File-I/O protocol uses the F packet as the request as well as reply packet. Since a File-I/O system call can only occur when GDB is waiting for a response from the continuing or stepping target, the File-I/O request is a reply that GDB has to expect as a result of a
previous ‘C’, ‘c’, ‘S’ or ‘s’ packet. This F packet contains all information needed to allow GDB to call the appropriate host system call:

- A unique identifier for the requested system call.
- All parameters to the system call. Pointers are given as addresses in the target memory address space. Pointers to strings are given as pointer/length pair. Numerical values are given as they are. Numerical control flags are given in a protocol-specific representation.

At this point, GDB has to perform the following actions.

- If the parameters include pointer values to data needed as input to a system call, GDB requests this data from the target with a standard m packet request. This additional communication has to be expected by the target implementation and is handled as any other m packet.
- GDB translates all value from protocol representation to host representation as needed. Datatypes are coerced into the host types.
- GDB calls the system call.
- It then coerces datatypes back to protocol representation.
- If the system call is expected to return data in buffer space specified by pointer parameters to the call, the data is transmitted to the target using a M or X packet. This packet has to be expected by the target implementation and is handled as any other M or X packet.

Eventually GDB replies with another F packet which contains all necessary information for the target to continue. This at least contains

- Return value.
- errno, if has been changed by the system call.
- “Ctrl-C” flag.

After having done the needed type and value coercion, the target continues the latest continue or step action.

**E.13.3 The F Request Packet**

The F request packet has the following format:

`Fcall-id,parameter...`

*call-id* is the identifier to indicate the host system call to be called. This is just the name of the function.

*parameter...* are the parameters to the system call. Parameters are hexadecimal integer values, either the actual values in case of scalar datatypes, pointers to target buffer space in case of compound datatypes and unspecified memory areas, or pointer/length pairs in case of string parameters. These are appended to the *call-id* as a comma-delimited list. All values are transmitted in ASCII string representation, pointer/length pairs separated by a slash.

**E.13.4 The F Reply Packet**

The F reply packet has the following format:
Appendix E: GDB Remote Serial Protocol

Fretcode, errno, Ctrl-C flag; call-specific attachment

retcode is the return code of the system call as hexadecimal value.
errno is the errno set by the call, in protocol-specific representation. This parameter can be omitted if the call was successful.
Ctrl-C flag is only sent if the user requested a break. In this case, errno must be sent as well, even if the call was successful. The Ctrl-C flag itself consists of the character ‘C’:
F0,0,C
or, if the call was interrupted before the host call has been performed:
F-1,4,C
assuming 4 is the protocol-specific representation of EINTR.

E.13.5 The ‘Ctrl-C’ Message

If the ‘Ctrl-C’ flag is set in the GDB reply packet (see Section E.13.4 [The F Reply Packet], page 658), the target should behave as if it had gotten a break message. The meaning for the target is “system call interrupted by SIGINT”. Consequentially, the target should actually stop (as with a break message) and return to GDB with a T02 packet.

It’s important for the target to know in which state the system call was interrupted. There are two possible cases:
• The system call hasn’t been performed on the host yet.
• The system call on the host has been finished.

These two states can be distinguished by the target by the value of the returned errno. If it’s the protocol representation of EINTR, the system call hasn’t been performed. This is equivalent to the EINTR handling on POSIX systems. In any other case, the target may presume that the system call has been finished — successfully or not — and should behave as if the break message arrived right after the system call.

GDB must behave reliably. If the system call has not been called yet, GDB may send the F reply immediately, setting EINTR as errno in the packet. If the system call on the host has been finished before the user requests a break, the full action must be finished by GDB. This requires sending M or X packets as necessary. The F packet may only be sent when either nothing has happened or the full action has been completed.

E.13.6 Console I/O

By default and if not explicitly closed by the target system, the file descriptors 0, 1 and 2 are connected to the GDB console. Output on the GDB console is handled as any other file output operation (write(1, ...) or write(2, ...)). Console input is handled by GDB so that after the target read request from file descriptor 0 all following typing is buffered until either one of the following conditions is met:
• The user types Ctrl-c. The behaviour is as explained above, and the read system call is treated as finished.
• The user presses RET. This is treated as end of input with a trailing newline.
• The user types Ctrl-d. This is treated as end of input. No trailing character (neither newline nor ‘Ctrl-D’) is appended to the input.
If the user has typed more characters than fit in the buffer given to the \texttt{read} call, the trailing characters are buffered in GDB until either another \texttt{read(0, \ldots)} is requested by the target, or debugging is stopped at the user’s request.

### E.13.7 List of Supported Calls

#### open

**Synopsis:**

\[
\begin{align*}
\text{int open(const char *pathname, int flags);} \\
\text{int open(const char *pathname, int flags, mode_t mode);} \\
\end{align*}
\]

**Request:** ‘\texttt{Fopen, pathptr/len, flags, mode’}

- \texttt{flags} is the bitwise OR of the following values:
  - \texttt{O_CREAT} If the file does not exist it will be created. The host rules apply as far as file ownership and time stamps are concerned.
  - \texttt{O_EXCL} When used with \texttt{O_CREAT}, if the file already exists it is an error and open() fails.
  - \texttt{O_TRUNC} If the file already exists and the open mode allows writing (\texttt{O_RDWR} or \texttt{O_WRONLY} is given) it will be truncated to zero length.
  - \texttt{O_APPEND} The file is opened in append mode.
  - \texttt{O_RDONLY} The file is opened for reading only.
  - \texttt{O_WRONLY} The file is opened for writing only.
  - \texttt{O_RDWR} The file is opened for reading and writing.

Other bits are silently ignored.

- \texttt{mode} is the bitwise OR of the following values:
  - \texttt{S_IRUSR} User has read permission.
  - \texttt{S_IWUSR} User has write permission.
  - \texttt{S_IRGRP} Group has read permission.
  - \texttt{S_IWGRP} Group has write permission.
  - \texttt{S_IROTH} Others have read permission.
  - \texttt{S_IWOTH} Others have write permission.

Other bits are silently ignored.

**Return value:**

- open returns the new file descriptor or -1 if an error occurred.

**Errors:**

- EEXIST \texttt{pathname} already exists and \texttt{O_CREAT} and \texttt{O_EXCL} were used.
- EISDIR \texttt{pathname} refers to a directory.
- EACCES The requested access is not allowed.
ENAMETOOLONG
   pathname was too long.
ENOENT   A directory component in pathname does not exist.
ENODEV   pathname refers to a device, pipe, named pipe or socket.
EROFS    pathname refers to a file on a read-only filesystem and write access was requested.
EFAULT   pathname is an invalid pointer value.
ENOSPC   No space on device to create the file.
EMFILE   The process already has the maximum number of files open.
ENFILE   The limit on the total number of files open on the system has been reached.
EINTR    The call was interrupted by the user.

close
Synopsis:
   int close(int fd);
Request: ‘Fclose,fd’
Return value:
   close returns zero on success, or -1 if an error occurred.
Errors:
   EBADF   fd isn’t a valid open file descriptor.
   EINTR   The call was interrupted by the user.

read
Synopsis:
   int read(int fd, void *buf, unsigned int count);
Request: ‘Fread,fd,bufptr,count’
Return value:
   On success, the number of bytes read is returned. Zero indicates end of file. If count is zero, read returns zero as well. On error, -1 is returned.
Errors:
   EBADF   fd is not a valid file descriptor or is not open for reading.
   EFAULT  bufptr is an invalid pointer value.
   EINTR   The call was interrupted by the user.
write

Synopsis:

    int write(int fd, const void *buf, unsigned int count);

Request: ‘Fwrite,fd,bufptr,count’

Return value:
On success, the number of bytes written are returned. Zero indicates nothing
was written. On error, -1 is returned.

Errors:

EBADF   fd is not a valid file descriptor or is not open for writing.
EFAULT  bufptr is an invalid pointer value.
EFBIG    An attempt was made to write a file that exceeds the host-specific
         maximum file size allowed.
ENOSPC   No space on device to write the data.
EINTR    The call was interrupted by the user.

lseek

Synopsis:

    long lseek (int fd, long offset, int flag);

Request: ‘Flseek,fd,offset,flag’

flag is one of:

SEEK_SET The offset is set to offset bytes.
SEEK_CUR  The offset is set to its current location plus offset bytes.
SEEK_END  The offset is set to the size of the file plus offset bytes.

Return value:
On success, the resulting unsigned offset in bytes from the beginning of the file
is returned. Otherwise, a value of -1 is returned.

Errors:

EBADF   fd is not a valid open file descriptor.
ESPIPE   fd is associated with the GDB console.
EINVAL   flag is not a proper value.
EINTR    The call was interrupted by the user.

rename

Synopsis:

    int rename(const char *oldpath, const char *newpath);

Request: ‘Frename,oldpathptr/len,newpathptr/len’
Return value:
On success, zero is returned. On error, -1 is returned.

Errors:
- **EISDIR**  
  `newpath` is an existing directory, but `oldpath` is not a directory.
- **EEXIST**  
  `newpath` is a non-empty directory.
- **EBUSY**  
  `oldpath` or `newpath` is a directory that is in use by some process.
- **EINVAL**  
  An attempt was made to make a directory a subdirectory of itself.
- **ENOTDIR**  
  A component used as a directory in `oldpath` or new path is not a directory. Or `oldpath` is a directory and `newpath` exists but is not a directory.
- **EFAULT**  
  `oldpathptr` or `newpathptr` are invalid pointer values.
- **EACCES**  
  No access to the file or the path of the file.
- **ENAMETOOLONG**  
  `oldpath` or `newpath` was too long.
- **ENOENT**  
  A directory component in `oldpath` or `newpath` does not exist.
- **EROFS**  
  The file is on a read-only filesystem.
- **ENOSPC**  
  The device containing the file has no room for the new directory entry.
- **EINTR**  
  The call was interrupted by the user.

**unlink**

Synopsis:
```c
int unlink(const char *pathname);
```

Request: ‘Funlink,pathnameptr/len’

Return value:
On success, zero is returned. On error, -1 is returned.

Errors:
- **EACCES**  
  No access to the file or the path of the file.
- **EPERM**  
  The system does not allow unlinking of directories.
- **EBUSY**  
  The file `pathname` cannot be unlinked because it’s being used by another process.
- **EFAULT**  
  `pathnameptr` is an invalid pointer value.
- **ENAMETOOLONG**  
  `pathname` was too long.
- **ENOENT**  
  A directory component in `pathname` does not exist.
- **ENOTDIR**  
  A component of the path is not a directory.
- **EROFS**  
  The file is on a read-only filesystem.
- **EINTR**  
  The call was interrupted by the user.
stat/fstat

Synopsis:
```
int stat(const char *pathname, struct stat *buf);
int fstat(int fd, struct stat *buf);
```

Request: ‘Fstat, pathnameptr/len, bufptr’
‘Ffstat, fd, bufptr’

Return value:
On success, zero is returned. On error, -1 is returned.

Errors:
- EBADF       fd is not a valid open file.
- ENOENT      A directory component in pathname does not exist or the path is an empty string.
- ENOTDIR     A component of the path is not a directory.
- EFAULT      pathnameptr is an invalid pointer value.
- EACCES      No access to the file or the path of the file.
- ENAMETOOLONG pathname was too long.
- EINTR       The call was interrupted by the user.

gettimeofday

Synopsis:
```
int gettimeofday(struct timeval *tv, void *tz);
```

Request: ‘Fgettimeofday, tvptr, tzptr’

Return value:
On success, 0 is returned, -1 otherwise.

Errors:
- EINVAL      tz is a non-NULL pointer.
- EFAULT      tvptr and/or tzptr is an invalid pointer value.

isatty

Synopsis:
```
int isatty(int fd);
```

Request: ‘Fisatty, fd’

Return value:
Returns 1 if fd refers to the GDB console, 0 otherwise.

Errors:
- EINTR       The call was interrupted by the user.

Note that the isatty call is treated as a special case: it returns 1 to the target if the file descriptor is attached to the GDB console, 0 otherwise. Implementing through system calls would require implementing ioctl and would be more complex than needed.
**system**

Synopsis:

```c
int system(const char *command);
```

Request: `Fsystem,commandptr/len`

Return value:

If `len` is zero, the return value indicates whether a shell is available. A zero return value indicates a shell is not available. For non-zero `len`, the value returned is -1 on error and the return status of the command otherwise. Only the exit status of the command is returned, which is extracted from the host’s `system` return value by calling `WEXITSTATUS(retval)`. In case `'/bin/sh'` could not be executed, 127 is returned.

Errors:

- **EINTR** The call was interrupted by the user.

GDB takes over the full task of calling the necessary host calls to perform the `system` call. The return value of `system` on the host is simplified before it’s returned to the target. Any termination signal information from the child process is discarded, and the return value consists entirely of the exit status of the called command.

Due to security concerns, the `system` call is by default refused by GDB. The user has to allow this call explicitly with the `set remote system-call-allowed 1` command.

`set remote system-call-allowed`

Control whether to allow the `system` calls in the File I/O protocol for the remote target. The default is zero (disabled).

`show remote system-call-allowed`

Show whether the `system` calls are allowed in the File I/O protocol.

**E.13.8 Protocol-specific Representation of Datatypes**

**Integral Datatypes**

The integral datatypes used in the system calls are `int`, `unsigned int`, `long`, `unsigned long`, `mode_t`, and `time_t`.

- `int`, `unsigned int`, `mode_t`, and `time_t` are implemented as 32 bit values in this protocol.
- `long` and `unsigned long` are implemented as 64 bit types.

See [Limits], page 668, for corresponding MIN and MAX values (similar to those in ‘limits.h’) to allow range checking on host and target.

`time_t` datatypes are defined as seconds since the Epoch.

All integral datatypes transferred as part of a memory read or write of a structured datatype e.g. a `struct stat` have to be given in big endian byte order.

**Pointer Values**

Pointers to target data are transmitted as they are. An exception is made for pointers to buffers for which the length isn’t transmitted as part of the function call, namely strings. Strings are transmitted as a pointer/length pair, both as hex values, e.g.
which is a pointer to data of length 18 bytes at position 0x1aaf. The length is defined as the full string length in bytes, including the trailing null byte. For example, the string "hello world" at address 0x123456 is transmitted as 0x123456/d

Memory Transfer

Structured data which is transferred using a memory read or write (for example, a struct stat) is expected to be in a protocol-specific format with all scalar multibyte datatypes being big endian. Translation to this representation needs to be done both by the target before the F packet is sent, and by GDB before it transfers memory to the target. Transferred pointers to structured data should point to the already-coerced data at any time.

struct stat

The buffer of type struct stat used by the target and GDB is defined as follows:

```c
struct stat {
    unsigned int st_dev; /* device */
    unsigned int st_ino; /* inode */
    mode_t st_mode; /* protection */
    unsigned int st_nlink; /* number of hard links */
    unsigned int st_uid; /* user ID of owner */
    unsigned int st_gid; /* group ID of owner */
    unsigned int st_rdev; /* device type (if inode device) */
    unsigned long st_size; /* total size, in bytes */
    unsigned long st_blksize; /* blocksize for filesystem I/O */
    unsigned long st_blocks; /* number of blocks allocated */
    time_t st_atime; /* time of last access */
    time_t st_mtime; /* time of last modification */
    time_t st_ctime; /* time of last change */
};
```

The integral datatypes conform to the definitions given in the appropriate section (see [Integral Datatypes], page 665, for details) so this structure is of size 64 bytes.

The values of several fields have a restricted meaning and/or range of values.

- **st_dev**: A value of 0 represents a file, 1 the console.
- **st_ino**: No valid meaning for the target. Transmitted unchanged.
- **st_mode**: Valid mode bits are described in Section E.13.9 [Constants], page 667. Any other bits have currently no meaning for the target.
- **st_uid**
- **st_gid**
- **st_rdev**: No valid meaning for the target. Transmitted unchanged.
- **st_atime**
- **st_mtime**
- **st_ctime**: These values have a host and file system dependent accuracy. Especially on Windows hosts, the file system may not support exact timing values.

The target gets a struct stat of the above representation and is responsible for coercing it to the target representation before continuing.
Note that due to size differences between the host, target, and protocol representations of `struct stat` members, these members could eventually get truncated on the target.

**struct timeval**

The buffer of type `struct timeval` used by the File-I/O protocol is defined as follows:

```c
struct timeval {
    time_t tv_sec; /* second */
    long tv_usec; /* microsecond */
};
```

The integral datatypes conform to the definitions given in the appropriate section (see [Integral Datatypes], page 665, for details) so this structure is of size 8 bytes.

**E.13.9 Constants**

The following values are used for the constants inside of the protocol. GDB and target are responsible for translating these values before and after the call as needed.

**Open Flags**

All values are given in hexadecimal representation.

- O_RDONLY 0x0
- O_WRONLY 0x1
- O_RDWR 0x2
- O_APPEND 0x8
- O_CREAT 0x200
- O_TRUNC 0x400
- O_EXCL 0x800

**mode_t Values**

All values are given in octal representation.

- S_IFREG 0100000
- S_IFDIR 040000
- S_IRUSR 0400
- S_IWUSR 0200
- S_IXUSR 0100
- S_IRGRP 040
- S_IWGRP 020
- S_IXGRP 010
- S_IROTH 04
- S_IWOTH 02
- S_IXOTH 01

**Errno Values**

All values are given in decimal representation.

- EPERM 1
- ENOENT 2
- EINTR 4
- Ebadf 9
- EACCES 13
- ENFALT 14
- EBUSY 16
- EXCIST 17
- ENODEV 19
ENOTDIR  20
EISDIR   21
EINVAL  22
ENFILE  23
EMFILE  24
EFBIG   27
ENOSPC  28
ESPIPE  29
ERofs   30
ENAMETOOLONG  91
EUNKNOWN  9999

EUNKNOWN is used as a fallback error value if a host system returns any error value not in the list of supported error numbers.

Lseek Flags

SEEK_SET     0
SEEK_CUR     1
SEEK_END     2

Limits

All values are given in decimal representation.

INT_MIN     -2147483648
INT_MAX     2147483647
UINT_MAX    4294967295
LONG_MIN    -9223372036854775808
LONG_MAX    9223372036854775807
ULONG_MAX   18446744073709551615

E.13.10 File-I/O Examples

Example sequence of a write call, file descriptor 3, buffer is at target address 0x1234, 6 bytes should be written:

<- Fwrite,3,1234,6
  request memory read from target
-> m1234,6
<- XXXXXX
  return "6 bytes written"
-> F6

Example sequence of a read call, file descriptor 3, buffer is at target address 0x1234, 6 bytes should be read:

<- Fread,3,1234,6
  request memory write to target
-> X1234,6:XXXXXX
  return "6 bytes read"
-> F6

Example sequence of a read call, call fails on the host due to invalid file descriptor (EBADF):

<- Fread,3,1234,6
  request memory write to target
-> F-1,9

Example sequence of a read call, user presses Ctrl-c before syscall on host is called:

<- Fread,3,1234,6
  request memory write to target
-> F-1,4,C

Example sequence of a read call, file descriptor 3, buffer is at target address 0x1234, 6 bytes should be read:

<- Fread,3,1234,6
  request memory write to target
-> X1234,6:XXXXXX
  return "6 bytes read"
-> F6

Example sequence of a read call, call fails on the host due to invalid file descriptor (EBADF):

<- Fread,3,1234,6
  request memory write to target
-> F-1,9

Example sequence of a read call, user presses Ctrl-c before syscall on host is called:

<- Fread,3,1234,6
  request memory write to target
-> F-1,4,C
Example sequence of a read call, user presses Ctrl-c after syscall on host is called:

\[-\ T02\]
\[-\ Fread,3,1234,6\]
\[->\ X1234,6:XXXXXX\]
\[-\ T02\]

### E.14 Library List Format

On some platforms, a dynamic loader (e.g. ‘ld.so’) runs in the same process as your application to manage libraries. In this case, GDB can use the loader’s symbol table and normal memory operations to maintain a list of shared libraries. On other platforms, the operating system manages loaded libraries. GDB can not retrieve the list of currently loaded libraries through memory operations, so it uses the ‘qXfer:libraries:read’ packet (see [qXfer library list read], page 638) instead. The remote stub queries the target’s operating system and reports which libraries are loaded.

The ‘qXfer:libraries:read’ packet returns an XML document which lists loaded libraries and their offsets. Each library has an associated name and one or more segment or section base addresses, which report where the library was loaded in memory.

For the common case of libraries that are fully linked binaries, the library should have a list of segments. If the target supports dynamic linking of a relocatable object file, its library XML element should instead include a list of allocated sections. The segment or section bases are start addresses, not relocation offsets; they do not depend on the library’s link-time base addresses.

GDB must be linked with the Expat library to support XML library lists. See [Expat], page 591.

A simple memory map, with one loaded library relocated by a single offset, looks like this:

```xml
<library-list>
  <library name="/lib/libc.so.6">
    <segment address="0x10000000"/>
  </library>
</library-list>
```

Another simple memory map, with one loaded library with three allocated sections (.text, .data, .bss), looks like this:

```xml
<library-list>
  <library name="sharedlib.o">
    <section address="0x10000000"/>
    <section address="0x20000000"/>
    <section address="0x30000000"/>
  </library>
</library-list>
```

The format of a library list is described by this DTD:

```xml
<!ELEMENT library-list (library)>
<!ATTLIST library-list version CDATA #FIXED "1.0">  
<!ELEMENT library (segment*, section*)>
<!ATTLIST library name CDATA #REQUIRED>
<!ATTLIST segment address CDATA #REQUIRED>
```
In addition, segments and section descriptors cannot be mixed within a single library element, and you must supply at least one segment or section for each library.

E.15 Library List Format for SVR4 Targets

On SVR4 platforms, GDB can use the symbol table of a dynamic loader (e.g., `ld.so`) and normal memory operations to maintain a list of shared libraries. Still, a special library list provided by this packet is more efficient for the GDB remote protocol.

The `qXfer:libraries-svr4:read` packet returns an XML document which lists loaded libraries and their SVR4 linker parameters. For each library on SVR4 target, the following parameters are reported:

- `name`, the absolute file name from the `l_name` field of `struct link_map`.
- `lm` with address of `struct link_map` used for TLS (Thread Local Storage) access.
- `l_addr`, the displacement as read from the field `l_addr` of `struct link_map`. For prelinked libraries, this is not an absolute memory address. It is a displacement of absolute memory address against address the file was prelinked to during the library load.
- `l_ld`, which is memory address of the `PT_DYNAMIC` segment

Additionally, the single `main-lm` attribute specifies address of `struct link_map` used for the main executable. This parameter is used for TLS access, and its presence is optional.

GDB must be linked with the Expat library to support XML SVR4 library lists. See [Expat], page 591.

A simple memory map, with two loaded libraries (which do not use prelink), looks like this:

```xml
<library-list-svr4 version="1.0" main-lm="0xe4f8f8">
  <library name="/lib/ld-linux.so.2" lm="0xe4f51c" l_addr="0xe2d000" l_ld="0xe4eefc"/>
  <library name="/lib/libc.so.6" lm="0xe4fbe8" l_addr="0x154000" l_ld="0x152350"/>
</library-list-svr4>
```

The format of an SVR4 library list is described by this DTD:

```xml
<!ELEMENT library-list-svr4 (library)*>
<!ATTLIST library-list-svr4 version CDATA #FIXED "1.0">
<!ATTLIST library-list-svr4 main-lm CDATA #IMPLIED>
<!ELEMENT library EMPTY>
<!ATTLIST library name CDATA #REQUIRED>
<!ATTLIST library lm CDATA #REQUIRED>
<!ATTLIST library l_addr CDATA #REQUIRED>
<!ATTLIST library l_ld CDATA #REQUIRED>
```

E.16 Memory Map Format

To be able to write into flash memory, GDB needs to obtain a memory map from the target. This section describes the format of the memory map.
The memory map is obtained using the `qXfer:memory-map:read` (see [qXfer memory map read], page 639) packet and is an XML document that lists memory regions.

GDB must be linked with the Expat library to support XML memory maps. See [Expat], page 591.

The top-level structure of the document is shown below:
```xml
<?xml version="1.0"?>
<!DOCTYPE memory-map
 PUBLIC "+/IDN gnu.org/DTD GDB Memory Map V1.0//EN"
 "http://sourceware.org/gdb/gdb-memory-map.dtd">
<memory-map>
  region...
</memory-map>
```

Each region can be either:

- A region of RAM starting at `addr` and extending for `length` bytes from there:
  ```xml
  <memory type="ram" start="addr" length="length"/>
  ```

- A region of read-only memory:
  ```xml
  <memory type="rom" start="addr" length="length"/>
  ```

- A region of flash memory, with erasure blocks `blocksize` bytes in length:
  ```xml
  <memory type="flash" start="addr" length="length">
    <property name="blocksize">blocksize</property>
  </memory>
  ```

Regions must not overlap. GDB assumes that areas of memory not covered by the memory map are RAM, and uses the ordinary ‘M’ and ‘X’ packets to write to addresses in such ranges.

The formal DTD for memory map format is given below:
```xml
<!-- ................................................... -->
<!-- Memory Map XML DTD ................................ -->
<!-- File: memory-map.dtd .............................. -->
<!-- .................................... .............. -->
<!-- memory-map.dtd -->
<!-- memory-map: Root element with versioning -->
<!ELEMENT memory-map (memory | property)>
<!ATTLIST memory-map version CDATA #FIXED "1.0.0">
<!ELEMENT memory (property)>
<!-- memory: Specifies a memory region, and its type, or device. -->
<!ATTLIST memory type CDATA #REQUIRED
 start CDATA #REQUIRED
 length CDATA #REQUIRED
 device CDATA #IMPLIED>
<!-- property: Generic attribute tag -->
<!ELEMENT property (#PCDATA | property)>*
<!ATTLIST property (#PCDATA | property)>
```

### E.17 Thread List Format

To efficiently update the list of threads and their attributes, GDB issues the `qXfer:threads:read` packet (see [qXfer threads read], page 640) and obtains the XML document with the following structure:
```xml
<?xml version="1.0"?>
<threads>
  <thread id="id" core="0">
```
Debugging with gdb

... description ...
</thread>
</threads>

Each ‘thread’ element must have the ‘id’ attribute that identifies the thread (see [thread-id syntax], page 608). The ‘core’ attribute, if present, specifies which processor core the thread was last executing on. The content of the of ‘thread’ element is interpreted as human-readable auxiliary information.

E.18 Traceframe Info Format

To be able to know which objects in the inferior can be examined when inspecting a trace-point hit, GDB needs to obtain the list of memory ranges, registers and trace state variables that have been collected in a traceframe.

This list is obtained using the ‘qXfer:traceframe-info:read’ (see [qXfer traceframe info read], page 640) packet and is an XML document.

GDB must be linked with the Expat library to support XML traceframe info discovery. See [Expat], page 591.

The top-level structure of the document is shown below:

```xml
<?xml version="1.0"?>
<!DOCTYPE traceframe-info
 PUBLIC "+//IDN gnu.org//DTD GDB Memory Map V1.0//EN"
 "http://sourceware.org/gdb/gdb-traceframe-info.dtd">
<traceframe-info>
 block...
</traceframe-info>
```

Each traceframe block can be either:

- A region of collected memory starting at `addr` and extending for `length` bytes from there:
  ```xml
  <memory start="addr" length="length"/>
  ```

- A block indicating trace state variable numbered `number` has been collected:
  ```xml
  <tvar id="number"/>
  ```

The formal DTD for the traceframe info format is given below:

```xml
<!ELEMENT traceframe-info (memory | tvar)* >
<!ATTLIST traceframe-info version CDATA #FIXED "1.0">

<!ELEMENT memory EMPTY>
<!ATTLIST memory start CDATA #REQUIRED
 length CDATA #REQUIRED>

<!ELEMENT tvar>
<!ATTLIST tvar id CDATA #REQUIRED>
```

E.19 Branch Trace Format

In order to display the branch trace of an inferior thread, GDB needs to obtain the list of branches. This list is represented as list of sequential code blocks that are connected via branches. The code in each block has been executed sequentially.

This list is obtained using the ‘qXfer:btrace:read’ (see [qXfer btrace read], page 637) packet and is an XML document.
GDB must be linked with the Expat library to support XML traceframe info discovery. See [Expat], page 591.

The top-level structure of the document is shown below:

```xml
<?xml version="1.0"?>
<!DOCTYPE btrace
   PUBLIC "-//IDN gnu.org//DTD GDB Branch Trace V1.0//EN"
   "http://sourceware.org/gdb/gdb-btrace.dtd">
<btrace>
  block...
</btrace>

• A block of sequentially executed instructions starting at begin and ending at end:
  <block begin="begin" end="end"/>
```

The formal DTD for the branch trace format is given below:

```xml
<!ELEMENT btrace (block* | pt) >
<!ATTLIST btrace version CDATA #FIXED "1.0">

<!ELEMENT block EMPTY>
<!ATTLIST block begin CDATA #REQUIRED
   end CDATA #REQUIRED>

<!ELEMENT pt (pt-config?, raw?)>
<!ELEMENT pt-config (cpu?)>
<!ELEMENT cpu EMPTY>
<!ATTLIST cpu vendor CDATA #REQUIRED
   family CDATA #REQUIRED
   model CDATA #REQUIRED
   stepping CDATA #REQUIRED>

<!ELEMENT raw (#PCDATA)>
```

### E.20 Branch Trace Configuration Format

For each inferior thread, GDB can obtain the branch trace configuration using the 'qXfer:btrace-conf:read' (see [qXfer btrace-conf read], page 638) packet.

The configuration describes the branch trace format and configuration settings for that format. The following information is described:

- **bts**
  This thread uses the Branch Trace Store (BTS) format.
  - **size**
    The size of the BTS ring buffer in bytes.

- **pt**
  This thread uses the Intel(R) Processor Trace (Intel(R) PT) format.
  - **size**
    The size of the Intel(R) PT ring buffer in bytes.

GDB must be linked with the Expat library to support XML branch trace configuration discovery. See [Expat], page 591.

The formal DTD for the branch trace configuration format is given below:

```xml
<!ELEMENT btrace-conf (bts?, pt?)>
<!ATTLIST btrace-conf version CDATA #FIXED "1.0">

<!ELEMENT bts EMPTY>
Debugging with GDB

<!ATTLIST bts size CDATA #IMPLIED>
<!ELEMENT pt EMPTY>
<!ATTLIST pt size CDATA #IMPLIED>
Appendix F The GDB Agent Expression Mechanism

In some applications, it is not feasible for the debugger to interrupt the program’s execution long enough for the developer to learn anything helpful about its behavior. If the program’s correctness depends on its real-time behavior, delays introduced by a debugger might cause the program to fail, even when the code itself is correct. It is useful to be able to observe the program’s behavior without interrupting it.

Using GDB’s `trace` and `collect` commands, the user can specify locations in the program, and arbitrary expressions to evaluate when those locations are reached. Later, using the `tfind` command, she can examine the values those expressions had when the program hit the trace points. The expressions may also denote objects in memory — structures or arrays, for example — whose values GDB should record; while visiting a particular tracepoint, the user may inspect those objects as if they were in memory at that moment. However, because GDB records these values without interacting with the user, it can do so quickly and unobtrusively, hopefully not disturbing the program’s behavior.

When GDB is debugging a remote target, the GDB agent code running on the target computes the values of the expressions itself. To avoid having a full symbolic expression evaluator on the agent, GDB translates expressions in the source language into a simpler bytecode language, and then sends the bytecode to the agent; the agent then executes the bytecode, and records the values for GDB to retrieve later.

The bytecode language is simple; there are forty-odd opcodes, the bulk of which are the usual vocabulary of C operands (addition, subtraction, shifts, and so on) and various sizes of literals and memory reference operations. The bytecode interpreter operates strictly on machine-level values — various sizes of integers and floating point numbers — and requires no information about types or symbols; thus, the interpreter’s internal data structures are simple, and each bytecode requires only a few native machine instructions to implement it. The interpreter is small, and strict limits on the memory and time required to evaluate an expression are easy to determine, making it suitable for use by the debugging agent in real-time applications.

F.1 General Bytecode Design

The agent represents bytecode expressions as an array of bytes. Each instruction is one byte long (thus the term bytecode). Some instructions are followed by operand bytes; for example, the `goto` instruction is followed by a destination for the jump.

The bytecode interpreter is a stack-based machine; most instructions pop their operands off the stack, perform some operation, and push the result back on the stack for the next instruction to consume. Each element of the stack may contain either an integer or a floating point value; these values are as many bits wide as the largest integer that can be directly manipulated in the source language. Stack elements carry no record of their type; bytecode could push a value as an integer, then pop it as a floating point value. However, GDB will not generate code which does this. In C, one might define the type of a stack element as follows:

```c
union agent_val {
    LONGEST l;
    DOUBLEST d;
}
```
};

where LONGEST and DOUBLEST are typedef names for the largest integer and floating point types on the machine.

By the time the bytecode interpreter reaches the end of the expression, the value of the expression should be the only value left on the stack. For tracing applications, trace bytecodes in the expression will have recorded the necessary data, and the value on the stack may be discarded. For other applications, like conditional breakpoints, the value may be useful.

Separate from the stack, the interpreter has two registers:

- **pc**: The address of the next bytecode to execute.
- **start**: The address of the start of the bytecode expression, necessary for interpreting the goto and if_goto instructions.

Neither of these registers is directly visible to the bytecode language itself, but they are useful for defining the meanings of the bytecode operations.

There are no instructions to perform side effects on the running program, or call the program’s functions; we assume that these expressions are only used for unobtrusive debugging, not for patching the running code.

Most bytecode instructions do not distinguish between the various sizes of values, and operate on full-width values; the upper bits of the values are simply ignored, since they do not usually make a difference to the value computed. The exceptions to this rule are:

- **Memory reference instructions (refn)**
  - There are distinct instructions to fetch different word sizes from memory. Once on the stack, however, the values are treated as full-size integers. They may need to be sign-extended; the ext instruction exists for this purpose.

- **The sign-extension instruction (ext n)**
  - These clearly need to know which portion of their operand is to be extended to occupy the full length of the word.

If the interpreter is unable to evaluate an expression completely for some reason (a memory location is inaccessible, or a divisor is zero, for example), we say that interpretation “terminates with an error”. This means that the problem is reported back to the interpreter’s caller in some helpful way. In general, code using agent expressions should assume that they may attempt to divide by zero, fetch arbitrary memory locations, and misbehave in other ways.

Even complicated C expressions compile to a few bytecode instructions; for example, the expression $x + y * z$ would typically produce code like the following, assuming that $x$ and $y$ live in registers, and $z$ is a global variable holding a 32-bit int:

```
reg 1
reg 2
const32 address of z
ref32
ext 32
mul
add
```
In detail, these mean:

- `reg 1` Push the value of register 1 (presumably holding x) onto the stack.
- `reg 2` Push the value of register 2 (holding y).
- `const32 address of z` Push the address of z onto the stack.
- `ref32` Fetch a 32-bit word from the address at the top of the stack; replace the address on the stack with the value. Thus, we replace the address of z with z’s value.
- `ext 32` Sign-extend the value on the top of the stack from 32 bits to full length. This is necessary because z is a signed integer.
- `mul` Pop the top two numbers on the stack, multiply them, and push their product. Now the top of the stack contains the value of the expression y * z.
- `add` Pop the top two numbers, add them, and push the sum. Now the top of the stack contains the value of x + y * z.
- `end` Stop executing; the value left on the stack top is the value to be recorded.

**F.2 Bytecode Descriptions**

Each bytecode description has the following form:

**add (0x02):** a b ⇒ a+b

Pop the top two stack items, a and b, as integers; push their sum, as an integer.

In this example, **add** is the name of the bytecode, and (0x02) is the one-byte value used to encode the bytecode, in hexadecimal. The phrase “a b ⇒ a+b” shows the stack before and after the bytecode executes. Beforehand, the stack must contain at least two values, a and b; since the top of the stack is to the right, b is on the top of the stack, and a is underneath it. After execution, the bytecode will have popped a and b from the stack, and replaced them with a single value, a+b. There may be other values on the stack below those shown, but the bytecode affects only those shown.

Here is another example:

**const8 (0x22) n: ⇒ n**

Push the 8-bit integer constant n on the stack, without sign extension.

In this example, the bytecode **const8** takes an operand n directly from the bytecode stream; the operand follows the **const8** bytecode itself. We write any such operands immediately after the name of the bytecode, before the colon, and describe the exact encoding of the operand in the bytecode stream in the body of the bytecode description.

For the **const8** bytecode, there are no stack items given before the ⇒; this simply means that the bytecode consumes no values from the stack. If a bytecode consumes no values, or produces no values, the list on either side of the ⇒ may be empty.

If a value is written as a, b, or n, then the bytecode treats it as an integer. If a value is written is **addr**, then the bytecode treats it as an address.
We do not fully describe the floating point operations here; although this design can be extended in a clean way to handle floating point values, they are not of immediate interest to the customer, so we avoid describing them, to save time.

**float (0x01):** 
Prefix for floating-point bytecodes. Not implemented yet.

**add (0x02):** \(a \ b \Rightarrow a+b\)
Pop two integers from the stack, and push their sum, as an integer.

**sub (0x03):** \(a \ b \Rightarrow a-b\)
Pop two integers from the stack, subtract the top value from the next-to-top value, and push the difference.

**mul (0x04):** \(a \ b \Rightarrow a*b\)
Pop two integers from the stack, multiply them, and push the product on the stack. Note that, when one multiplies two \(n\)-bit numbers yielding another \(n\)-bit number, it is irrelevant whether the numbers are signed or not; the results are the same.

**div_signed (0x05):** \(a \ b \Rightarrow a/b\)
Pop two signed integers from the stack; divide the next-to-top value by the top value, and push the quotient. If the divisor is zero, terminate with an error.

**div_unsigned (0x06):** \(a \ b \Rightarrow a/b\)
Pop two unsigned integers from the stack; divide the next-to-top value by the top value, and push the quotient. If the divisor is zero, terminate with an error.

**rem_signed (0x07):** \(a \ b \Rightarrow a \mod b\)
Pop two signed integers from the stack; divide the next-to-top value by the top value, and push the remainder. If the divisor is zero, terminate with an error.

**rem_unsigned (0x08):** \(a \ b \Rightarrow a \mod b\)
Pop two unsigned integers from the stack; divide the next-to-top value by the top value, and push the remainder. If the divisor is zero, terminate with an error.

**lsh (0x09):** \(a \ b \Rightarrow a\ll b\)
Pop two integers from the stack; let \(a\) be the next-to-top value, and \(b\) be the top value. Shift \(a\) left by \(b\) bits, and push the result.

**rsh_signed (0x0a):** \(a \ b \Rightarrow (\text{signed})a\gg b\)
Pop two integers from the stack; let \(a\) be the next-to-top value, and \(b\) be the top value. Shift \(a\) right by \(b\) bits, inserting copies of the top bit at the high end, and push the result.

**rsh_unsigned (0x0b):** \(a \ b \Rightarrow a\gg b\)
Pop two integers from the stack; let \(a\) be the next-to-top value, and \(b\) be the top value. Shift \(a\) right by \(b\) bits, inserting zero bits at the high end, and push the result.

**log_not (0x0e):** \(a \Rightarrow \neg a\)
Pop an integer from the stack; if it is zero, push the value one; otherwise, push the value zero.
bit_and (0x0f): \( a \ b \Rightarrow a \& b \)
Pop two integers from the stack, and push their bitwise \texttt{and}.

bit_or (0x10): \( a \ b \Rightarrow a \| b \)
Pop two integers from the stack, and push their bitwise \texttt{or}.

bit_xor (0x11): \( a \ b \Rightarrow a \^ b \)
Pop two integers from the stack, and push their bitwise exclusive-or.

bit_not (0x12): \( a \Rightarrow \neg a \)
Pop an integer from the stack, and push its bitwise complement.

equal (0x13): \( a \ b \Rightarrow a = b \)
Pop two integers from the stack; if they are equal, push the value one; otherwise, push the value zero.

less_signed (0x14): \( a \ b \Rightarrow a < b \)
Pop two signed integers from the stack; if the next-to-top value is less than the top value, push the value one; otherwise, push the value zero.

less_unsigned (0x15): \( a \ b \Rightarrow a < b \)
Pop two unsigned integers from the stack; if the next-to-top value is less than the top value, push the value one; otherwise, push the value zero.

ext (0x16) \( n \): \( a \Rightarrow a \), sign-extended from \( n \) bits
Pop an unsigned value from the stack; treating it as an \( n \)-bit twos-complement value, extend it to full length. This means that all bits to the left of bit n-1 (where the least significant bit is bit 0) are set to the value of bit n-1. Note that \( n \) may be larger than or equal to the width of the stack elements of the bytecode engine; in this case, the bytecode should have no effect.

The number of source bits to preserve, \( n \), is encoded as a single byte unsigned integer following the \texttt{ext} bytecode.

zero_ext (0x2a) \( n \): \( a \Rightarrow a \), zero-extended from \( n \) bits
Pop an unsigned value from the stack; zero all but the bottom \( n \) bits. This means that all bits to the left of bit n-1 (where the least significant bit is bit 0) are set to the value of bit n-1.

The number of source bits to preserve, \( n \), is encoded as a single byte unsigned integer following the \texttt{zero_ext} bytecode.

ref8 (0x17): \( \text{addr} \Rightarrow a \)
ref16 (0x18): \( \text{addr} \Rightarrow a \)
ref32 (0x19): \( \text{addr} \Rightarrow a \)
ref64 (0x1a): \( \text{addr} \Rightarrow a \)
Pop an address \texttt{addr} from the stack. For bytecode \texttt{refn}, fetch an \( n \)-bit value from \texttt{addr}, using the natural target endianness. Push the fetched value as an unsigned integer.

Note that \texttt{addr} may not be aligned in any particular way; the \texttt{refn} bytecodes should operate correctly for any address.

If attempting to access memory at \texttt{addr} would cause a processor exception of some sort, terminate with an error.
ref_float (0x1b): addr ⇒ d
ref_double (0x1c): addr ⇒ d
ref_long_double (0x1d): addr ⇒ d
l_to_d (0x1e): a ⇒ d

d_to_l (0x1f): d ⇒ a

Not implemented yet.
dup (0x28): a =⇒ a a
 Push another copy of the stack’s top element.
swap (0x2b): a b =⇒ b a
 Exchange the top two items on the stack.
pop (0x29): a =⇒
 Discard the top value on the stack.
pick (0x32) n: a . . . b =⇒ a . . . b a
 Duplicate an item from the stack and push it on the top of the stack. n, a single byte, indicates the stack item to copy. If n is zero, this is the same as dup; if n is one, it copies the item under the top item, etc. If n exceeds the number of items on the stack, terminate with an error.
rot (0x33): a b c =⇒ c b a
 Rotate the top three items on the stack.
if_goto (0x20) offset: a =⇒
 Pop an integer off the stack; if it is non-zero, branch to the given offset in the bytecode string. Otherwise, continue to the next instruction in the bytecode stream. In other words, if a is non-zero, set the pc register to start + offset. Thus, an offset of zero denotes the beginning of the expression.
The offset is stored as a sixteen-bit unsigned value, stored immediately following the if_goto bytecode. It is always stored most significant byte first, regardless of the target’s normal endianness. The offset is not guaranteed to fall at any particular alignment within the bytecode stream; thus, on machines where fetching a 16-bit on an unaligned address raises an exception, you should fetch the offset one byte at a time.
goto (0x21) offset: =⇒
 Branch unconditionally to offset; in other words, set the pc register to start + offset.
The offset is stored in the same way as for the if_goto bytecode.

const8 (0x22) n: =⇒ n
const16 (0x23) n: =⇒ n
const32 (0x24) n: =⇒ n
const64 (0x25) n: =⇒ n
 Push the integer constant n on the stack, without sign extension. To produce a small negative value, push a small twos-complement value, and then sign-extend it using the ext bytecode.
The constant n is stored in the appropriate number of bytes following the constb bytecode. The constant n is always stored most significant byte first,
reg (0x26) \( n \): \( \Rightarrow a \)

Push the value of register number \( n \), without sign extension. The registers are numbered following GDB’s conventions.

The register number \( n \) is encoded as a 16-bit unsigned integer immediately following the \texttt{reg} bytecode. It is always stored most significant byte first, regardless of the target’s normal endianness. The register number is not guaranteed to fall at any particular alignment within the bytecode stream; thus, on machines where fetching a 16-bit on an unaligned address raises an exception, you should fetch \( n \) one byte at a time.

getv (0x2c) \( n \): \( \Rightarrow v \)

Push the value of trace state variable number \( n \), without sign extension.

The variable number \( n \) is encoded as a 16-bit unsigned integer immediately following the \texttt{getv} bytecode. It is always stored most significant byte first, regardless of the target’s normal endianness. The variable number is not guaranteed to fall at any particular alignment within the bytecode stream; thus, on machines where fetching a 16-bit on an unaligned address raises an exception, you should fetch the register number one byte at a time.

setv (0x2d) \( n \): \( v \Rightarrow v \)

Set trace state variable number \( n \) to the value found on the top of the stack. The stack is unchanged, so that the value is readily available if the assignment is part of a larger expression. The handling of \( n \) is as described for \texttt{getv}.

trace (0x0c): \( addr \ size \Rightarrow \)

Record the contents of the \texttt{size} bytes at \texttt{addr} in a trace buffer, for later retrieval by GDB.

trace\_quick (0x0d) \( size: addr \Rightarrow addr \)

Record the contents of the \texttt{size} bytes at \texttt{addr} in a trace buffer, for later retrieval by GDB. \texttt{size} is a single byte unsigned integer following the \texttt{trace} opcode.

This bytecode is equivalent to the sequence \texttt{dup const8 size trace}, but we provide it anyway to save space in bytecode strings.

trace16 (0x30) \( size: addr \Rightarrow addr \)

Identical to \texttt{trace\_quick}, except that \texttt{size} is a 16-bit big-endian unsigned integer, not a single byte. This should probably have been named \texttt{trace\_quick16}, for consistency.

tracev (0x2e) \( n \): \( \Rightarrow a \)

Record the value of trace state variable number \( n \) in the trace buffer. The handling of \( n \) is as described for \texttt{getv}.

tracenz (0x2f) \( addr \ size \Rightarrow \)

Record the bytes at \texttt{addr} in a trace buffer, for later retrieval by GDB. Stop at either the first zero byte, or when \texttt{size} bytes have been recorded, whichever occurs first.
printf (0x34) numargs string ⇒
Do a formatted print, in the style of the C function printf. The value of numargs is the number of arguments to expect on the stack, while string is the format string, prefixed with a two-byte length. The last byte of the string must be zero, and is included in the length. The format string includes escaped sequences just as it appears in C source, so for instance the format string "\t%d\n" is six characters long, and the output will consist of a tab character, a decimal number, and a newline. At the top of the stack, above the values to be printed, this bytecode will pop a “function” and “channel”. If the function is nonzero, then the target may treat it as a function and call it, passing the channel as a first argument, as with the C function fprintf. If the function is zero, then the target may simply call a standard formatted print function of its choice. In all, this bytecode pops 2 + numargs stack elements, and pushes nothing.

end (0x27): ⇒
Stop executing bytecode; the result should be the top element of the stack. If the purpose of the expression was to compute an lvalue or a range of memory, then the next-to-top of the stack is the lvalue’s address, and the top of the stack is the lvalue’s size, in bytes.

F.3 Using Agent Expressions
Agent expressions can be used in several different ways by GDB, and the debugger can generate different bytecode sequences as appropriate.

One possibility is to do expression evaluation on the target rather than the host, such as for the conditional of a conditional tracepoint. In such a case, GDB compiles the source expression into a bytecode sequence that simply gets values from registers or memory, does arithmetic, and returns a result.

Another way to use agent expressions is for tracepoint data collection. GDB generates a different bytecode sequence for collection; in addition to bytecodes that do the calculation, GDB adds trace bytecodes to save the pieces of memory that were used.

• The user selects trace points in the program’s code at which GDB should collect data.
• The user specifies expressions to evaluate at each trace point. These expressions may denote objects in memory, in which case those objects’ contents are recorded as the program runs, or computed values, in which case the values themselves are recorded.
• GDB transmits the tracepoints and their associated expressions to the GDB agent, running on the debugging target.
• The agent arranges to be notified when a trace point is hit.
• When execution on the target reaches a trace point, the agent evaluates the expressions associated with that trace point, and records the resulting values and memory ranges.
• Later, when the user selects a given trace event and inspects the objects and expression values recorded, GDB talks to the agent to retrieve recorded data as necessary to meet the user’s requests. If the user asks to see an object whose contents have not been recorded, GDB reports an error.
F.4 Varying Target Capabilities

Some targets don’t support floating-point, and some would rather not have to deal with \texttt{long long} operations. Also, different targets will have different stack sizes, and different bytecode buffer lengths.

Thus, GDB needs a way to ask the target about itself. We haven’t worked out the details yet, but in general, GDB should be able to send the target a packet asking it to describe itself. The reply should be a packet whose length is explicit, so we can add new information to the packet in future revisions of the agent, without confusing old versions of GDB, and it should contain a version number. It should contain at least the following information:

- whether floating point is supported
- whether \texttt{long long} is supported
- maximum acceptable size of bytecode stack
- maximum acceptable length of bytecode expressions
- which registers are actually available for collection
- whether the target supports disabled tracepoints

F.5 Rationale

Some of the design decisions apparent above are arguable.

What about stack overflow/underflow?

GDB should be able to query the target to discover its stack size. Given that information, GDB can determine at translation time whether a given expression will overflow the stack. But this spec isn’t about what kinds of error-checking GDB ought to do.

Why are you doing everything in LONGEST?

Speed isn’t important, but agent code size is; using LONGEST brings in a bunch of support code to do things like division, etc. So this is a serious concern.

First, note that you don’t need different bytecodes for different operand sizes. You can generate code without knowing how big the stack elements actually are on the target. If the target only supports 32-bit ints, and you don’t send any 64-bit bytecodes, everything just works. The observation here is that the MIPS and the Alpha have only fixed-size registers, and you can still get C’s semantics even though most instructions only operate on full-sized words. You just need to make sure everything is properly sign-extended at the right times. So there is no need for 32- and 64-bit variants of the bytecodes. Just implement everything using the largest size you support.

GDB should certainly check to see what sizes the target supports, so the user can get an error earlier, rather than later. But this information is not necessary for correctness.

Why don’t you have $>$ or $\leq$ operators?

I want to keep the interpreter small, and we don’t need them. We can combine the \texttt{less} opcodes with \texttt{log not}, and swap the order of the operands, yielding all four asymmetrical comparison operators. For example, \((x \leq y)\) is \(! (x > y)\), which is \(! (y < x)\).
Why do you have `log_not`?
Why do you have `ext`?
Why do you have `zero_ext`?

These are all easily synthesized from other instructions, but I expect them to be used frequently, and they’re simple, so I include them to keep bytecode strings short.

`log_not` is equivalent to `const8 0 equal`; it’s used in half the relational operators.

`ext n` is equivalent to `const8 s-n lsh const8 s-n rsh_signed`, where `s` is the size of the stack elements; it follows `refm` and `reg` bytecodes when the value should be signed. See the next bulleted item.

`zero_ext n` is equivalent to `constm mask log_and`; it’s used whenever we push the value of a register, because we can’t assume the upper bits of the register aren’t garbage.

Why not have sign-extending variants of the `ref` operators?

Because that would double the number of `ref` operators, and we need the `ext` bytecode anyway for accessing bitfields.

Why not have constant-address variants of the `ref` operators?

Because that would double the number of `ref` operators again, and `const32 address ref32` is only one byte longer.

Why do the `refn` operators have to support unaligned fetches?

GDB will generate bytecode that fetches multi-byte values at unaligned addresses whenever the executable’s debugging information tells it to. Furthermore, GDB does not know the value the pointer will have when GDB generates the bytecode, so it cannot determine whether a particular fetch will be aligned or not.

In particular, structure bitfields may be several bytes long, but follow no alignment rules; members of packed structures are not necessarily aligned either.

In general, there are many cases where unaligned references occur in correct C code, either at the programmer’s explicit request, or at the compiler’s discretion. Thus, it is simpler to make the GDB agent bytecodes work correctly in all circumstances than to make GDB guess in each case whether the compiler did the usual thing.

Why are there no side-effecting operators?

Because our current client doesn’t want them? That’s a cheap answer. I think the real answer is that I’m afraid of implementing function calls. We should re-visit this issue after the present contract is delivered.

Why aren’t the `goto` ops PC-relative?

The interpreter has the base address around anyway for PC bounds checking, and it seemed simpler.

Why is there only one offset size for the `goto` ops?

Offsets are currently sixteen bits. I’m not happy with this situation either:
Suppose we have multiple branch ops with different offset sizes. As I generate code left-to-right, all my jumps are forward jumps (there are no loops in expressions), so I never know the target when I emit the jump opcode. Thus, I have to either always assume the largest offset size, or do jump relaxation on the code after I generate it, which seems like a big waste of time.

I can imagine a reasonable expression being longer than 256 bytes. I can’t imagine one being longer than 64k. Thus, we need 16-bit offsets. This kind of reasoning is so bogus, but relaxation is pathetic.

The other approach would be to generate code right-to-left. Then I’d always know my offset size. That might be fun.

**Where is the function call bytecode?**
When we add side-effects, we should add this.

**Why does the reg bytecode take a 16-bit register number?**
Intel’s IA-64 architecture has 128 general-purpose registers, and 128 floating-point registers, and I’m sure it has some random control registers.

**Why do we need trace and trace_quick?**
Because GDB needs to record all the memory contents and registers an expression touches. If the user wants to evaluate an expression $x\rightarrow y\rightarrow z$, the agent must record the values of $x$ and $x\rightarrow y$ as well as the value of $x\rightarrow y\rightarrow z$.

**Don’t the trace bytecodes make the interpreter less general?**
They do mean that the interpreter contains special-purpose code, but that doesn’t mean the interpreter can only be used for that purpose. If an expression doesn’t use the trace bytecodes, they don’t get in its way.

**Why doesn’t trace_quick consume its arguments the way everything else does?**
In general, you do want your operators to consume their arguments; it’s consistent, and generally reduces the amount of stack rearrangement necessary. However, trace_quick is a kludge to save space; it only exists so we needn’t write `dup const8 SIZE trace` before every memory reference. Therefore, it’s okay for it not to consume its arguments; it’s meant for a specific context in which we know exactly what it should do with the stack. If we’re going to have a kludge, it should be an effective kludge.

**Why does trace16 exist?**
That opcode was added by the customer that contracted Cygnus for the data tracing work. I personally think it is unnecessary; objects that large will be quite rare, so it is okay to use `dup const16 size trace` in those cases.

Whatever we decide to do with trace16, we should at least leave opcode 0x30 reserved, to remain compatible with the customer who added it.
Appendix G Target Descriptions

One of the challenges of using GDB to debug embedded systems is that there are so many minor variants of each processor architecture in use. It is common practice for vendors to start with a standard processor core — ARM, PowerPC, or MIPS, for example — and then make changes to adapt it to a particular market niche. Some architectures have hundreds of variants, available from dozens of vendors. This leads to a number of problems:

- With so many different customized processors, it is difficult for the GDB maintainers to keep up with the changes.
- Since individual variants may have short lifetimes or limited audiences, it may not be worthwhile to carry information about every variant in the GDB source tree.
- When GDB does support the architecture of the embedded system at hand, the task of finding the correct architecture name to give the set architecture command can be error-prone.

To address these problems, the GDB remote protocol allows a target system to not only identify itself to GDB, but to actually describe its own features. This lets GDB support processor variants it has never seen before — to the extent that the descriptions are accurate, and that GDB understands them.

GDB must be linked with the Expat library to support XML target descriptions. See [Expat], page 591.

G.1 Retrieving Descriptions

Target descriptions can be read from the target automatically, or specified by the user manually. The default behavior is to read the description from the target. GDB retrieves it via the remote protocol using 'qXfer' requests (see Section E.4 [General Query Packets], page 621). The annex in the 'qXfer' packet will be 'target.xml'. The contents of the 'target.xml' annex are an XML document, of the form described in Section G.2 [Target Description Format], page 687.

Alternatively, you can specify a file to read for the target description. If a file is set, the target will not be queried. The commands to specify a file are:

set tdesc filename path
Read the target description from path.

unset tdesc filename
Do not read the XML target description from a file. GDB will use the description supplied by the current target.

show tdesc filename
Show the filename to read for a target description, if any.

G.2 Target Description Format

A target description annex is an XML document which complies with the Document Type Definition provided in the GDB sources in 'gdb/features/gdb-target.dtd'. This means you can use generally available tools like xmllint to check that your feature descriptions
are well-formed and valid. However, to help people unfamiliar with XML write descriptions for their targets, we also describe the grammar here.

Target descriptions can identify the architecture of the remote target and (for some architectures) provide information about custom register sets. They can also identify the OS ABI of the remote target. GDB can use this information to autoconfigure for your target, or to warn you if you connect to an unsupported target.

Here is a simple target description:

```xml
<?xml version="1.0"?>
<!DOCTYPE target SYSTEM "gdb-target.dtd">
<target version="1.0">
  [architecture]
  [osabi]
  [compatible]
  [feature...]
</target>
```

This minimal description only says that the target uses the x86-64 architecture.

A target description has the following overall form, with [] marking optional elements and ... marking repeatable elements. The elements are explained further below.

The description is generally insensitive to whitespace and line breaks, under the usual common-sense rules. The XML version declaration and document type declaration can generally be omitted (GDB does not require them), but specifying them may be useful for XML validation tools. The ‘version’ attribute for ‘<target>’ may also be omitted, but we recommend including it; if future versions of GDB use an incompatible revision of ‘gdb-target.dtd’, they will detect and report the version mismatch.

G.2.1 Inclusion

It can sometimes be valuable to split a target description up into several different annexes, either for organizational purposes, or to share files between different possible target descriptions. You can divide a description into multiple files by replacing any element of the target description with an inclusion directive of the form:

```xml
<xi:include href="document"/>
```

When GDB encounters an element of this form, it will retrieve the named XML document, and replace the inclusion directive with the contents of that document. If the current description was read using ‘qXfer’, then so will be the included document; document will be interpreted as the name of an annex. If the current description was read from a file, GDB will look for document as a file in the same directory where it found the original description.

G.2.2 Architecture

An ‘<architecture>’ element has this form:

```xml
<architecture>arch</architecture>
```

arch is one of the architectures from the set accepted by set architecture (see Chapter 19 [Specifying a Debugging Target], page 253).
Appendix G: Target Descriptions

G.2.3 OS ABI
This optional field was introduced in GDB version 7.0. Previous versions of GDB ignore it.

An `<osabi>` element has this form:

```
<osabi>abi-name</osabi>
```

`abi-name` is an OS ABI name from the same selection accepted by `set osabi` (see Section 22.6 [Configuring the Current ABI], page 301).

G.2.4 Compatible Architecture
This optional field was introduced in GDB version 7.0. Previous versions of GDB ignore it.

A `<compatible>` element has this form:

```
<compatible>arch</compatible>
```

`arch` is one of the architectures from the set accepted by `set architecture` (see Chapter 19 [Specifying a Debugging Target], page 253).

A `<compatible>` element is used to specify that the target is able to run binaries in some other than the main target architecture given by the `<architecture>` element. For example, on the Cell Broadband Engine, the main architecture is `powerpc:common` or `powerpc:common64`, but the system is able to run binaries in the `spu` architecture as well. The way to describe this capability with `<compatible>` is as follows:

```
<architecture>powerpc:common</architecture>
<compatible>spu</compatible>
```

G.2.5 Features
Each `<feature>` describes some logical portion of the target system. Features are currently used to describe available CPU registers and the types of their contents. A `<feature>` element has this form:

```
<feature name="name">
  [type...]
  reg...
</feature>
```

Each feature’s name should be unique within the description. The name of a feature does not matter unless GDB has some special knowledge of the contents of that feature; if it does, the feature should have its standard name. See Section G.4 [Standard Target Features], page 692.

G.2.6 Types
Any register's value is a collection of bits which GDB must interpret. The default interpretation is a two's complement integer, but other types can be requested by name in the register description. Some predefined types are provided by GDB (see Section G.3 [Predefined Target Types], page 691), and the description can define additional composite types.

Each type element must have an `id` attribute, which gives a unique (within the containing `<feature>`) name to the type. Types must be defined before they are used.

Some targets offer vector registers, which can be treated as arrays of scalar elements. These types are written as `<vector>` elements, specifying the array element type, `type`, and the number of elements, `count`:
If a register’s value is usefully viewed in multiple ways, define it with a union type containing the useful representations. The `<union>` element contains one or more `<field>` elements, each of which has a name and a type:

```xml
<union id="id">
  <field name="name" type="type"/>
  ...
</union>
```

If a register’s value is composed from several separate values, define it with a structure type. There are two forms of the `<struct>` element; a `<struct>` element must either contain only bitfields or contain no bitfields. If the structure contains only bitfields, its total size in bytes must be specified, each bitfield must have an explicit start and end, and bitfields are automatically assigned an integer type. The field’s start should be less than or equal to its end, and zero represents the least significant bit.

```xml
<struct id="id" size="size">
  <field name="name" start="start" end="end"/>
  ...
</struct>
```

If the structure contains no bitfields, then each field has an explicit type, and no implicit padding is added.

```xml
<struct id="id">
  <field name="name" type="type"/>
  ...
</struct>
```

If a register’s value is a series of single-bit flags, define it with a flags type. The `<flags>` element has an explicit size and contains one or more `<field>` elements. Each field has a name, a start, and an end. Only single-bit flags are supported.

```xml
<flags id="id" size="size">
  <field name="name" start="start" end="end"/>
  ...
</flags>
```

G.2.7 Registers

Each register is represented as an element with this form:

```xml
<reg name="name"
  bitsize="size"
  [regnum="num"]
  [save-restore="save-restore"]
  [type="type"]
  [group="group"]/>
```

The components are as follows:

- **name**: The register’s name; it must be unique within the target description.
- **bitsize**: The register’s size, in bits.
- **regnum**: The register’s number. If omitted, a register’s number is one greater than that of the previous register (either in the current feature or in a preceding feature); the first register in the target description defaults to zero. This register number is used to read or write the register; e.g. it is used in the remote `p` and `P`
packets, and registers appear in the \textit{g} and \textit{G} packets in order of increasing register number.

\textit{save-restore} \hspace{1em} Whether the register should be preserved across inferior function calls; this must be either \texttt{yes} or \texttt{no}. The default is \texttt{yes}, which is appropriate for most registers except for some system control registers; this is not related to the target’s ABI.

\textit{type} \hspace{1em} The type of the register. It may be a predefined type, a type defined in the current feature, or one of the special types \texttt{int} and \texttt{float}. \texttt{int} is an integer type of the correct size for \textit{bitsize}, and \texttt{float} is a floating point type (in the architecture’s normal floating point format) of the correct size for \textit{bitsize}. The default is \texttt{int}.

\textit{group} \hspace{1em} The register group to which this register belongs. It must be either \texttt{general}, \texttt{float}, or \texttt{vector}. If no \textit{group} is specified, GDB will not display the register in \texttt{info registers}.

\section*{G.3 Predefined Target Types}

Type definitions in the self-description can build up composite types from basic building blocks, but can not define fundamental types. Instead, standard identifiers are provided by \texttt{gdb} for the fundamental types. The currently supported types are:

\texttt{int8} \hspace{1em} Signed integer types holding the specified number of bits.

\texttt{int16} \hspace{1em} \texttt{int32} \hspace{1em} \texttt{int64}

\texttt{int128} \hspace{1em} Signed integer types holding the specified number of bits.

\texttt{uint8} \hspace{1em} \texttt{uint16} \hspace{1em} \texttt{uint32} \hspace{1em} \texttt{uint64} \hspace{1em} \texttt{uint128}

\texttt{uint128} \hspace{1em} Unsigned integer types holding the specified number of bits.

\texttt{code_ptr} \hspace{1em} \texttt{data_ptr} \hspace{1em} Pointers to unspecified code and data. The program counter and any dedicated return address register may be marked as code pointers; printing a code pointer converts it into a symbolic address. The stack pointer and any dedicated address registers may be marked as data pointers.

\texttt{ieee_single} \hspace{1em} Single precision IEEE floating point.

\texttt{ieee_double} \hspace{1em} Double precision IEEE floating point.

\texttt{arm_fpa_ext} \hspace{1em} The 12-byte extended precision format used by ARM FPA registers.

\texttt{i387_ext} \hspace{1em} The 10-byte extended precision format used by x87 registers.
i386_eflags
32bit EFLAGS register used by x86.

i386_mxcsr
32bit MXCSR register used by x86.

G.4 Standard Target Features

A target description must contain either no registers or all the target’s registers. If the
description contains no registers, then GDB will assume a default register layout, selected
based on the architecture. If the description contains any registers, the default layout will
not be used; the standard registers must be described in the target description, in such a
way that GDB can recognize them.

This is accomplished by giving specific names to feature elements which contain standard
registers. GDB will look for features with those names and verify that they contain the
expected registers; if any known feature is missing required registers, or if any required
feature is missing, GDB will reject the target description. You can add additional registers
to any of the standard features — GDB will display them just as if they were added to an
unrecognized feature.

This section lists the known features and their expected contents. Sample XML docu-
ments for these features are included in the GDB source tree, in the directory ‘gdb/features’.

Names recognized by GDB should include the name of the company or organization
which selected the name, and the overall architecture to which the feature applies; so e.g.
the feature containing ARM core registers is named ‘org.gnu.gdb.arm.core’.

The names of registers are not case sensitive for the purpose of recognizing standard
features, but GDB will only display registers using the capitalization used in the description.

G.4.1 AArch64 Features

The ‘org.gnu.gdb.aarch64.core’ feature is required for AArch64 targets. It should con-
tain registers ‘x0’ through ‘x30’, ‘sp’, ‘pc’, and ‘cpsr’.

The ‘org.gnu.gdb.aarch64.fpu’ feature is optional. If present, it should contain registers ‘v0’ through ‘v31’, ‘fpsr’, and ‘fpcr’.

G.4.2 ARM Features


For M-profile targets (e.g. Cortex-M3), the ‘org.gnu.gdb.arm.core’ feature is replaced
by ‘org.gnu.gdb.arm.m-profile’. It should contain registers ‘r0’ through ‘r13’, ‘sp’, ‘lr’, ‘pc’, and ‘xpsr’.

The ‘org.gnu.gdb.arm.fpa’ feature is optional. If present, it should contain registers ‘f0’ through ‘f7’ and ‘fps’.

The ‘org.gnu.gdb.xscale.iwmmxt’ feature is optional. If present, it should contain at least registers ‘wR0’ through ‘wR15’ and ‘wCGR0’ through ‘wCGR3’. The ‘wCID’, ‘wCon’, ‘wCSSF’, and ‘wCASF’ registers are optional.

The ‘org.gnu.gdb.arm.vfp’ feature is optional. If present, it should contain at least registers ‘d0’ through ‘d15’. If they are present, ‘d16’ through ‘d31’ should also be included.
GDB will synthesize the single-precision registers from halves of the double-precision registers.

The ‘org.gnu.gdb.arm.neon’ feature is optional. It does not need to contain registers; it instructs GDB to display the VFP double-precision registers as vectors and to synthesize the quad-precision registers from pairs of double-precision registers. If this feature is present, ‘org.gnu.gdb.arm.vfp’ must also be present and include 32 double-precision registers.

G.4.3 i386 Features

The ‘org.gnu.gdb.i386.core’ feature is required for i386/ amd64 targets. It should describe the following registers:

- ‘eax’ through ‘edi’ plus ‘eip’ for i386
- ‘rax’ through ‘r15’ plus ‘rip’ for amd64
- ‘st0’ through ‘st7’

The register sets may be different, depending on the target.

The ‘org.gnu.gdb.i386.sse’ feature is optional. It should describe registers:

- ‘xmm0’ through ‘xmm7’ for i386
- ‘xmm0’ through ‘xmm15’ for amd64
- ‘mxcsr’

The ‘org.gnu.gdb.i386.avx’ feature is optional and requires the ‘org.gnu.gdb.i386.sse’ feature. It should describe the upper 128 bits of YMM registers:

- ‘ymm0h’ through ‘ymm7h’ for i386
- ‘ymm0h’ through ‘ymm15h’ for amd64

The ‘org.gnu.gdb.i386.mpex’ is an optional feature representing Intel(R) Memory Protection Extension (MPX). It should describe the following registers:

- ‘bnd0raw’ through ‘bnd3raw’ for i386 and amd64.
- ‘bndcfgu’ and ‘bndstatus’ for i386 and amd64.

The ‘org.gnu.gdb.i386.linux’ feature is optional. It should describe a single register, ‘orig_eax’.

The ‘org.gnu.gdb.i386.avx512’ feature is optional and requires the ‘org.gnu.gdb.i386.avx’ feature. It should describe additional XMM registers:

- ‘xmm16h’ through ‘xmm31h’, only valid for amd64.

It should describe the upper 128 bits of additional YMM registers:

- ‘ymm16h’ through ‘ymm31h’, only valid for amd64.

It should describe the upper 256 bits of ZMM registers:

- ‘zmm0h’ through ‘zmm7h’ for i386.
- ‘zmm0h’ through ‘zmm15h’ for amd64.

It should describe the additional ZMM registers:

- ‘zmm16h’ through ‘zmm31h’, only valid for amd64.
G.4.4 MicroBlaze Features

The `org.gnu.gdb.microblaze.core` feature is required for MicroBlaze targets. It should contain registers `r0` through `r31`, `rpc`, `rmsr`, `rear`, `resr`, `rfsr`, `rbtr`, `rpvr`, `rpvr1` through `rpvr11`, `redr`, `rp', `rzpr`, `rtlbx`, `rtlbsx`, `rtlblo`, and `rtlbhi`.

The `org.gnu.gdb.microblaze.stack-protect` feature is optional. If present, it should contain registers `rshr` and `rslr`.

G.4.5 MIPS Features

The `org.gnu.gdb.mips.cpu` feature is required for MIPS targets. It should contain registers `r0` through `r31`, `lo`, `hi`, and `pc`. They may be 32-bit or 64-bit depending on the target.

The `org.gnu.gdb.mips.cp0` feature is also required. It should contain at least the `status`, `badvaddr`, and `cause` registers. They may be 32-bit or 64-bit depending on the target.

The `org.gnu.gdb.mips.fpu` feature is currently required, though it may be optional in a future version of GDB. It should contain registers `f0` through `f31`, `fcsr`, and `fir`. They may be 32-bit or 64-bit depending on the target.

The `org.gnu.gdb.mips.dsp` feature is optional. It should contain registers `hi1` through `hi3`, `lo1` through `lo3`, and `dspctl`. The `dspctl` register should be 32-bit and the rest may be 32-bit or 64-bit depending on the target.

The `org.gnu.gdb.mips.linux` feature is optional. It should contain a single register, `restart`, which is used by the Linux kernel to control restartable syscalls.

G.4.6 M68K Features

`org.gnu.gdb.m68k.core`
`org.gnu.gdb.coldfire.core`
`org.gnu.gdb.fido.core`

One of those features must be always present. The feature that is present determines which flavor of m68k is used. The feature that is present should contain registers `d0` through `d7`, `a0` through `a5`, `fp`, `sp`, `ps` and `pc`.

`org.gnu.gdb.coldfire.fp`

This feature is optional. If present, it should contain registers `fp0` through `fp7`, `fpcontrol`, `fpstatus` and `fpiaddr`.

G.4.7 Nios II Features

The `org.gnu.gdb.nios2.cpu` feature is required for Nios II targets. It should contain the 32 core registers (`zero`, `at`, `r2` through `r23`, `et` through `ra`), `pc`, and the 16 control registers (`status` through `mpuacc`).

G.4.8 PowerPC Features

The `org.gnu.gdb.power.core` feature is required for PowerPC targets. It should contain registers `r0` through `r31`, `pc`, `msr`, `cr`, `lr`, `ctr`, and `xer`. They may be 32-bit or 64-bit depending on the target.
The ‘org.gnu.gdb.power.fpu’ feature is optional. It should contain registers ‘f0’ through ‘f31’ and ‘fpscr’.

The ‘org.gnu.gdb.power.altivec’ feature is optional. It should contain registers ‘vr0’ through ‘vr31’, ‘vscr’, and ‘vrsave’.

The ‘org.gnu.gdb.power.vsx’ feature is optional. It should contain registers ‘vs0h’ through ‘vs31h’. GDB will combine these registers with the floating point registers (‘f0’ through ‘f31’) and the altivec registers (‘vr0’ through ‘vr31’) to present the 128-bit wide registers ‘vs0’ through ‘vs63’, the set of vector registers for POWER7.

The ‘org.gnu.gdb.power.spe’ feature is optional. It should contain registers ‘ev0h’ through ‘ev31h’, ‘acc’, and ‘spefscr’. SPE targets should provide 32-bit registers in ‘org.gnu.gdb.power.core’ and provide the upper halves in ‘ev0h’ through ‘ev31h’. GDB will combine these to present registers ‘ev0’ through ‘ev31’ to the user.

G.4.9 S/390 and System z Features

The ‘org.gnu.gdb.s390.core’ feature is required for S/390 and System z targets. It should contain the PSW and the 16 general registers. In particular, System z targets should provide the 64-bit registers ‘pswm’, ‘pswa’, and ‘r0’ through ‘r15’. S/390 targets should provide the 32-bit versions of these registers. A System z target that runs in 31-bit addressing mode should provide 32-bit versions of ‘pswm’ and ‘pswa’, as well as the general register’s upper halves ‘r0h’ through ‘r15h’, and their lower halves ‘r0l’ through ‘r15l’.

The ‘org.gnu.gdb.s390.fpr’ feature is required. It should contain the 64-bit registers ‘f0’ through ‘f15’, and ‘fpc’.

The ‘org.gnu.gdb.s390.acr’ feature is required. It should contain the 32-bit registers ‘acr0’ through ‘acr15’.

The ‘org.gnu.gdb.s390.linux’ feature is optional. It should contain the register ‘orig_r2’, which is 64-bit wide on System z targets and 32-bit otherwise. In addition, the feature may contain the ‘last_break’ register, whose width depends on the addressing mode, as well as the ‘system_call’ register, which is always 32-bit wide.

The ‘org.gnu.gdb.s390.tdb’ feature is optional. It should contain the 64-bit registers ‘tdbo’, ‘tac’, ‘tct’, ‘atia’, and ‘tr0’ through ‘tr15’.

The ‘org.gnu.gdb.s390.vx’ feature is optional. It should contain 64-bit wide registers ‘v0l’ through ‘v15l’, which will be combined by GDB with the floating point registers ‘f0’ through ‘f15’ to present the 128-bit wide vector registers ‘v0’ through ‘v15’. In addition, this feature should contain the 128-bit wide vector registers ‘v16’ through ‘v31’.

G.4.10 TMS320C6x Features

The ‘org.gnu.gdb.tic6x.core’ feature is required for TMS320C6x targets. It should contain registers ‘A0’ through ‘A15’, registers ‘B0’ through ‘B15’, ‘CSR’ and ‘PC’.

The ‘org.gnu.gdb.tic6x.gp’ feature is optional. It should contain registers ‘A16’ through ‘A31’ and ‘B16’ through ‘B31’.

The ‘org.gnu.gdb.tic6x.c6xp’ feature is optional. It should contain registers ‘TSR’, ‘ILC’ and ‘RILC’.
Appendix H Operating System Information

Users of GDB often wish to obtain information about the state of the operating system running on the target—for example the list of processes, or the list of open files. This section describes the mechanism that makes it possible. This mechanism is similar to the target features mechanism (see Appendix G [Target Descriptions], page 687), but focuses on a different aspect of target.

Operating system information is retrieved from the target via the remote protocol, using ‘qXfer’ requests (see [qXfer osdata read], page 641). The object name in the request should be ‘osdata’, and the annex identifies the data to be fetched.

H.1 Process list

When requesting the process list, the annex field in the ‘qXfer’ request should be ‘processes’. The returned data is an XML document. The formal syntax of this document is defined in ‘gdb/features/osdata.dtd’.

An example document is:

```xml
<?xml version="1.0"?>
<!DOCTYPE target SYSTEM "osdata.dtd">
<osdata type="processes">
  <item>
    <column name="pid">1</column>
    <column name="user">root</column>
    <column name="command">/sbin/init</column>
    <column name="cores">1,2,3</column>
  </item>
</osdata>
```

Each item should include a column whose name is ‘pid’. The value of that column should identify the process on the target. The ‘user’ and ‘command’ columns are optional, and will be displayed by GDB. The ‘cores’ column, if present, should contain a comma-separated list of cores that this process is running on. Target may provide additional columns, which GDB currently ignores.
Appendix I Trace File Format

The trace file comes in three parts: a header, a textual description section, and a trace frame section with binary data.

The header has the form `\x7fTRACE0\n`. The first byte is `0x7f` so as to indicate that the file contains binary data, while the `0` is a version number that may have different values in the future.

The description section consists of multiple lines of ASCII text separated by newline characters (`0xa`). The lines may include a variety of optional descriptive or context-setting information, such as tracepoint definitions or register set size. GDB will ignore any line that it does not recognize. An empty line marks the end of this section.

The trace frame section consists of a number of consecutive frames. Each frame begins with a two-byte tracepoint number, followed by a four-byte size giving the amount of data in the frame. The data in the frame consists of a number of blocks, each introduced by a character indicating its type (at least register, memory, and trace state variable). The data in this section is raw binary, not a hexadecimal or other encoding; its endianness matches the target’s endianness.

R bytes Register block. The number and ordering of bytes matches that of a g packet in the remote protocol. Note that these are the actual bytes, in target order and GDB register order, not a hexadecimal encoding.

M address length bytes... Memory block. This is a contiguous block of memory, at the 8-byte address address, with a 2-byte length length, followed by length bytes.

V number value Trace state variable block. This records the 8-byte signed value value of trace state variable numbered number.

Future enhancements of the trace file format may include additional types of blocks.
Appendix J .gdb_index section format

This section documents the index section that is created by `save gdb-index` (see Section 18.5 [Index Files], page 250). The index section is DWARF-specific; some knowledge of DWARF is assumed in this description.

The mapped index file format is designed to be directly mmapable on any architecture. In most cases, a datum is represented using a little-endian 32-bit integer value, called an offset_type. Big endian machines must byte-swap the values before using them. Exceptions to this rule are noted. The data is laid out such that alignment is always respected.

A mapped index consists of several areas, laid out in order.

1. The file header. This is a sequence of values, of offset_type unless otherwise noted:
   1. The version number, currently 8. Versions 1, 2 and 3 are obsolete. Version 4 uses a different hashing function from versions 5 and 6. Version 6 includes symbols for inlined functions, whereas versions 4 and 5 do not. Version 7 adds attributes to the CU indices in the symbol table. Version 8 specifies that symbols from DWARF type units (‘DW_TAG_type_unit’) refer to the type unit’s symbol table and not the compilation unit (‘DW_TAG_comp_unit’) using the type.

   GDB will only read version 4, 5, or 6 indices by specifying `set use-deprecated-index-sections` on. GDB has a workaround for potentially broken version 7 indices so it is currently not flagged as deprecated.

2. The offset, from the start of the file, of the CU list.

3. The offset, from the start of the file, of the types CU list. Note that this area can be empty, in which case this offset will be equal to the next offset.

4. The offset, from the start of the file, of the address area.

5. The offset, from the start of the file, of the constant pool.

2. The CU list. This is a sequence of pairs of 64-bit little-endian values, sorted by the CU offset. The first element in each pair is the offset of a CU in the .debug_info section. The second element in each pair is the length of that CU. References to a CU elsewhere in the map are done using a CU index, which is just the 0-based index into this table. Note that if there are type CUs, then conceptually CUs and type CUs form a single list for the purposes of CU indices.

3. The types CU list. This is a sequence of triplets of 64-bit little-endian values. In a triplet, the first value is the CU offset, the second value is the type offset in the CU, and the third value is the type signature. The types CU list is not sorted.

4. The address area. The address area consists of a sequence of address entries. Each address entry has three elements:
   1. The low address. This is a 64-bit little-endian value.
   2. The high address. This is a 64-bit little-endian value. Like DW_AT_high_pc, the value is one byte beyond the end.
   3. The CU index. This is an offset_type value.

5. The symbol table. This is an open-addressed hash table. The size of the hash table is always a power of 2.
Each slot in the hash table consists of a pair of `offset_type` values. The first value is the offset of the symbol’s name in the constant pool. The second value is the offset of the CU vector in the constant pool.

If both values are 0, then this slot in the hash table is empty. This is ok because while 0 is a valid constant pool index, it cannot be a valid index for both a string and a CU vector.

The hash value for a table entry is computed by applying an iterative hash function to the symbol’s name. Starting with an initial value of \( r = 0 \), each (unsigned) character ‘c’ in the string is incorporated into the hash using the formula depending on the index version:

**Version 4** The formula is \( r = r \times 67 + c - 113 \).

**Versions 5 to 7** The formula is \( r = r \times 67 + \text{tolower} (c) - 113 \).

The terminating ‘\0’ is not incorporated into the hash.

The step size used in the hash table is computed via \(((\text{hash} \times 17) \& (\text{size} - 1)) \mid 1)\), where ‘\text{hash}’ is the hash value, and ‘\text{size}’ is the size of the hash table. The step size is used to find the next candidate slot when handling a hash collision.

The names of C++ symbols in the hash table are canonicalized. We don’t currently have a simple description of the canonicalization algorithm; if you intend to create new index sections, you must read the code.

6. The constant pool. This is simply a bunch of bytes. It is organized so that alignment is correct: CU vectors are stored first, followed by strings.

A CU vector in the constant pool is a sequence of `offset_type` values. The first value is the number of CU indices in the vector. Each subsequent value is the index and symbol attributes of a CU in the CU list. This element in the hash table is used to indicate which CUs define the symbol and how the symbol is used. See below for the format of each CU index+attributes entry.

A string in the constant pool is zero-terminated.

Attributes were added to CU index values in `.gdb_index` version 7. If a symbol has multiple uses within a CU then there is one CU index+attributes value for each use.

The format of each CU index+attributes entry is as follows (bit 0 = LSB):

- **Bits 0-23** This is the index of the CU in the CU list.
- **Bits 24-27** These bits are reserved for future purposes and must be zero.
- **Bits 28-30** The kind of the symbol in the CU.
  - 0 This value is reserved and should not be used. By reserving zero the full `offset_type` value is backwards compatible with previous versions of the index.
  - 1 The symbol is a type.
  - 2 The symbol is a variable or an enum value.
  - 3 The symbol is a function.
4 Any other kind of symbol.
5,6,7 These values are reserved.

Bit 31 This bit is zero if the value is global and one if it is static.
The determination of whether a symbol is global or static is complicated. The authoritative reference is the file `dwarf2read.c` in GDB sources.

This pseudo-code describes the computation of a symbol’s kind and global/static attributes in the index.
```c
is_external = get_attribute (die, DW_AT_external);
language = get_attribute (cu_die, DW_AT_language);
switch (die->tag)
{
    case DW_TAG_typedef:
    case DW_TAG_base_type:
    case DW_TAG_subrange_type:
        kind = TYPE;
        is_static = 1;
        break;
    case DW_TAG_enumerator:
        kind = VARIABLE;
        is_static = (language != CPLUS && language != JAVA);
        break;
    case DW_TAG_subprogram:
        kind = FUNCTION;
        is_static = ! (is_external || language == ADA);
        break;
    case DW_TAG_constant:
        kind = VARIABLE;
        is_static = ! is_external;
        break;
    case DW_TAG_variable:
        kind = VARIABLE;
        is_static = ! is_external;
        break;
    case DW_TAG_namespace:
        kind = TYPE;
        is_static = 0;
        break;
    case DW_TAG_class_type:
    case DW_TAG_interface_type:
    case DW_TAG_structure_type:
    case DW_TAG_union_type:
    case DW_TAG_enumeration_type:
        kind = TYPE;
        is_static = (language != CPLUS && language != JAVA);
        break;
    default:
        assert (0);
}
```
Appendix K Manual pages

**gdb man**

gdb [\(-\text{help}\) [\(-\text{nh}\) [\(-\text{nx}\) [\(-\text{q}\) [\(-\text{batch}\) [\(-\text{cd}=\text{dir}\) [\(-\text{f}\) [\(-\text{b} \text{ bps}\) [\(-\text{tty}=\text{dev}\) [\(-\text{s}\) symfile] [\(-\text{e} \text{ prog}\) [\(-\text{se} \text{ prog}\) [\(-\text{c} \text{ core}\) [\(-\text{p} \text{ procID}\) [\(-\text{x} \text{ cmd}\) [\(-\text{d} \text{ dir}\) [\text{prog} [\text{prog procID | prog core}\]

The purpose of a debugger such as GDB is to allow you to see what is going on “inside” another program while it executes – or what another program was doing at the moment it crashed.

GDB can do four main kinds of things (plus other things in support of these) to help you catch bugs in the act:

- Start your program, specifying anything that might affect its behavior.
- Make your program stop on specified conditions.
- Examine what has happened, when your program has stopped.
- Change things in your program, so you can experiment with correcting the effects of one bug and go on to learn about another.

You can use GDB to debug programs written in C, C++, Fortran and Modula-2.

GDB is invoked with the shell command `gdb`. Once started, it reads commands from the terminal until you tell it to exit with the GDB command `quit`. You can get online help from GDB itself by using the command `help`.

You can run `gdb` with no arguments or options; but the most usual way to start GDB is with one argument or two, specifying an executable program as the argument:

```
gdb program
```

You can also start with both an executable program and a core file specified:

```
gdb program core
```

You can, instead, specify a process ID as a second argument, if you want to debug a running process:

```
gdb program 1234
gdb -p 1234
```

would attach GDB to process 1234 (unless you also have a file named ‘1234’; GDB does check for a core file first). With option ‘-p’ you can omit the `program` filename.

Here are some of the most frequently needed GDB commands:

```
break [file:]function
    Set a breakpoint at function (in file).
run [arglist]
    Start your program (with arglist, if specified).
bt
    Backtrace: display the program stack.
print expr
    Display the value of an expression.
c
    Continue running your program (after stopping, e.g. at a breakpoint).
```
next    Execute next program line (after stopping); step over any function calls in the line.
edit [file:]function
   look at the program line where it is presently stopped.
list [file:]function
   type the text of the program in the vicinity of where it is presently stopped.
step    Execute next program line (after stopping); step into any function calls in the line.
help [name]
   Show information about GDB command name, or general information about using GDB.
quit    Exit from GDB.

Any arguments other than options specify an executable file and core file (or process ID); that is, the first argument encountered with no associated option flag is equivalent to a ‘-se’ option, and the second, if any, is equivalent to a ‘-c’ option if it’s the name of a file. Many options have both long and short forms; both are shown here. The long forms are also recognized if you truncate them, so long as enough of the option is present to be unambiguous. (If you prefer, you can flag option arguments with ‘+’ rather than ‘-’, though we illustrate the more usual convention.)

All the options and command line arguments you give are processed in sequential order. The order makes a difference when the ‘-x’ option is used.

-help
-h    List all options, with brief explanations.
-symbols=file
-s file    Read symbol table from file file.
-write   Enable writing into executable and core files.
-exec=file
-e file    Use file file as the executable file to execute when appropriate, and for examining pure data in conjunction with a core dump.
-se=file
   Read symbol table from file file and use it as the executable file.
-core=file
-c file    Use file file as a core dump to examine.
-command=file
-x file    Execute GDB commands from file file.
-ex command
   Execute given GDB command.
-directory=directory
-d directory
   Add directory to the path to search for source files.
-nh    Do not execute commands from ‘~/.gdbinit’.
Appendix K: Manual pages

-nx
-n
Do not execute commands from any `.gdbinit’ initialization files.

-quiet
-q
“Quiet”. Do not print the introductory and copyright messages. These messages are also suppressed in batch mode.

-batch
Run in batch mode. Exit with status 0 after processing all the command files specified with `-x’ (and `.gdbinit’, if not inhibited). Exit with nonzero status if an error occurs in executing the GDB commands in the command files.

Batch mode may be useful for running GDB as a filter, for example to download and run a program on another computer; in order to make this more useful, the message

Program exited normally.

(which is ordinarily issued whenever a program running under GDB control terminates) is not issued when running in batch mode.

-cd=directory
Run GDB using directory as its working directory, instead of the current directory.

-fullname
-f
Emacs sets this option when it runs GDB as a subprocess. It tells GDB to output the full file name and line number in a standard, recognizable fashion each time a stack frame is displayed (which includes each time the program stops). This recognizable format looks like two ‘\032’ characters, followed by the file name, line number and character position separated by colons, and a newline. The Emacs-to-GDB interface program uses the two ‘\032’ characters as a signal to display the source code for the frame.

-b bps
Set the line speed (baud rate or bits per second) of any serial interface used by GDB for remote debugging.

-tty=device
Run using device for your program’s standard input and output.

***

**gdbserver man**

\[ \textit{gdbserver comm prog [args...] } \]

\[ \textit{gdbserver --attach comm pid} \]

\[ \textit{gdbserver --multi comm} \]

\texttt{gdbserver} is a program that allows you to run GDB on a different machine than the one which is running the program being debugged.

**Usage (server (target) side)**

First, you need to have a copy of the program you want to debug put onto the target system. The program can be stripped to save space if needed, as \texttt{gdbserver} doesn’t care about symbols. All symbol handling is taken care of by the GDB running on the host system.
To use the server, you log on to the target system, and run the `gdbserver` program. You must tell it (a) how to communicate with GDB, (b) the name of your program, and (c) its arguments. The general syntax is:

```
target> gdbserver comm program [args ...]
```

For example, using a serial port, you might say:

```
target> gdbserver '/dev/com1' emacs foo.txt
```

This tells `gdbserver` to debug emacs with an argument of foo.txt, and to communicate with GDB via `/dev/com1`. `gdbserver` now waits patiently for the host GDB to communicate with it.

To use a TCP connection, you could say:

```
target> gdbserver host:2345 emacs foo.txt
```

This says pretty much the same thing as the last example, except that we are going to communicate with the host GDB via TCP. The `host:2345` argument means that we are expecting to see a TCP connection from host to local TCP port 2345. (Currently, the `host` part is ignored.) You can choose any number you want for the port number as long as it does not conflict with any existing TCP ports on the target system. This same port number must be used in the host GDBs `target remote` command, which will be described shortly. Note that if you chose a port number that conflicts with another service, `gdbserver` will print an error message and exit.

`gdbserver` can also attach to running programs. This is accomplished via the `--attach` argument. The syntax is:

```
target> gdbserver --attach comm pid
```

`pid` is the process ID of a currently running process. It isn’t necessary to point `gdbserver` at a binary for the running process.

To start `gdbserver` without supplying an initial command to run or process ID to attach, use the `--multi` command line option. In such case you should connect using `target extended-remote` to start the program you want to debug.

```
target> gdbserver --multi comm
```

**Usage (host side)**

You need an unstripped copy of the target program on your host system, since GDB needs to examine it’s symbol tables and such. Start up GDB as you normally would, with the target program as the first argument. (You may need to use the `--baud` option if the serial line is running at anything except 9600 baud.) That is `gdb TARGET-PROG`, or `gdb --baud BAUD TARGET-PROG`. After that, the only new command you need to know about is `target remote` (or `target extended-remote`). Its argument is either a device name (usually a serial device, like ‘/dev/ttyb’), or a HOST:PORT descriptor. For example:

```
(gdb) target remote '/dev/ttyb'
```

communicates with the server via serial line ‘/dev/ttyb’, and:

```
(gdb) target remote the-target:2345
```

communicates via a TCP connection to port 2345 on host ‘the-target’, where you previously started up `gdbserver` with the same port number. Note that for TCP connections, you must start up `gdbserver` prior to using the ‘target remote’ command, otherwise you may get an error that looks something like ‘Connection refused’.  


**gdbserver** can also debug multiple inferiors at once, described in Section 4.9 [Inferiors and Programs], page 33. In such case use the extended-remote GDB command variant:

```
(gdb) target extended-remote the-target:2345
```

The **gdbserver** option `--multi` may or may not be used in such case.

There are three different modes for invoking **gdbserver**:

- **Debug a specific program specified by its program name:**

  ```
  gdbserver comm prog [args...]
  ```

  The `comm` parameter specifies how should the server communicate with GDB; it is either a device name (to use a serial line), a TCP port number (:1234), or `-` or `stdio` to use stdin/stdout of **gdbserver**. Specify the name of the program to debug in `prog`. Any remaining arguments will be passed to the program verbatim. When the program exits, GDB will close the connection, and **gdbserver** will exit.

- **Debug a specific program by specifying the process ID of a running program:**

  ```
  gdbserver --attach comm pid
  ```

  The `comm` parameter is as described above. Supply the process ID of a running program in `pid`; GDB will do everything else. Like with the previous mode, when the process `pid` exits, GDB will close the connection, and **gdbserver** will exit.

- **Multi-process mode – debug more than one program/process:**

  ```
  gdbserver --multi comm
  ```

  In this mode, GDB can instruct **gdbserver** which command(s) to run. Unlike the other 2 modes, GDB will not close the connection when a process being debugged exits, so you can debug several processes in the same session.

In each of the modes you may specify these options:

- **--help** List all options, with brief explanations.

- **--version** This option causes **gdbserver** to print its version number and exit.

- **--attach** **gdbserver** will attach to a running program. The syntax is:

  ```
  target> gdbserver --attach comm pid
  ```

  `pid` is the process ID of a currently running process. It isn’t necessary to point **gdbserver** at a binary for the running process.

- **--multi** To start **gdbserver** without supplying an initial command to run or process ID to attach, use this command line option. Then you can connect using **target extended-remote** and start the program you want to debug. The syntax is:

  ```
  target> gdbserver --multi comm
  ```

- **--debug** Instruct **gdbserver** to display extra status information about the debugging process. This option is intended for **gdbserver** development and for bug reports to the developers.

- **--remote-debug** Instruct **gdbserver** to display remote protocol debug output. This option is intended for **gdbserver** development and for bug reports to the developers.
--debug-format=option1[,option2,...]
Instruct gdbserver to include extra information in each line of debugging output. See [Other Command-Line Arguments for gdbserver], page 261.

--wrapper
Specify a wrapper to launch programs for debugging. The option should be followed by the name of the wrapper, then any command-line arguments to pass to the wrapper, then -- indicating the end of the wrapper arguments.

--once
By default, gdbserver keeps the listening TCP port open, so that additional connections are possible. However, if you start gdbserver with the '--once' option, it will stop listening for any further connection attempts after connecting to the first GDB session.

gcore

gcore [-o filename] pid
Generate a core dump of a running program with process ID pid. Produced file is equivalent to a kernel produced core file as if the process crashed (and if ulimit -c were used to set up an appropriate core dump limit). Unlike after a crash, after gcore the program remains running without any change.

-o filename
The optional argument filename specifies the file name where to put the core dump. If not specified, the file name defaults to 'core.pid', where pid is the running program process ID.

gdbinit

`~/.gdbinit`

These files contain GDB commands to automatically execute during GDB startup. The lines of contents are canned sequences of commands, described in Section 23.1 [Sequences], page 315.

Please read more in Section 2.1.3 [Startup], page 16.

(not enabled with --with-system-gdbinit during compilation)
System-wide initialization file. It is executed unless user specified GDB option -nx or -n. See more in Section C.6 [System-wide configuration], page 596.

`~/.gdbinit`
User initialization file. It is executed unless user specified GDB options -nx, -n or -nh.

`./.gdbinit`
Initialization file for current directory. It may need to be enabled with GDB security command set auto-load local-gdbinit. See more in Section 22.7.1 [Init File in the Current Directory], page 304.
Appendix L GNU GENERAL PUBLIC LICENSE

Version 3, 29 June 2007

Everyone is permitted to copy and distribute verbatim copies of this license document, but changing it is not allowed.

Preamble
The GNU General Public License is a free, copyleft license for software and other kinds of works.

The licenses for most software and other practical works are designed to take away your freedom to share and change the works. By contrast, the GNU General Public License is intended to guarantee your freedom to share and change all versions of a program—to make sure it remains free software for all its users. We, the Free Software Foundation, use the GNU General Public License for most of our software; it applies also to any other work released this way by its authors. You can apply it to your programs, too.

When we speak of free software, we are referring to freedom, not price. Our General Public Licenses are designed to make sure that you have the freedom to distribute copies of free software (and charge for them if you wish), that you receive source code or can get it if you want it, that you can change the software or use pieces of it in new free programs, and that you know you can do these things.

To protect your rights, we need to prevent others from denying you these rights or asking you to surrender the rights. Therefore, you have certain responsibilities if you distribute copies of the software, or if you modify it: responsibilities to respect the freedom of others.

For example, if you distribute copies of such a program, whether gratis or for a fee, you must pass on to the recipients the same freedoms that you received. You must make sure that they, too, receive or can get the source code. And you must show them these terms so they know their rights.

Developers that use the GNU GPL protect your rights with two steps: (1) assert copyright on the software, and (2) offer you this License giving you legal permission to copy, distribute and/or modify it.

For the developers’ and authors’ protection, the GPL clearly explains that there is no warranty for this free software. For both users’ and authors’ sake, the GPL requires that modified versions be marked as changed, so that their problems will not be attributed erroneously to authors of previous versions.

Some devices are designed to deny users access to install or run modified versions of the software inside them, although the manufacturer can do so. This is fundamentally incompatible with the aim of protecting users’ freedom to change the software. The systematic pattern of such abuse occurs in the area of products for individuals to use, which is precisely where it is most unacceptable. Therefore, we have designed this version of the GPL to prohibit the practice for those products. If such problems arise substantially in other domains, we stand ready to extend this provision to those domains in future versions of the GPL, as needed to protect the freedom of users.
Finally, every program is threatened constantly by software patents. States should not allow patents to restrict development and use of software on general-purpose computers, but in those that do, we wish to avoid the special danger that patents applied to a free program could make it effectively proprietary. To prevent this, the GPL assures that patents cannot be used to render the program non-free.

The precise terms and conditions for copying, distribution and modification follow.

**TERMS AND CONDITIONS**

0. Definitions.

“This License” refers to version 3 of the GNU General Public License.

“Copyright” also means copyright-like laws that apply to other kinds of works, such as semiconductor masks.

“The Program” refers to any copyrightable work licensed under this License. Each licensee is addressed as “you”. “Licensees” and “recipients” may be individuals or organizations.

To “modify” a work means to copy from or adapt all or part of the work in a fashion requiring copyright permission, other than the making of an exact copy. The resulting work is called a “modified version” of the earlier work or a work “based on” the earlier work.

A “covered work” means either the unmodified Program or a work based on the Program.

To “propagate” a work means to do anything with it that, without permission, would make you directly or secondarily liable for infringement under applicable copyright law, except executing it on a computer or modifying a private copy. Propagation includes copying, distribution (with or without modification), making available to the public, and in some countries other activities as well.

To “convey” a work means any kind of propagation that enables other parties to make or receive copies. Mere interaction with a user through a computer network, with no transfer of a copy, is not conveying.

An interactive user interface displays “Appropriate Legal Notices” to the extent that it includes a convenient and prominently visible feature that (1) displays an appropriate copyright notice, and (2) tells the user that there is no warranty for the work (except to the extent that warranties are provided), that licensees may convey the work under this License, and how to view a copy of this License. If the interface presents a list of user commands or options, such as a menu, a prominent item in the list meets this criterion.


The “source code” for a work means the preferred form of the work for making modifications to it. “Object code” means any non-source form of a work.

A “Standard Interface” means an interface that either is an official standard defined by a recognized standards body, or, in the case of interfaces specified for a particular programming language, one that is widely used among developers working in that language.
Appendix L: GNU GENERAL PUBLIC LICENSE

The “System Libraries” of an executable work include anything, other than the work as a whole, that (a) is included in the normal form of packaging a Major Component, but which is not part of that Major Component, and (b) serves only to enable use of the work with that Major Component, or to implement a Standard Interface for which an implementation is available to the public in source code form. A “Major Component”, in this context, means a major essential component (kernel, window system, and so on) of the specific operating system (if any) on which the executable work runs, or a compiler used to produce the work, or an object code interpreter used to run it.

The “Corresponding Source” for a work in object code form means all the source code needed to generate, install, and (for an executable work) run the object code and to modify the work, including scripts to control those activities. However, it does not include the work’s System Libraries, or general-purpose tools or generally available free programs which are used unmodified in performing those activities but which are not part of the work. For example, Corresponding Source includes interface definition files associated with source files for the work, and the source code for shared libraries and dynamically linked subprograms that the work is specifically designed to require, such as by intimate data communication or control flow between those subprograms and other parts of the work.

The Corresponding Source need not include anything that users can regenerate automatically from other parts of the Corresponding Source.

The Corresponding Source for a work in source code form is that same work.

2. Basic Permissions.

All rights granted under this License are granted for the term of copyright on the Program, and are irrevocable provided the stated conditions are met. This License explicitly affirms your unlimited permission to run the unmodified Program. The output from running a covered work is covered by this License only if the output, given its content, constitutes a covered work. This License acknowledges your rights of fair use or other equivalent, as provided by copyright law.

You may make, run and propagate covered works that you do not convey, without conditions so long as your license otherwise remains in force. You may convey covered works to others for the sole purpose of having them make modifications exclusively for you, or provide you with facilities for running those works, provided that you comply with the terms of this License in conveying all material for which you do not control copyright. Those thus making or running the covered works for you must do so exclusively on your behalf, under your direction and control, on terms that prohibit them from making any copies of your copyrighted material outside their relationship with you.

Conveying under any other circumstances is permitted solely under the conditions stated below. Sublicensing is not allowed; section 10 makes it unnecessary.


No covered work shall be deemed part of an effective technological measure under any applicable law fulfilling obligations under article 11 of the WIPO copyright treaty adopted on 20 December 1996, or similar laws prohibiting or restricting circumvention of such measures.
When you convey a covered work, you waive any legal power to forbid circumvention of technological measures to the extent such circumvention is effected by exercising rights under this License with respect to the covered work, and you disclaim any intention to limit operation or modification of the work as a means of enforcing, against the work’s users, your or third parties’ legal rights to forbid circumvention of technological measures.


You may convey verbatim copies of the Program’s source code as you receive it, in any medium, provided that you conspicuously and appropriately publish on each copy an appropriate copyright notice; keep intact all notices stating that this License and any non-permissive terms added in accord with section 7 apply to the code; keep intact all notices of the absence of any warranty; and give all recipients a copy of this License along with the Program.

You may charge any price or no price for each copy that you convey, and you may offer support or warranty protection for a fee.

5. Conveying Modified Source Versions.

You may convey a work based on the Program, or the modifications to produce it from the Program, in the form of source code under the terms of section 4, provided that you also meet all of these conditions:

a. The work must carry prominent notices stating that you modified it, and giving a relevant date.

b. The work must carry prominent notices stating that it is released under this License and any conditions added under section 7. This requirement modifies the requirement in section 4 to “keep intact all notices”.

c. You must license the entire work, as a whole, under this License to anyone who comes into possession of a copy. This License will therefore apply, along with any applicable section 7 additional terms, to the whole of the work, and all its parts, regardless of how they are packaged. This License gives no permission to license the work in any other way, but it does not invalidate such permission if you have separately received it.

d. If the work has interactive user interfaces, each must display Appropriate Legal Notices; however, if the Program has interactive interfaces that do not display Appropriate Legal Notices, your work need not make them do so.

A compilation of a covered work with other separate and independent works, which are not by their nature extensions of the covered work, and which are not combined with it such as to form a larger program, in or on a volume of a storage or distribution medium, is called an “aggregate” if the compilation and its resulting copyright are not used to limit the access or legal rights of the compilation’s users beyond what the individual works permit. Inclusion of a covered work in an aggregate does not cause this License to apply to the other parts of the aggregate.

6. Conveying Non-Source Forms.

You may convey a covered work in object code form under the terms of sections 4 and 5, provided that you also convey the machine-readable Corresponding Source under the terms of this License, in one of these ways:
a. Convey the object code in, or embodied in, a physical product (including a physical distribution medium), accompanied by the Corresponding Source fixed on a durable physical medium customarily used for software interchange.

b. Convey the object code in, or embodied in, a physical product (including a physical distribution medium), accompanied by a written offer, valid for at least three years and valid for as long as you offer spare parts or customer support for that product model, to give anyone who possesses the object code either (1) a copy of the Corresponding Source for all the software in the product that is covered by this License, on a durable physical medium customarily used for software interchange, for a price no more than your reasonable cost of physically performing this conveying of source, or (2) access to copy the Corresponding Source from a network server at no charge.

c. Convey individual copies of the object code with a copy of the written offer to provide the Corresponding Source. This alternative is allowed only occasionally and noncommercially, and only if you received the object code with such an offer, in accord with subsection 6b.

d. Convey the object code by offering access from a designated place (gratis or for a charge), and offer equivalent access to the Corresponding Source in the same way through the same place at no further charge. You need not require recipients to copy the Corresponding Source along with the object code. If the place to copy the object code is a network server, the Corresponding Source may be on a different server (operated by you or a third party) that supports equivalent copying facilities, provided you maintain clear directions next to the object code saying where to find the Corresponding Source. Regardless of what server hosts the Corresponding Source, you remain obligated to ensure that it is available for as long as needed to satisfy these requirements.

e. Convey the object code using peer-to-peer transmission, provided you inform other peers where the object code and Corresponding Source of the work are being offered to the general public at no charge under subsection 6d.

A separable portion of the object code, whose source code is excluded from the Corresponding Source as a System Library, need not be included in conveying the object code work.

A “User Product” is either (1) a “consumer product”, which means any tangible personal property which is normally used for personal, family, or household purposes, or (2) anything designed or sold for incorporation into a dwelling. In determining whether a product is a consumer product, doubtful cases shall be resolved in favor of coverage. For a particular product received by a particular user, “normally used” refers to a typical or common use of that class of product, regardless of the status of the particular user or of the way in which the particular user actually uses, or expects or is expected to use, the product. A product is a consumer product regardless of whether the product has substantial commercial, industrial or non-consumer uses, unless such uses represent the only significant mode of use of the product.

“Installation Information” for a User Product means any methods, procedures, authorization keys, or other information required to install and execute modified versions of a covered work in that User Product from a modified version of its Corresponding Source.
The information must suffice to ensure that the continued functioning of the modified object code is in no case prevented or interfered with solely because modification has been made.

If you convey an object code work under this section in, or with, or specifically for use in, a User Product, and the conveying occurs as part of a transaction in which the right of possession and use of the User Product is transferred to the recipient in perpetuity or for a fixed term (regardless of how the transaction is characterized), the Corresponding Source conveyed under this section must be accompanied by the Installation Information. But this requirement does not apply if neither you nor any third party retains the ability to install modified object code on the User Product (for example, the work has been installed in ROM).

The requirement to provide Installation Information does not include a requirement to continue to provide support service, warranty, or updates for a work that has been modified or installed by the recipient, or for the User Product in which it has been modified or installed. Access to a network may be denied when the modification itself materially and adversely affects the operation of the network or violates the rules and protocols for communication across the network.

Corresponding Source conveyed, and Installation Information provided, in accord with this section must be in a format that is publicly documented (and with an implementation available to the public in source code form), and must require no special password or key for unpacking, reading or copying.

7. Additional Terms.

“Additional permissions” are terms that supplement the terms of this License by making exceptions from one or more of its conditions. Additional permissions that are applicable to the entire Program shall be treated as though they were included in this License, to the extent that they are valid under applicable law. If additional permissions apply only to part of the Program, that part may be used separately under those permissions, but the entire Program remains governed by this License without regard to the additional permissions.

When you convey a copy of a covered work, you may at your option remove any additional permissions from that copy, or from any part of it. (Additional permissions may be written to require their own removal in certain cases when you modify the work.) You may place additional permissions on material, added by you to a covered work, for which you have or can give appropriate copyright permission.

Notwithstanding any other provision of this License, for material you add to a covered work, you may (if authorized by the copyright holders of that material) supplement the terms of this License with terms:

a. Disclaiming warranty or limiting liability differently from the terms of sections 15 and 16 of this License; or

b. Requiring preservation of specified reasonable legal notices or author attributions in that material or in the Appropriate Legal Notices displayed by works containing it; or

c. Prohibiting misrepresentation of the origin of that material, or requiring that modified versions of such material be marked in reasonable ways as different from the original version; or
d. Limiting the use for publicity purposes of names of licensors or authors of the material; or

e. Declining to grant rights under trademark law for use of some trade names, trademarks, or service marks; or

f. Requiring indemnification of licensors and authors of that material by anyone who conveys the material (or modified versions of it) with contractual assumptions of liability to the recipient, for any liability that these contractual assumptions directly impose on those licensors and authors.

All other non-permissive additional terms are considered “further restrictions” within the meaning of section 10. If the Program as you received it, or any part of it, contains a notice stating that it is governed by this License along with a term that is a further restriction, you may remove that term. If a license document contains a further restriction but permits relicensing or conveying under this License, you may add to a covered work material governed by the terms of that license document, provided that the further restriction does not survive such relicensing or conveying.

If you add terms to a covered work in accord with this section, you must place, in the relevant source files, a statement of the additional terms that apply to those files, or a notice indicating where to find the applicable terms.

Additional terms, permissive or non-permissive, may be stated in the form of a separately written license, or stated as exceptions; the above requirements apply either way.

8. Termination.

You may not propagate or modify a covered work except as expressly provided under this License. Any attempt otherwise to propagate or modify it is void, and will automatically terminate your rights under this License (including any patent licenses granted under the third paragraph of section 11).

However, if you cease all violation of this License, then your license from a particular copyright holder is reinstated (a) provisionally, unless and until the copyright holder explicitly and finally terminates your license, and (b) permanently, if the copyright holder fails to notify you of the violation by some reasonable means prior to 60 days after the cessation.

Moreover, your license from a particular copyright holder is reinstated permanently if the copyright holder notifies you of the violation by some reasonable means, this is the first time you have received notice of violation of this License (for any work) from that copyright holder, and you cure the violation prior to 30 days after your receipt of the notice.

Termination of your rights under this section does not terminate the licenses of parties who have received copies or rights from you under this License. If your rights have been terminated and not permanently reinstated, you do not qualify to receive new licenses for the same material under section 10.


You are not required to accept this License in order to receive or run a copy of the Program. Ancillary propagation of a covered work occurring solely as a consequence of using peer-to-peer transmission to receive a copy likewise does not require acceptance.
However, nothing other than this License grants you permission to propagate or modify any covered work. These actions infringe copyright if you do not accept this License. Therefore, by modifying or propagating a covered work, you indicate your acceptance of this License to do so.

10. Automatic Licensing of Downstream Recipients.

Each time you convey a covered work, the recipient automatically receives a license from the original licensors, to run, modify and propagate that work, subject to this License. You are not responsible for enforcing compliance by third parties with this License.

An “entity transaction” is a transaction transferring control of an organization, or substantially all assets of one, or subdividing an organization, or merging organizations. If propagation of a covered work results from an entity transaction, each party to that transaction who receives a copy of the work also receives whatever licenses to the work the party’s predecessor in interest had or could give under the previous paragraph, plus a right to possession of the Corresponding Source of the work from the predecessor in interest, if the predecessor has it or can get it with reasonable efforts.

You may not impose any further restrictions on the exercise of the rights granted or affirmed under this License. For example, you may not impose a license fee, royalty, or other charge for exercise of rights granted under this License, and you may not initiate litigation (including a cross-claim or counterclaim in a lawsuit) alleging that any patent claim is infringed by making, using, selling, offering for sale, or importing the Program or any portion of it.

11. Patents.

A “contributor” is a copyright holder who authorizes use under this License of the Program or a work on which the Program is based. The work thus licensed is called the contributor’s “contributor version”.

A contributor’s “essential patent claims” are all patent claims owned or controlled by the contributor, whether already acquired or hereafter acquired, that would be infringed by some manner, permitted by this License, of making, using, or selling its contributor version, but do not include claims that would be infringed only as a consequence of further modification of the contributor version. For purposes of this definition, “control” includes the right to grant patent sublicenses in a manner consistent with the requirements of this License.

Each contributor grants you a non-exclusive, worldwide, royalty-free patent license under the contributor’s essential patent claims, to make, use, sell, offer for sale, import and otherwise run, modify and propagate the contents of its contributor version.

In the following three paragraphs, a “patent license” is any express agreement or commitment, however denominated, not to enforce a patent (such as an express permission to practice a patent or covenant not to sue for patent infringement). To “grant” such a patent license to a party means to make such an agreement or commitment not to enforce a patent against the party.

If you convey a covered work, knowingly relying on a patent license, and the Corresponding Source of the work is not available for anyone to copy, free of charge and under the terms of this License, through a publicly available network server or other readily accessible means, then you must either (1) cause the Corresponding Source to be so
available, or (2) arrange to deprive yourself of the benefit of the patent license for this particular work, or (3) arrange, in a manner consistent with the requirements of this License, to extend the patent license to downstream recipients. “Knowingly relying” means you have actual knowledge that, but for the patent license, your conveying the covered work in a country, or your recipient’s use of the covered work in a country, would infringe one or more identifiable patents in that country that you have reason to believe are valid.

If, pursuant to or in connection with a single transaction or arrangement, you convey, or propagate by procuring conveyance of, a covered work, and grant a patent license to some of the parties receiving the covered work authorizing them to use, propagate, modify or convey a specific copy of the covered work, then the patent license you grant is automatically extended to all recipients of the covered work and works based on it.

A patent license is “discriminatory” if it does not include within the scope of its coverage, prohibits the exercise of, or is conditioned on the non-exercise of one or more of the rights that are specifically granted under this License. You may not convey a covered work if you are a party to an arrangement with a third party that is in the business of distributing software, under which you make payment to the third party based on the extent of your activity of conveying the work, and under which the third party grants, to any of the parties who would receive the covered work from you, a discriminatory patent license (a) in connection with copies of the covered work conveyed by you (or copies made from those copies), or (b) primarily for and in connection with specific products or compilations that contain the covered work, unless you entered into that arrangement, or that patent license was granted, prior to 28 March 2007.

Nothing in this License shall be construed as excluding or limiting any implied license or other defenses to infringement that may otherwise be available to you under applicable patent law.


If conditions are imposed on you (whether by court order, agreement or otherwise) that contradict the conditions of this License, they do not excuse you from the conditions of this License. If you cannot convey a covered work so as to satisfy simultaneously your obligations under this License and any other pertinent obligations, then as a consequence you may not convey it at all. For example, if you agree to terms that obligate you to collect a royalty for further conveying from those to whom you convey the Program, the only way you could satisfy both those terms and this License would be to refrain entirely from conveying the Program.

13. Use with the GNU Affero General Public License.

Notwithstanding any other provision of this License, you have permission to link or combine any covered work with a work licensed under version 3 of the GNU Affero General Public License into a single combined work, and to convey the resulting work. The terms of this License will continue to apply to the part which is the covered work, but the special requirements of the GNU Affero General Public License, section 13, concerning interaction through a network will apply to the combination as such.

14. Revised Versions of this License.
The Free Software Foundation may publish revised and/or new versions of the GNU General Public License from time to time. Such new versions will be similar in spirit to the present version, but may differ in detail to address new problems or concerns.

Each version is given a distinguishing version number. If the Program specifies that a certain numbered version of the GNU General Public License “or any later version” applies to it, you have the option of following the terms and conditions either of that numbered version or of any later version published by the Free Software Foundation.

If the Program does not specify a version number of the GNU General Public License, you may choose any version ever published by the Free Software Foundation.

If the Program specifies that a proxy can decide which future versions of the GNU General Public License can be used, that proxy’s public statement of acceptance of a version permanently authorizes you to choose that version for the Program.

Later license versions may give you additional or different permissions. However, no additional obligations are imposed on any author or copyright holder as a result of your choosing to follow a later version.

15. Disclaimer of Warranty.

THERE IS NO WARRANTY FOR THE PROGRAM, TO THE EXTENT PERMITTED BY APPLICABLE LAW. EXCEPT WHEN OTHERWISE STATED IN WRITING THE COPYRIGHT HOLDERS AND/OR OTHER PARTIES PROVIDE THE PROGRAM “AS IS” WITHOUT WARRANTY OF ANY KIND, EITHER EXPRESSED OR IMPLIED, INCLUDING, BUT NOT LIMITED TO, THE IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE. THE ENTIRE RISK AS TO THE QUALITY AND PERFORMANCE OF THE PROGRAM IS WITH YOU. SHOULD THE PROGRAM PROVE DEFECTIVE, YOU ASSUME THE COST OF ALL NECESSARY SERVICING, REPAIR OR CORRECTION.

16. Limitation of Liability.

IN NO EVENT UNLESS REQUIRED BY APPLICABLE LAW OR AGREED TO IN WRITING WILL ANY COPYRIGHT HOLDER, OR ANY OTHER PARTY WHO MODIFIES AND/OR CONVEYS THE PROGRAM AS PERMITTED ABOVE, BE LIABLE TO YOU FOR DAMAGES, INCLUDING ANY GENERAL, SPECIAL, INCIDENTAL OR CONSEQUENTIAL DAMAGES ARISING OUT OF THE USE OR INABILITY TO USE THE PROGRAM (INCLUDING BUT NOT LIMITED TO LOSS OF DATA OR DATA BEING RENDERED INACCURATE OR LOSSES SUSTAINED BY YOU OR THIRD PARTIES OR A FAILURE OF THE PROGRAM TO OPERATE WITH ANY OTHER PROGRAMS), EVEN IF SUCH HOLDER OR OTHER PARTY HAS BEEN ADVISED OF THE POSSIBILITY OF SUCH DAMAGES.

17. Interpretation of Sections 15 and 16.

If the disclaimer of warranty and limitation of liability provided above cannot be given local legal effect according to their terms, reviewing courts shall apply local law that most closely approximates an absolute waiver of all civil liability in connection with the Program, unless a warranty or assumption of liability accompanies a copy of the Program in return for a fee.
END OF TERMS AND CONDITIONS

How to Apply These Terms to Your New Programs

If you develop a new program, and you want it to be of the greatest possible use to the public, the best way to achieve this is to make it free software which everyone can redistribute and change under these terms.

To do so, attach the following notices to the program. It is safest to attach them to the start of each source file to most effectively state the exclusion of warranty; and each file should have at least the “copyright” line and a pointer to where the full notice is found.

Copyright (C) year name of author

This program is free software: you can redistribute it and/or modify it under the terms of the GNU General Public License as published by the Free Software Foundation, either version 3 of the License, or (at your option) any later version.

This program is distributed in the hope that it will be useful, but WITHOUT ANY WARRANTY; without even the implied warranty of MERCHANTABILITY or FITNESS FOR A PARTICULAR PURPOSE. See the GNU General Public License for more details.

You should have received a copy of the GNU General Public License along with this program. If not, see http://www.gnu.org/licenses/.

Also add information on how to contact you by electronic and paper mail.

If the program does terminal interaction, make it output a short notice like this when it starts in an interactive mode:

program Copyright (C) year name of author
This program comes with ABSOLUTELY NO WARRANTY; for details type ‘show w’.
This is free software, and you are welcome to redistribute it under certain conditions; type ‘show c’ for details.

The hypothetical commands ‘show w’ and ‘show c’ should show the appropriate parts of the General Public License. Of course, your program’s commands might be different; for a GUI interface, you would use an “about box”.

You should also get your employer (if you work as a programmer) or school, if any, to sign a “copyright disclaimer” for the program, if necessary. For more information on this, and how to apply and follow the GNU GPL, see http://www.gnu.org/licenses/.

The GNU General Public License does not permit incorporating your program into proprietary programs. If your program is a subroutine library, you may consider it more useful to permit linking proprietary applications with the library. If this is what you want to do, use the GNU Lesser General Public License instead of this License. But first, please read http://www.gnu.org/philosophy/why-not-lgpl.html.
Appendix M GNU Free Documentation License

Version 1.3, 3 November 2008

http://fsf.org/

Everyone is permitted to copy and distribute verbatim copies of this license document, but changing it is not allowed.

0. PREAMBLE

The purpose of this License is to make a manual, textbook, or other functional and useful document free in the sense of freedom: to assure everyone the effective freedom to copy and redistribute it, with or without modifying it, either commercially or non-commercially. Secondarily, this License preserves for the author and publisher a way to get credit for their work, while not being considered responsible for modifications made by others.

This License is a kind of “copyleft”, which means that derivative works of the document must themselves be free in the same sense. It complements the GNU General Public License, which is a copyleft license designed for free software.

We have designed this License in order to use it for manuals for free software, because free software needs free documentation: a free program should come with manuals providing the same freedoms that the software does. But this License is not limited to software manuals; it can be used for any textual work, regardless of subject matter or whether it is published as a printed book. We recommend this License principally for works whose purpose is instruction or reference.

1. APPLICABILITY AND DEFINITIONS

This License applies to any manual or other work, in any medium, that contains a notice placed by the copyright holder saying it can be distributed under the terms of this License. Such a notice grants a world-wide, royalty-free license, unlimited in duration, to use that work under the conditions stated herein. The “Document”, below, refers to any such manual or work. Any member of the public is a licensee, and is addressed as “you”. You accept the license if you copy, modify or distribute the work in a way requiring permission under copyright law.

A “Modified Version” of the Document means any work containing the Document or a portion of it, either copied verbatim, or with modifications and/or translated into another language.

A “Secondary Section” is a named appendix or a front-matter section of the Document that deals exclusively with the relationship of the publishers or authors of the Document to the Document’s overall subject (or to related matters) and contains nothing that could fall directly within that overall subject. (Thus, if the Document is in part a textbook of mathematics, a Secondary Section may not explain any mathematics.) The relationship could be a matter of historical connection with the subject or with related matters, or of legal, commercial, philosophical, ethical or political position regarding them.

The “Invariant Sections” are certain Secondary Sections whose titles are designated, as being those of Invariant Sections, in the notice that says that the Document is released...
under this License. If a section does not fit the above definition of Secondary then it is not allowed to be designated as Invariant. The Document may contain zero Invariant Sections. If the Document does not identify any Invariant Sections then there are none.

The “Cover Texts” are certain short passages of text that are listed, as Front-Cover Texts or Back-Cover Texts, in the notice that says that the Document is released under this License. A Front-Cover Text may be at most 5 words, and a Back-Cover Text may be at most 25 words.

A “Transparent” copy of the Document means a machine-readable copy, represented in a format whose specification is available to the general public, that is suitable for revising the document straightforwardly with generic text editors or (for images composed of pixels) generic paint programs or (for drawings) some widely available drawing editor, and that is suitable for input to text formatters or for automatic translation to a variety of formats suitable for input to text formatters. A copy made in an otherwise Transparent file format whose markup, or absence of markup, has been arranged to thwart or discourage subsequent modification by readers is not Transparent. An image format is not Transparent if used for any substantial amount of text. A copy that is not “Transparent” is called “Opaque”.

Examples of suitable formats for Transparent copies include plain ASCII without markup, Texinfo input format, LaTeX input format, SGML or XML using a publicly available DTD, and standard-conforming simple HTML, PostScript or PDF designed for human modification. Examples of transparent image formats include PNG, XCF, and JPG. Opaque formats include proprietary formats that can be read and edited only by proprietary word processors, SGML or XML for which the DTD and/or processing tools are not generally available, and the machine-generated HTML, PostScript or PDF produced by some word processors for output purposes only.

The “Title Page” means, for a printed book, the title page itself, plus such following pages as are needed to hold, legibly, the material this License requires to appear in the title page. For works in formats which do not have any title page as such, “Title Page” means the text near the most prominent appearance of the work’s title, preceding the beginning of the body of the text.

The “publisher” means any person or entity that distributes copies of the Document to the public.

A section “Entitled XYZ” means a named subunit of the Document whose title either is precisely XYZ or contains XYZ in parentheses following text that translates XYZ in another language. (Here XYZ stands for a specific section name mentioned below, such as “Acknowledgements”, “Dedications”, “Endorsements”, or “History”.) To “Preserve the Title” of such a section when you modify the Document means that it remains a section “Entitled XYZ” according to this definition.

The Document may include Warranty Disclaimers next to the notice which states that this License applies to the Document. These Warranty Disclaimers are considered to be included by reference in this License, but only as regards disclaiming warranties: any other implication that these Warranty Disclaimers may have is void and has no effect on the meaning of this License.

2. VERBATIM COPYING
You may copy and distribute the Document in any medium, either commercially or noncommercially, provided that this License, the copyright notices, and the license notice saying this License applies to the Document are reproduced in all copies, and that you add no other conditions whatsoever to those of this License. You may not use technical measures to obstruct or control the reading or further copying of the copies you make or distribute. However, you may accept compensation in exchange for copies. If you distribute a large enough number of copies you must also follow the conditions in section 3.

You may also lend copies, under the same conditions stated above, and you may publicly display copies.

3. COPYING IN QUANTITY

If you publish printed copies (or copies in media that commonly have printed covers) of the Document, numbering more than 100, and the Document’s license notice requires Cover Texts, you must enclose the copies in covers that carry, clearly and legibly, all these Cover Texts: Front-Cover Texts on the front cover, and Back-Cover Texts on the back cover. Both covers must also clearly and legibly identify you as the publisher of these copies. The front cover must present the full title with all words of the title equally prominent and visible. You may add other material on the covers in addition. Copying with changes limited to the covers, as long as they preserve the title of the Document and satisfy these conditions, can be treated as verbatim copying in other respects.

If the required texts for either cover are too voluminous to fit legibly, you should put the first ones listed (as many as fit reasonably) on the actual cover, and continue the rest onto adjacent pages.

If you publish or distribute Opaque copies of the Document numbering more than 100, you must either include a machine-readable Transparent copy along with each Opaque copy, or state in or with each Opaque copy a computer-network location from which the general network-using public has access to download using public-standard network protocols a complete Transparent copy of the Document, free of added material. If you use the latter option, you must take reasonably prudent steps, when you begin distribution of Opaque copies in quantity, to ensure that this Transparent copy will remain thus accessible at the stated location until at least one year after the last time you distribute an Opaque copy (directly or through your agents or retailers) of that edition to the public.

It is requested, but not required, that you contact the authors of the Document well before redistributing any large number of copies, to give them a chance to provide you with an updated version of the Document.

4. MODIFICATIONS

You may copy and distribute a Modified Version of the Document under the conditions of sections 2 and 3 above, provided that you release the Modified Version under precisely this License, with the Modified Version filling the role of the Document, thus licensing distribution and modification of the Modified Version to whoever possesses a copy of it. In addition, you must do these things in the Modified Version:

A. Use in the Title Page (and on the covers, if any) a title distinct from that of the Document, and from those of previous versions (which should, if there were any,
be listed in the History section of the Document). You may use the same title as a previous version if the original publisher of that version gives permission.

B. List on the Title Page, as authors, one or more persons or entities responsible for authorship of the modifications in the Modified Version, together with at least five of the principal authors of the Document (all of its principal authors, if it has fewer than five), unless they release you from this requirement.

C. State on the Title page the name of the publisher of the Modified Version, as the publisher.

D. Preserve all the copyright notices of the Document.

E. Add an appropriate copyright notice for your modifications adjacent to the other copyright notices.

F. Include, immediately after the copyright notices, a license notice giving the public permission to use the Modified Version under the terms of this License, in the form shown in the Addendum below.

G. Preserve in that license notice the full lists of Invariant Sections and required Cover Texts given in the Document’s license notice.

H. Include an unaltered copy of this License.

I. Preserve the section Entitled “History”, Preserve its Title, and add to it an item stating at least the title, year, new authors, and publisher of the Modified Version as given on the Title Page. If there is no section Entitled “History” in the Document, create one stating the title, year, authors, and publisher of the Document as given on its Title Page, then add an item describing the Modified Version as stated in the previous sentence.

J. Preserve the network location, if any, given in the Document for public access to a Transparent copy of the Document, and likewise the network locations given in the Document for previous versions it was based on. These may be placed in the “History” section. You may omit a network location for a work that was published at least four years before the Document itself, or if the original publisher of the version it refers to gives permission.

K. For any section Entitled “Acknowledgements” or “Dedications”, Preserve the Title of the section, and preserve in the section all the substance and tone of each of the contributor acknowledgements and/or dedications given therein.

L. Preserve all the Invariant Sections of the Document, unaltered in their text and in their titles. Section numbers or the equivalent are not considered part of the section titles.

M. Delete any section Entitled “Endorsements”. Such a section may not be included in the Modified Version.

N. Do not retitle any existing section to be Entitled “Endorsements” or to conflict in title with any Invariant Section.

O. Preserve any Warranty Disclaimers.

If the Modified Version includes new front-matter sections or appendices that qualify as Secondary Sections and contain no material copied from the Document, you may at your option designate some or all of these sections as invariant. To do this, add their
titles to the list of Invariant Sections in the Modified Version’s license notice. These
titles must be distinct from any other section titles.

You may add a section Entitled “Endorsements”, provided it contains nothing but
endorsements of your Modified Version by various parties—for example, statements of
peer review or that the text has been approved by an organization as the authoritative
definition of a standard.

You may add a passage of up to five words as a Front-Cover Text, and a passage of up
to 25 words as a Back-Cover Text, to the end of the list of Cover Texts in the Modified
Version. Only one passage of Front-Cover Text and one of Back-Cover Text may be
added by (or through arrangements made by) any one entity. If the Document already
includes a cover text for the same cover, previously added by you or by arrangement
made by the same entity you are acting on behalf of, you may not add another; but
you may replace the old one, on explicit permission from the previous publisher that
added the old one.

The author(s) and publisher(s) of the Document do not by this License give permission
to use their names for publicity for or to assert or imply endorsement of any Modified
Version.

5. COMBINING DOCUMENTS

You may combine the Document with other documents released under this License,
under the terms defined in section 4 above for modified versions, provided that you
include in the combination all of the Invariant Sections of all of the original documents,
unmodified, and list them all as Invariant Sections of your combined work in its license
notice, and that you preserve all their Warranty Disclaimers.

The combined work need only contain one copy of this License, and multiple identical
Invariant Sections may be replaced with a single copy. If there are multiple Invariant
Sections with the same name but different contents, make the title of each such section
unique by adding at the end of it, in parentheses, the name of the original author or
publisher of that section if known, or else a unique number. Make the same adjustment
to the section titles in the list of Invariant Sections in the license notice of the combined
work.

In the combination, you must combine any sections Entitled “History” in the vari-
ous original documents, forming one section Entitled “History”; likewise combine any
sections Entitled “Acknowledgements”, and any sections Entitled “Dedications”. You
must delete all sections Entitled “Endorsements.”

6. COLLECTIONS OF DOCUMENTS

You may make a collection consisting of the Document and other documents released
under this License, and replace the individual copies of this License in the various
documents with a single copy that is included in the collection, provided that you
follow the rules of this License for verbatim copying of each of the documents in all
other respects.

You may extract a single document from such a collection, and distribute it individu-
ally under this License, provided you insert a copy of this License into the extracted
document, and follow this License in all other respects regarding verbatim copying of
that document.
7. AGGREGATION WITH INDEPENDENT WORKS

A compilation of the Document or its derivatives with other separate and independent documents or works, in or on a volume of a storage or distribution medium, is called an “aggregate” if the copyright resulting from the compilation is not used to limit the legal rights of the compilation’s users beyond what the individual works permit. When the Document is included in an aggregate, this License does not apply to the other works in the aggregate which are not themselves derivative works of the Document.

If the Cover Text requirement of section 3 is applicable to these copies of the Document, then if the Document is less than one half of the entire aggregate, the Document’s Cover Texts may be placed on covers that bracket the Document within the aggregate, or the electronic equivalent of covers if the Document is in electronic form. Otherwise they must appear on printed covers that bracket the whole aggregate.

8. TRANSLATION

Translation is considered a kind of modification, so you may distribute translations of the Document under the terms of section 4. Replacing Invariant Sections with translations requires special permission from their copyright holders, but you may include translations of some or all Invariant Sections in addition to the original versions of these Invariant Sections. You may include a translation of this License, and all the license notices in the Document, and any Warranty Disclaimers, provided that you also include the original English version of this License and the original versions of those notices and disclaimers. In case of a disagreement between the translation and the original version of this License or a notice or disclaimer, the original version will prevail.

If a section in the Document is Entitled “Acknowledgements”, “Dedications”, or “History”, the requirement (section 4) to Preserve its Title (section 1) will typically require changing the actual title.

9. TERMINATION

You may not copy, modify, sublicense, or distribute the Document except as expressly provided under this License. Any attempt otherwise to copy, modify, sublicense, or distribute it is void, and will automatically terminate your rights under this License. However, if you cease all violation of this License, then your license from a particular copyright holder is reinstated (a) provisionally, unless and until the copyright holder explicitly and finally terminates your license, and (b) permanently, if the copyright holder fails to notify you of the violation by some reasonable means prior to 60 days after the cessation.

Moreover, your license from a particular copyright holder is reinstated permanently if the copyright holder notifies you of the violation by some reasonable means, this is the first time you have received notice of violation of this License (for any work) from that copyright holder, and you cure the violation prior to 30 days after your receipt of the notice.

Termination of your rights under this section does not terminate the licenses of parties who have received copies or rights from you under this License. If your rights have been terminated and not permanently reinstated, receipt of a copy of some or all of the same material does not give you any rights to use it.
10. FUTURE REVISIONS OF THIS LICENSE

The Free Software Foundation may publish new, revised versions of the GNU Free Documentation License from time to time. Such new versions will be similar in spirit to the present version, but may differ in detail to address new problems or concerns. See http://www.gnu.org/copyleft/.

Each version of the License is given a distinguishing version number. If the Document specifies that a particular numbered version of this License “or any later version” applies to it, you have the option of following the terms and conditions either of that specified version or of any later version that has been published (not as a draft) by the Free Software Foundation. If the Document does not specify a version number of this License, you may choose any version ever published (not as a draft) by the Free Software Foundation. If the Document specifies that a proxy can decide which future versions of this License can be used, that proxy’s public statement of acceptance of a version permanently authorizes you to choose that version for the Document.

11. RELICENSING

“Massive Multiauthor Collaboration Site” (or “MMC Site”) means any World Wide Web server that publishes copyrightable works and also provides prominent facilities for anybody to edit those works. A public wiki that anybody can edit is an example of such a server. A “Massive Multiauthor Collaboration” (or “MMC”) contained in the site means any set of copyrightable works thus published on the MMC site.

“CC-BY-SA” means the Creative Commons Attribution-Share Alike 3.0 license published by Creative Commons Corporation, a not-for-profit corporation with a principal place of business in San Francisco, California, as well as future copyleft versions of that license published by that same organization.

“Incorporate” means to publish or republish a Document, in whole or in part, as part of another Document.

An MMC is “eligible for relicensing” if it is licensed under this License, and if all works that were first published under this License somewhere other than this MMC, and subsequently incorporated in whole or in part into the MMC, (1) had no cover texts or invariant sections, and (2) were thus incorporated prior to November 1, 2008.

The operator of an MMC Site may republish an MMC contained in the site under CC-BY-SA on the same site at any time before August 1, 2009, provided the MMC is eligible for relicensing.
ADDENDUM: How to use this License for your documents

To use this License in a document you have written, include a copy of the License in the
document and put the following copyright and license notices just after the title page:

Copyright (C) year your name.
Permission is granted to copy, distribute and/or modify this document
under the terms of the GNU Free Documentation License, Version 1.3
or any later version published by the Free Software Foundation;
with no Invariant Sections, no Front-Cover Texts, and no Back-Cover
Texts. A copy of the license is included in the section entitled “GNU
Free Documentation License”.

If you have Invariant Sections, Front-Cover Texts and Back-Cover Texts, replace the
“with...Texts.” line with this:

with the Invariant Sections being list their titles, with
the Front-Cover Texts being list, and with the Back-Cover Texts
being list.

If you have Invariant Sections without Cover Texts, or some other combination of the
three, merge those two alternatives to suit the situation.

If your document contains nontrivial examples of program code, we recommend releasing
these examples in parallel under your choice of free software license, such as the GNU
General Public License, to permit their use in free software.
Concept Index

! '!' packet .......................................................... 609
#
# in Modula-2 ..................................................... 206
$
$_$ ................................................................. 136
$_$$_$ ................................................................. 136
$_$ and info breakpoints ......................................... 48
$_$ and info line .................................................... 108
$_$$_$, and value history .......................................... 123

--annotate ......................................................... 15
--args ............................................................. 15
'--attach', gdbserver option .................................. 260
--batch ........................................................... 13
--batch-silent .................................................... 14
--bfind ........................................................... 15
--cd ............................................................... 14
--command ........................................................ 12
--configuration ................................................. 16
--core ............................................................. 12
--data-directory ................................................ 14
'--debug', gdbserver option .................................. 261
'--debug-format', gdbserver option ......................... 262
--directory ....................................................... 13
--eval-command ................................................ 12
--exec ............................................................ 12
--fullname ......................................................... 14
--init-command ................................................ 12
--init-eval-command ............................................ 12
--interpreter ..................................................... 15
'--multi', gdbserver option .................................. 261
--nh ............................................................... 13
--nowindows ....................................................... 14
--nx ............................................................... 13
'--once', gdbserver option .................................... 261
--pid ............................................................. 12
--quiet ........................................................... 13
--readnov ........................................................ 13
'--remote-debug', gdbserver option ......................... 261
--return-child-result .......................................... 14
--se .............................................................. 12
--silent .......................................................... 13
--statistics ....................................................... 16
--symbols ........................................................ 12
--tty ............................................................. 15
--tui ............................................................. 15
--version ........................................................ 16

--windows .......................................................... 14
'--with-gdb-datadir' ........................................... 252
'--with-relocated-sources' .................................... 107
'--with-sysroot' ................................................ 244
'--wrapper', gdbserver option ................................ 262
--write ........................................................... 15
-b ................................................................. 15
-c ................................................................. 12
-d ................................................................. 13
-D ................................................................. 14
-e ................................................................. 12
-ex ............................................................... 12
-f ................................................................. 14
-iex ............................................................. 12
--info-gdb-mi-command ......................................... 534
--ix ................................................................ 12
-l ................................................................. 15
-n ................................................................. 13
-nv ............................................................... 14
-p ................................................................. 12
-q ................................................................. 13
-r ................................................................. 13
-s ................................................................. 12
-t ................................................................. 15
-w ................................................................. 14
-x ................................................................. 12

#...# Modula-2 scope operator ................................ 205
'./build-id' directory .......................................... 246
'.debug' subdirectories .......................................... 246
.debug_gdb_scripts section ...................................... 443
'gdb_index' section .............................................. 250
gdb_index section format ........................................ 701
gdbinit ........................................................... 17
.gnu_debugdata' section ......................................... 249
gnu_debuglink sections .......................................... 247
.note.gnu.build-id sections .................................... 247
'..'. files, reading symbols from ................................ 239

/ /proc .................................................................... 275

:: context for variables/functions ............................... 117

< <architecture> .................................................. 688
<compatible> ....................................................... 689
<feature> .......................................................... 689
<table>
<thead>
<tr>
<th>Concept Index</th>
<th>733</th>
</tr>
</thead>
<tbody>
<tr>
<td>branch trace store</td>
<td>85</td>
</tr>
<tr>
<td>break in overloaded functions</td>
<td>195</td>
</tr>
<tr>
<td>break on a system call</td>
<td>56</td>
</tr>
<tr>
<td>break on fork/exec</td>
<td>56</td>
</tr>
<tr>
<td>BREAK signal instead of Ctrl-C</td>
<td>265</td>
</tr>
<tr>
<td>breakpoint address adjusted</td>
<td>67</td>
</tr>
<tr>
<td>breakpoint at static probe point</td>
<td>103</td>
</tr>
<tr>
<td>breakpoint commands</td>
<td>62</td>
</tr>
<tr>
<td>breakpoint commands for GDB/MI</td>
<td>472</td>
</tr>
<tr>
<td>breakpoint commands, in remote protocol</td>
<td>635</td>
</tr>
<tr>
<td>breakpoint conditions</td>
<td>60</td>
</tr>
<tr>
<td>breakpoint kinds, ARM</td>
<td>643</td>
</tr>
<tr>
<td>breakpoint kinds, MIPS</td>
<td>644</td>
</tr>
<tr>
<td>breakpoint numbers</td>
<td>45</td>
</tr>
<tr>
<td>breakpoint on events</td>
<td>45</td>
</tr>
<tr>
<td>breakpoint on memory address</td>
<td>45</td>
</tr>
<tr>
<td>breakpoint on variable modification</td>
<td>45</td>
</tr>
<tr>
<td>breakpoint ranges</td>
<td>45</td>
</tr>
<tr>
<td>breakpoint subroutine, remote</td>
<td>272</td>
</tr>
<tr>
<td>breakpointing Ada elaboration code</td>
<td>209</td>
</tr>
<tr>
<td>breakpoints</td>
<td>45</td>
</tr>
<tr>
<td>breakpoints and tasks, in Ada</td>
<td>212</td>
</tr>
<tr>
<td>breakpoints and threads</td>
<td>79</td>
</tr>
<tr>
<td>breakpoints at functions matching a regexp</td>
<td>47</td>
</tr>
<tr>
<td>breakpoints in guile</td>
<td>430</td>
</tr>
<tr>
<td>breakpoints in overlays</td>
<td>184</td>
</tr>
<tr>
<td>breakpoints in python</td>
<td>382</td>
</tr>
<tr>
<td>breakpoints, multiple locations</td>
<td>49</td>
</tr>
<tr>
<td><code>bs</code> packet</td>
<td>610</td>
</tr>
<tr>
<td>bug criteria</td>
<td>557</td>
</tr>
<tr>
<td>bug reports</td>
<td>557</td>
</tr>
<tr>
<td>bugs in GDB</td>
<td>557</td>
</tr>
<tr>
<td>build ID sections</td>
<td>247</td>
</tr>
<tr>
<td>build ID, and separate debugging files</td>
<td>246</td>
</tr>
<tr>
<td>building GDB, requirements for</td>
<td>591</td>
</tr>
<tr>
<td>built-in simulator target</td>
<td>254</td>
</tr>
<tr>
<td>built-in Go functions</td>
<td>197</td>
</tr>
<tr>
<td>built-in Go types</td>
<td>197</td>
</tr>
<tr>
<td>caching of opened files</td>
<td>245</td>
</tr>
<tr>
<td>call dummy stack unwinding</td>
<td>229</td>
</tr>
<tr>
<td>call dummy stack unwinding on unhandled exception</td>
<td>229</td>
</tr>
<tr>
<td>call overloaded functions</td>
<td>194</td>
</tr>
<tr>
<td>call stack</td>
<td>93</td>
</tr>
<tr>
<td>call stack traces</td>
<td>94</td>
</tr>
<tr>
<td>call-clobbered registers</td>
<td>143</td>
</tr>
<tr>
<td>caller-saved registers</td>
<td>143</td>
</tr>
<tr>
<td>calling functions</td>
<td>229</td>
</tr>
<tr>
<td>calling make</td>
<td>17</td>
</tr>
<tr>
<td>case sensitivity in symbol names</td>
<td>217</td>
</tr>
<tr>
<td>case-insensitive symbol names</td>
<td>217</td>
</tr>
<tr>
<td>casts, in expressions</td>
<td>115</td>
</tr>
<tr>
<td>casts, to view memory</td>
<td>115</td>
</tr>
<tr>
<td>catch Ada exceptions</td>
<td>56</td>
</tr>
<tr>
<td>catchpoints</td>
<td>45</td>
</tr>
<tr>
<td>catchpoints, setting</td>
<td>55</td>
</tr>
<tr>
<td>Cell Broadband Engine</td>
<td>295</td>
</tr>
<tr>
<td>character sets</td>
<td>149</td>
</tr>
<tr>
<td>charset</td>
<td>149</td>
</tr>
<tr>
<td>checkpoint</td>
<td>42</td>
</tr>
<tr>
<td>checkpoints and process id</td>
<td>43</td>
</tr>
<tr>
<td>checks, range</td>
<td>190</td>
</tr>
<tr>
<td>checks, type</td>
<td>189</td>
</tr>
<tr>
<td>checksum, for GDB remote</td>
<td>607</td>
</tr>
<tr>
<td>choosing target byte order</td>
<td>255</td>
</tr>
<tr>
<td>circular trace buffer</td>
<td>173</td>
</tr>
<tr>
<td>clearing breakpoints, watchpoints, catchpoints</td>
<td>59</td>
</tr>
<tr>
<td>close, file-i/o system call</td>
<td>661</td>
</tr>
<tr>
<td>closest symbol and offset for an address</td>
<td>218</td>
</tr>
<tr>
<td>code address and its source line</td>
<td>108</td>
</tr>
<tr>
<td>code compression, MIPS</td>
<td>294</td>
</tr>
<tr>
<td>COFF/PE exported symbols</td>
<td>309</td>
</tr>
<tr>
<td>collected data discarded</td>
<td>172</td>
</tr>
<tr>
<td>colon, doubled as scope operator</td>
<td>205</td>
</tr>
<tr>
<td>colon-colon, context for variables/functions</td>
<td>117</td>
</tr>
<tr>
<td>command editing</td>
<td>561</td>
</tr>
<tr>
<td>command files</td>
<td>318</td>
</tr>
<tr>
<td>command history</td>
<td>298</td>
</tr>
<tr>
<td>command hooks</td>
<td>317</td>
</tr>
<tr>
<td>command interpreters</td>
<td>447</td>
</tr>
<tr>
<td>command line editing</td>
<td>297</td>
</tr>
<tr>
<td>command scripts, debugging</td>
<td>308</td>
</tr>
<tr>
<td>command tracing</td>
<td>308</td>
</tr>
<tr>
<td>commands for C++</td>
<td>195</td>
</tr>
<tr>
<td>commands in guile</td>
<td>413</td>
</tr>
<tr>
<td>commands in python</td>
<td>362</td>
</tr>
<tr>
<td>commands to access guile</td>
<td>391</td>
</tr>
<tr>
<td>commands to access python</td>
<td>322</td>
</tr>
<tr>
<td>comment</td>
<td>19</td>
</tr>
<tr>
<td>COMMON blocks, Fortran</td>
<td>200</td>
</tr>
<tr>
<td>common targets</td>
<td>254</td>
</tr>
<tr>
<td>compatibility, GDB/MI and CLI</td>
<td>463</td>
</tr>
<tr>
<td>compilation directory</td>
<td>107</td>
</tr>
<tr>
<td>compile command debugging info</td>
<td>231</td>
</tr>
<tr>
<td>compile command options override</td>
<td>232</td>
</tr>
</tbody>
</table>
Debugging with GDB

D

D .............................................. 197
'd' packet .................................. 610
'D' packet .................................. 610
Darwin ....................................... 284
data breakpoints ........................... 45
data manipulation, in GDB/MI .......... 513
dcache line-size ............................ 153
dcache size ................................ 153
dead names, GNU Hurd ...................... 283
debug expression parser .................. 311
debug formats and C++ ..................... 194
debug link sections ....................... 247
debug remote protocol ..................... 311
debugger crash ............................ 557
debugging agent ........................... 553
debugging C++ programs ................. 194
debugging information directory, global 246
debugging information in separate files 246
debugging libthread_db ................... 39
debugging multiple processes .......... 40
debugging optimized code ............... 155
debugging stub, example .................. 270
debugging target ......................... 253
debugging the Cygwin DLL ............... 280
decimal floating point format .......... 197
default collection action ............... 170
default data directory ................... 107
default source path substitution ...... 107
default system root ...................... 244
define trace state variable, remote request 646
defining macros interactively .......... 159
definition of a macro, showing .......... 159
delete breakpoints ....................... 59
deleting breakpoints, watchpoints, catchpoints 59
deliver a signal to a program .......... 227
demangle .................................. 218
demangler crashes ....................... 599, 600
demangling C++ names .................... 132
deprecated commands ..................... 599
derived type of an object, printing ..... 132
descriptor tables display ............... 277
detach from task, GNU Hurd ............. 283
detach from thread, GNU Hurd .......... 284
direct memory access (DMA) on MS-DOS .. 278
directories for source files ............ 105
directory, compilation ................... 107
directory, current ....................... 107
disable address space randomization, remote request 623
disconnected tracing ..................... 172
displaced stepping debugging info ..... 310
displaced stepping support ............. 598
displaced stepping, and process record and replay 86
display command history ............... 299
display derived types ................... 132
display disabled out of scope .......... 125
display GDB copyright .................. 24
display of expressions ................... 124
display remote monitor communications 255
display remote packets .................. 311
DlGPP debugging .......................... 277
DLLs with no debugging symbols ....... 281
do not print frame argument values ...... 128
documentation ............................ 589
Concept Index

don’t repeat command .................................. 316
don’t repeat Guile command .......................... 414
don’t repeat Python command .......................... 363
DOS file-name semantics of file names ................. 244
DOS serial data link, remote debugging ............... 279
DOS serial port status ................................ 279
DPMI .................................................. 277
dprintf ............................................... 63
dump all data collected at tracepoint ................. 177
dump core from inferior ............................... 148
dump data to a file .................................. 148
dump/restore files .................................... 148
DVC register ......................................... 290
DWARF compilation units cache ....................... 602
DWARF DIEs ......................................... 309
DWARF Line Tables ................................... 309
DWARF Reading ....................................... 309
DWARF-2 CFI and CRIS ............................... 291
dynamic linking ..................................... 238
dynamic printf ...................................... 63
dynamic varobj ..................................... 505

E

editing ............................................... 297
editing command lines ................................ 561
editing source files ................................ 104
eight-bit characters in strings ........................ 131
elevation phase ...................................... 27
ELinOS system-wide configuration script ............. 596
Emacs ............................................... 455
empty response, for unsupported packets ............... 608
enable/disable a breakpoint ......................... 59
enabling and disabling probes ....................... 66
entering numbers .................................... 300
environment (of your program) .................... 30
errno values, in file-i/o protocol .................. 667
error on valid input ................................ 557
event debugging info ................................ 310
event designators ................................... 583
event handling ....................................... 55
examine process image .............................. 275
examining data ...................................... 113
examining memory ................................... 121
exception handlers .................................. 55
exceptions, guile ................................... 396
exceptions, python .................................. 326
exec events, remote reply ............................ 620
executable file ....................................... 237
executable file, target ............................... 254
executable file, for remote target ................. 266
execute commands from a file ....................... 318
execute forward or backward in time ............... 84
execute remote command, remote request .......... 627
execution, foreground, background and
  asynchronous ...................................... 78
executing GDB ....................................... 17
expand macro once .................................. 159

expanding preprocessor macros ....................... 159
explicit locations ................................... 103
explore type ........................................ 115
explore value ........................................ 115
exploring hierarchical data structures ............... 113
expression debugging info .......................... 310
expression parser, debugging info ................. 311
expressions ......................................... 115
expressions in Ada .................................. 206
expressions in C or C++ ............................ 191
expressions in C++ .................................. 194
expressions in Modula-2 ............................ 200
extend GDB for remote targets ....................... 258
extending GDB ....................................... 315
extra signal information ............................ 75

F

‘F’ packet ........................................... 610
F reply packet ....................................... 658
F request packet ..................................... 658
fast tracepoints ..................................... 163
fast tracepoints, setting ............................ 165
fatal signal .......................................... 557
fatal signals ......................................... 73
features of the remote protocol .................... 628
file name canonicalization .......................... 245
file transfer ......................................... 259
file transfer, remote protocol ....................... 651
file-i/o examples .................................... 668
file-i/o overview .................................... 657
File-I/O remote protocol extension ................. 657
file-i/o reply packet ................................ 658
file-i/o request packet ............................. 658
filename-display .................................... 96
find trace snapshot .................................. 175
flinching .............................................. 308
float promotion ...................................... 301
floating point ....................................... 143
floating point registers ............................. 141
floating point, MIPS remote ......................... 288
focus of debugging .................................. 37
foo .................................................... 252
foreground execution ................................ 78
fork events, remote reply ............................ 620
fork, debugging programs which call ............... 39
format options ...................................... 125
formatted output ................................... 120
Fortran .............................................. 1
Fortran Defaults ..................................... 199
Fortran operators and expressions ................. 199
Fortran-specific support in GDB .................... 199
FR-V shared-library debugging....................... 312
frame debugging info ................................ 310
frame decorator api .................................. 343
frame filters api .................................... 341
frame number ........................................ 93
frame pointer ....................................... 93
frame pointer register ........................................ 142
frame, definition ............................................. 93
frameless execution ........................................... 93
frames in guile ............................................... 421
frames in python ............................................. 372
free memory information (MS-DOS) ......................... 277
fstat, file-i/o system call ................................ 664
Fujitsu .......................................................... 271
full symbol tables, listing GDB's internal ................ 223
function call arguments, optimized out .................... 95
function entry/exit, wrong values of variables ............... 118
functions without line info, and stepping .................. 69

G

'g' packet .................................................. 610
'G' packet .................................................. 611
g++, GNU C++ compiler ..................................... 191
garbled pointers ............................................. 277
GCC and C++ .................................................. 194
GDB bugs, reporting .......................................... 557
GDB internal error ........................................... 600
gdb module ................................................. 323
gdb objects .................................................. 394
GDB reference card .......................................... 589
GDB startup .................................................. 16
GDB version number .......................................... 24
'gdb.ini' .................................................... 47
.gdbinit ...................................................... 17
gdb.printing ............................................... 388
gdb.types .................................................... 389
gdb.Value ................................................... 327
GDB/MI development .......................................... 463
GDB/MI General Design ...................................... 457
GDB/MI, async records .................................... 465
GDB/MI, breakpoint commands ................................ 472
GDB/MI, compatibility with CLI ........................... 463
GDB/MI, data manipulation ................................ 513
GDB/MI, input syntax ...................................... 461
GDB/MI, its purpose ........................................ 457
GDB/MI, output syntax ..................................... 461
GDB/MI, result records .................................... 464
GDB/MI, simple examples .................................. 471
GDB/MI, stream records ................................... 464
gdbarch debugging info .................................... 308
GDBHISTFILE, environment variable ....................... 298
GDBHISTSIZE, environment variable ....................... 298
gdbserver, command-line arguments ....................... 259
gdbserver, multiple processes ............................... 261
gdbserver, search path for libthread_db ................. 263
GDT ............................................................ 277
get thread information block address ....................... 624
get thread-local storage address, remote request .......... 624
gettimeofday, file-i/o system call ........................ 664
getting structure elements using gdb.Field objects as
subscripts ................................................... 328
global debugging information directories ................. 246
GNAT descriptive types .................................... 214
GNAT encoding .............................................. 214
GNU C++ ..................................................... 191
GNU Emacs ................................................... 455
GNU Hurd debugging ......................................... 282
GNU/Hurd debug messages ................................ 310
GNU/Linux LWP debug messages ............................ 310
GNU/Linux namespaces debug messages ..................... 311
Go (programming language) ................................ 197
guile .......................................................... 392
guile architectures .......................................... 434
guile auto-loading .......................................... 440
guile commands ............................................. 391, 413
guile configuration .......................................... 394
guile exceptions ............................................ 396
guile gdb module ........................................... 392
guile iterators ............................................... 438
guile modules ................................................. 441
guile pagination ............................................. 392
guile parameters ............................................ 417
guile pretty printing api ................................... 408
guile scripting ............................................... 391
guile scripts directory ..................................... 391
guile stdout .................................................. 392
guile, working with types .................................. 404
guile, working with values from inferior ................... 397

H

'H' packet ................................................... 611
handling signals ............................................. 73
hardware breakpoints ........................................ 47
hardware debug registers .................................. 603
hardware watchpoints ....................................... 52
hash mark while downloading ............................... 255
heuristic-fence-post (Alpha, MIPS) ......................... 293
history events .............................................. 583
history expansion .......................................... 583
history expansion, turn on/off ............................. 299
history file .................................................. 298
history number ............................................. 136
history of values printed by GDB ......................... 136
history size .................................................. 298
history substitution ......................................... 298
hooks, for commands ....................................... 317
hooks, post-command ...................................... 317
hooks, pre-command ....................................... 317
host character set .......................................... 149
Host I/O, remote protocol .................................. 651
how many arguments (user-defined commands) ............. 315
HPAA support ................................................ 295

I

'i' packet ................................................... 611
'T' packet ................................................... 611
<table>
<thead>
<tr>
<th>Topic</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>MS-DOS-specific commands</td>
<td>277</td>
</tr>
<tr>
<td>multiple locations, breakpoints</td>
<td>49</td>
</tr>
<tr>
<td>multiple processes</td>
<td>39</td>
</tr>
<tr>
<td>multiple processes with gdbserver</td>
<td>261</td>
</tr>
<tr>
<td>multiple targets</td>
<td>253</td>
</tr>
<tr>
<td>multiple threads</td>
<td>36</td>
</tr>
<tr>
<td>multiple threads, backtrace</td>
<td>95</td>
</tr>
<tr>
<td>multiple-symbols menu</td>
<td>116</td>
</tr>
<tr>
<td>multiprocess extensions, in remote protocol</td>
<td>634</td>
</tr>
<tr>
<td>N</td>
<td></td>
</tr>
<tr>
<td>name a thread</td>
<td>38</td>
</tr>
<tr>
<td>names of symbols</td>
<td>217</td>
</tr>
<tr>
<td>namespace in C++</td>
<td>194</td>
</tr>
<tr>
<td>non-member C++ functions, set breakpoint in</td>
<td>47</td>
</tr>
<tr>
<td>non-stop mode</td>
<td>77</td>
</tr>
<tr>
<td>non-stop mode, and process record and replay</td>
<td>86</td>
</tr>
<tr>
<td>non-stop mode, and ‘set displaced-stepping’</td>
<td>599</td>
</tr>
<tr>
<td>non-stop mode, remote request</td>
<td>625</td>
</tr>
<tr>
<td>noninvasive task options</td>
<td>283</td>
</tr>
<tr>
<td>notation, readline</td>
<td>561</td>
</tr>
<tr>
<td>notational conventions, for gdb/mi</td>
<td>457</td>
</tr>
<tr>
<td>notification packets</td>
<td>653</td>
</tr>
<tr>
<td>notify output in gdb/mi</td>
<td>463</td>
</tr>
<tr>
<td>NULL elements in arrays</td>
<td>130</td>
</tr>
<tr>
<td>number of array elements to print</td>
<td>127</td>
</tr>
<tr>
<td>number representation</td>
<td>300</td>
</tr>
<tr>
<td>numbers for breakpoints</td>
<td>45</td>
</tr>
<tr>
<td>O</td>
<td></td>
</tr>
<tr>
<td>object files, relocatable, reading symbols from</td>
<td>239</td>
</tr>
<tr>
<td>Objective-C</td>
<td>198</td>
</tr>
<tr>
<td>Objective-C, classes and selectors</td>
<td>222</td>
</tr>
<tr>
<td>Objective-C, print objects</td>
<td>198</td>
</tr>
<tr>
<td>'objfile-gdb.gdb'</td>
<td>442</td>
</tr>
<tr>
<td>'objfile-gdb.py'</td>
<td>442</td>
</tr>
<tr>
<td>'objfile-gdb.scm'</td>
<td>442</td>
</tr>
<tr>
<td>objfiles in guile</td>
<td>420</td>
</tr>
<tr>
<td>objfiles in python</td>
<td>370</td>
</tr>
<tr>
<td>observer debugging info</td>
<td>311</td>
</tr>
<tr>
<td>octal escapes in strings</td>
<td>131</td>
</tr>
<tr>
<td>online documentation</td>
<td>22</td>
</tr>
<tr>
<td>opaque data types</td>
<td>222</td>
</tr>
<tr>
<td>open flags, in file-i/o protocol</td>
<td>667</td>
</tr>
<tr>
<td>open, file-i/o system call</td>
<td>660</td>
</tr>
</tbody>
</table>
python directory .................................. 321
python exceptions ................................ 326
python finish breakpoints ......................... 385
python functions .................................. 323
python module ...................................... 323
python modules .................................... 388
python pagination .................................. 323
python parameters .................................. 366
python pretty printing api .......................... 336
python scripting ................................... 321
python stdout ...................................... 323
Python, working with types ....................... 332
python, working with values from inferior ...... 327

Q
‘q’ packet ........................................... 613
‘Q’ packet .......................................... 613
‘QAllow’ packet .................................... 622
‘qAttached’ packet ................................ 642
‘qC’ packet .......................................... 622
‘qCRC’ packet ....................................... 622
‘QDisableRandomization’ packet .................. 623
‘qfThreadInfo’ packet .............................. 623
‘qGetTIBAddr’ packet .............................. 624
‘qGetTLSAddr’ packet .............................. 624
‘QNonStop’ packet .................................. 625
‘qOffsets’ packet ................................... 625
‘qP’ packet ......................................... 625
‘QPassSignals’ packet .............................. 626
‘QProgramSignals’ packet ......................... 626
‘qRcmd’ packet ..................................... 627
‘qSearch memory’ packet ......................... 627
‘QSearch:memory’ packet ........................... 627
‘QStartNoAckMode’ packet ....................... 627
‘qsThreadInfo’ packet ............................. 623
‘qSupported’ packet ............................... 628
‘qSymbol’ packet ................................. 636
‘qBuffer’ packet ................................. 650
‘QTBuffer size’ packet ............................ 650
‘QDisable’ packet .................................. 647
‘QDisconnected’ packet ............................ 647
‘QDP’ packet ........................................ 644
‘QDPsrc’ packet .................................... 645
‘QDV’ packet ........................................ 646
‘QEnable’ packet .................................... 647
‘qfp’ packet ........................................ 649
‘QFrame’ packet ..................................... 646
‘qfSTM’ packet ...................................... 649
‘qfV’ packet ......................................... 649
‘qThreadExtraInfo’ packet ....................... 636
‘QInit’ packet ....................................... 647
‘qMinMaxFTPFLen’ packet ......................... 646
‘QNotes’ packet .................................... 650
‘qTP’ packet ........................................ 649
‘Qtro’ packet ....................................... 647
‘QSave’ packet ...................................... 650
‘qSave’ packet ...................................... 649

R
‘r’ packet ........................................... 613
‘R’ packet .......................................... 613
range checking ...................................... 190
range stepping ...................................... 71
ranged breakpoint ................................... 290
ranges of breakpoints ................................ 45
Ravenscar Profile .................................. 213
raw printing ........................................ 121
read special object, remote request ............. 637
read, file-i/o system call .......................... 661
read-only sections .................................. 241
reading symbols from relocatable object files ... 239
reading symbols immediately ...................... 238
readline ............................................. 297
receive rights, GNU Hurd ......................... 283
recent tracepoint number ......................... 166
record aggregates (Ada) ......................... 207
record mode ........................................ 85
record serial communications on file .......... 265
recording a session script ....................... 558
recording inferior’s execution and replaying it 85
redirection ......................................... 32
reference card ...................................... 589
reference declarations .............................. 194
register packet format, MIPS ..................... 643
registers .......................................... 141
regular expression ................................ 47
reloading the overlay table ....................... 183
relocatable object files, reading symbols from . 239
remote async notification debugging info ...... 311
remote connection without stubs ................. 259
remote debugging .................................. 257
remote memory comparison ....................... 123
remote monitor prompt ............................ 289
remote packets, enabling and disabling .......... 267
remote programs, interrupting ................... 258
remote protocol debugging ....................... 311
remote protocol, binary data ..................... 607
remote protocol, field separator ................. 607
remote query requests ............................ 621
remote serial debugging summary ............... 273
remote serial debugging, overview .............. 270
remote serial protocol ........................... 607
symbol names ........................................ 217
symbol table ........................................ 237
symbol table creation ................................ 312
symbol tables in guile ................................ 429
symbol tables in python ............................. 380
symbol tables, listing GDB’s internal ............. 223
symbol, source file and line ......................... 126
symbols in guile ..................................... 425
symbols in python .................................. 377
symbols, reading from relocatable object files ... 239
symbols, reading immediately ...................... 238
synchronize with remote MIPS target .............. 289
syscall DSO ......................................... 239
system calls and thread breakpoints ............... 80
system root, alternate ................................ 243
system, file-i/o system call ......................... 665
system-wide configuration scripts .................. 596
system-wide init file .............................. 596

\textbf{T}

\begin{itemize}
\item \texttt{t} packet ........................................ 613
\item \texttt{T} packet ....................................... 613
\item \texttt{T} packet reply .............................. 619
tail call frames, debugging ......................... 156
target architecture ................................. 253
target byte order .................................. 255
target character set ................................ 149
target debugging info .............................. 312
target descriptions ................................. 687
target descriptions, AArch64 features .......... 692
target descriptions, ARM features ............... 692
target descriptions, i386 features ............... 693
target descriptions, inclusion ..................... 688
target descriptions, M68K features .............. 694
target descriptions, MicroBlaze features ....... 694
target descriptions, MIPS features .............. 694
target descriptions, Nios II features .......... 694
target descriptions, PowerPC features .......... 694
target descriptions, predefined types .......... 691
target descriptions, S/390 features ............. 695
target descriptions, standard features .......... 692
target descriptions, System z features .......... 695
target descriptions, TIC6x features ............. 695
target descriptions, TMS320C6x features ....... 695
target descriptions, XML format ................. 687
target memory comparison ......................... 123
target output in GDB/MI ............................ 463
target remote ......................................... 257
target stack description ........................... 602
target-assisted range stepping .................... 71
task attributes (GNU Hurd) ......................... 283
task breakpoints, in Ada ........................... 212
task exception port, GNU Hurd .................... 283
task suspend count .................................. 283
task switching with program using Ravenscar
Profile ............................................... 213
TCP port, target remote ........................................... 257
terminal .......................................................... 32
Text User Interface ............................................. 449
thread attributes info, remote request .................. 636
thread breakpoints ............................................... 79
thread breakpoints and system calls .................... 80
thread default settings, GNU Hurd ....................... 284
thread identifier (GDB) ......................................... 37
thread identifier (system) .................................... 37
thread info (Solaris) ........................................... 37
thread information, remote request .................... 625
thread list format ............................................... 671
thread number ................................................... 37
thread properties, GNU Hurd ................................. 284
thread suspend count, GNU Hurd ......................... 284
thread-id, in remote protocol ............................... 608
threads and watchpoints ...................................... 54
threads in python ............................................... 361
threads of execution ......................................... 36
threads, automatic switching ............................... 76
threads, continuing ......................................... 75
threads, stopped .............................................. 75
time of command execution ................................ 604
timeout for commands ........................................ 605
timeout for serial communications ...................... 265
timeout, for remote target connection .................. 267
timeout, MIPS protocol ....................................... 289
timestamping debugging info ............................... 312
trace experiment, status of ............................... 172
trace file format ............................................... 699
trace files ....................................................... 179
trace state variable value, remote request ........... 649
trace state variables ......................................... 167
traceback ....................................................... 94
traceframe info format ...................................... 672
tracepoint actions ............................................ 168
tracepoint conditions ........................................ 167
tracepoint data, display .................................... 177
tracepoint deletion ........................................... 166
tracepoint number ............................................ 166
tracepoint packets ........................................... 644
tracepoint pass count ......................................... 166
tracepoint restrictions ..................................... 174
tracepoint status, remote request ..................... 649
tracepoint variables ......................................... 178
tracepoints ..................................................... 163
tracepoints support in gdbserver ....................... 263
trailing underscore, in Fortran symbols ................ 199
translating between character sets ..................... 149
TUI ............................................................... 187
TUI commands .................................................. 449
TUI configuration variables ............................... 451
TUI key bindings ............................................. 450
TUI single key mode ......................................... 451
type casting memory ......................................... 115
type chain of a data type ................................... 602
type checking ................................................... 189
type conversions in C++ ................................... 194
type printer ..................................................... 340
type printing API for Python ............................. 340
types in guile ................................................... 404
types in Python ............................................... 332

U

UDP port, target remote ...................................... 258
union field name completion ................................ 21
unions in structures, printing ............................. 131
unknown address, locating ................................ 121
unlink, file-i/o system call ................................ 663
unlinked object files .......................................... 237
unload symbols from shared libraries .................. 242
unmap an overlay ............................................. 183
unmapped overlays ........................................... 181
unset tdesc filename ........................................ 687
unsupported languages ...................................... 215
unwind stack in called functions ....................... 229
unwind stack in called functions with unhandled
  exceptions .................................................. 229
unwinding frames in Python ................................ 350
use only software watchpoints ............................ 53
user registers ............................................... 601
user-defined command ...................................... 315
user-defined macros ......................................... 159
user-defined variables ...................................... 137

V

value history .................................................... 136
values from inferior, in guile ............................ 397
values from inferior, with Python ....................... 327
variable name conflict ..................................... 117
variable object debugging info ......................... 312
variable objects in GDB/MI ............................... 502
variable values, wrong ..................................... 118
variables, readline .......................................... 564
variables, setting .......................................... 225
\`Attach\' packet .............................................. 613
\`Cont\' packet ................................................. 614
\`Cont?\' packet .............................................. 615
vector unit .................................................... 143
vector, auxiliary ............................................ 143
verbose operation .......................................... 307
verify remote memory image .............................. 123
verify target memory image ............................... 123
\`File\' packet ................................................ 615
\`FlashDone\' packet .......................................... 615
\`FlashErase\' packet ......................................... 615
\`FlashWrite\' packet ......................................... 615
vfork events, remote reply ................................ 620
vforkdone events, remote reply ......................... 620
virtual functions (C++) display ......................... 133
\`Kill\' packet ............................................... 616
volatile registers .......................................... 143
\`Run\' packet ................................................ 616
\`Stopped\' packet ........................................... 616
VTBL display ........................................... 133

W
watchdog timer ..................................... 605
watchpoints .......................................... 45
watchpoints and threads ............................. 54
weak alias functions ................................. 230
where to look for shared libraries .............. 243
wild pointer, interpreting ......................... 127
Wind River Linux system-wide configuration script
 .................................................. 596
word completion ...................................... 19
working directory .................................... 107
working directory (of your program) ............ 31
working language ..................................... 187
write data into object, remote request .......... 641
write, file-i/o system call ........................ 662
writing a frame filter ............................... 346
writing a Guile pretty-printer .................... 411
writing a pretty-printer ............................ 338
writing convenience functions ................... 368
writing into corefiles ................................ 230
writing into executables ............................ 230
writing JIT debug info readers ................... 551
writing xmethods in Python ....................... 354
wrong values ......................................... 118

X
x command, default address ....................... 108
'X' packet ........................................... 616
Xilinx MicroBlaze ................................... 287
XInclude ............................................... 688
XMD, Xilinx Microprocessor Debugger ............ 287
xmethod API ........................................... 353
xmethods in Python ................................... 352
XML parser debugging ............................... 312

Y
yanking text ........................................... 562

Z
'z' packet ............................................. 616
'Z' packets ........................................... 616
'z0' packet ........................................... 617
'z1' packet ........................................... 617
'z2' packet ........................................... 617
'z3' packet ........................................... 617
'z4' packet ........................................... 617
Command, Variable, and Function Index

! ............................................................. 17

#  
# (a comment) ............................................... 19

$  
$., convenience variable .................................. 137
$._., convenience variable ................................. 137
$_any_caller_is, convenience function ................. 141
$_any_caller_matches, convenience function .......... 141
$_caller_is, convenience function ...................... 140
$_caller_matches, convenience function ............... 141
$_exception, convenience variable ..................... 55
$_exitcode, convenience variable ....................... 138
$_exit_signal, convenience variable .................... 138
$_is_void, convenience function ........................ 139
$_mem_eq, convenience function ......................... 140
$_probe_arg, convenience function ...................... 66
$_regex, convenience function ........................... 140
$_sdata, collect ........................................... 169
$_sdata, inspect, convenience variable ............... 139
$_sig_info, convenience variable ....................... 139
$_streq, convenience function ......................... 140
$_strlen, convenience function ........................ 140
$_thread, convenience variable ......................... 38
$_tlb ......................................................... 139
$_tpnum, convenience variable ......................... 46
$_dir, convenience variable ................................ 107
$_cwd, convenience variable ............................. 107
$_tpnum ...................................................... 166
$_trace_file ............................................... 178
$_trace_frame ............................................. 178
$_trace_func ................................................ 178
$_trace_line .............................................. 178
$_tracepoint ............................................... 178

(make-command ............................................. 413
(make-parameter .......................................... 417

-break-disable ............................................ 475
-break-enable ............................................. 475
-break-info ................................................ 476
-break-insert ............................................. 476
-break-list ................................................ 479
-break-passcount ......................................... 480
-break-watch .............................................. 480
-catch-assert .............................................. 483
-catch-exception .......................................... 484
-catch-load ................................................. 482
-catch-unload .............................................. 483
-data-disassemble ......................................... 513
-data-evaluate-expression ............................... 516
-data-list-changed-registers ............................ 516
-data-list-register-values ............................... 517
-data-read-memory ........................................ 519
-data-read-memory-bytes ................................ 520
-data-write-memory-bytes ................................ 521
-dprintf-insert ........................................... 478
-enable-frame-filters .................................... 497
-enable-pretty-printing .................................. 504
-enable-timings ........................................... 542
-environment-cd ........................................... 485
-environment-directory ................................... 485
-environment-path ......................................... 486
-environment-pwd .......................................... 486
-exec-arguments .......................................... 485
-exec-continue ............................................ 490
-exec-finish ............................................... 491
-exec-interrupt .......................................... 491
-exec-jump .................................................. 492
-exec-next .................................................. 492
-exec-next-instruction ................................... 493
-exec-return ............................................... 493
-exec-run ................................................... 494
-exec-stop .................................................. 495
-exec-step .................................................. 496
-exec-step-instruction ................................... 496
-exec-untill ............................................... 496
-file-exec-and-symbols ................................... 528
-file-exec-file ............................................ 528
-file-list-exec-source-file ............................... 528
-file-list-exec-source-files ............................. 529
-file-symbol-file .......................................... 529
-gdb-exit .................................................... 536
-gdb-set ..................................................... 537
-gdb-show .................................................... 537
-gdb-version ............................................... 537
-inferior-tty-set ......................................... 541
-inferior-tty-show ........................................ 542
-info-ada-exceptions ..................................... 534
-info-gdb-mi-command .................................... 534
-info-os ..................................................... 540
-interpreter-exec .......................................... 541
Debugging with GDB

- list-features .................................. 535
- list-target-features .............................. 536
- list-thread-groups .................................. 538
- stack-info-depth .................................. 497
- stack-info-frame .................................. 497
- stack-list-arguments .................................. 498
- stack-list-frames .................................. 499
- stack-list-locals .................................. 501
- stack-list-variables .................................. 501
- stack-select-frame .................................. 502
- symbol-list-lines .................................. 527
- target-attach ...................................... 529
- target-detach ...................................... 530
- target-disconnect .................................. 530
- target-download .................................... 530
- target-file-delete .................................. 533
- target-file-get ..................................... 533
- target-file-put ..................................... 533
- target-select ....................................... 532
- thread-info ......................................... 487
- thread-list-ids ..................................... 488
- thread-select ....................................... 488
- trace-define-variable .................................. 523
- trace-find .......................................... 522
- trace-frame-collected .................................. 523
- trace-list-variables .................................. 525
- trace-save .......................................... 525
- trace-start ......................................... 526
- trace-status ........................................ 526
- trace-stop .......................................... 527
- var-assign ......................................... 509
- var-create .......................................... 504
- var-delete .......................................... 506
- var-evaluate-expression .............................. 509
- var-info-expression .................................. 508
- var-info-num-children .................................. 506
- var-info-path-expression ............................ 508
- var-info-type ....................................... 508
- var-list-children .................................... 506
- var-set-format ....................................... 506
- var-set-frozen ....................................... 511
- var-set-update-range .................................. 512
- var-set-visualizer .................................... 512
- var-show-attributes .................................. 509
- var-show-format ...................................... 506
- var-update .......................................... 510

: in Modula-2 ....................................... 205

<
  <gdb:arch> ......................................... 434
  <gdb:block> ......................................... 424
  <gdb:breakpoint> .................................... 430
  <gdb:iterator> ...................................... 438
  <gdb:lazy-string> .................................... 433

Q
  $, referencing memory as an array .................. 119

^-connected .......................................... 464
^done .................................................. 464
^error ............................................... 464
^exit ............................................... 464
^running ............................................ 464

A
  abort (C-g) ......................................... 579
  accept-line (newline or Return) ................. 574
  actions ............................................. 168
  ada-task-info ....................................... 536
  add-auto-load-safe-path ............................ 305
  add-auto-load-scripts-directory .................. 443
  add-inferior ....................................... 34
  add-symbol-file ...................................... 238
  add-symbol-file-from-memory ....................... 239
  advance-location .................................... 70
  alias ............................................... 446
  append ............................................. 148
  append-pretty-printer! ................................ 441
  apropos .............................................. 22
  arch-char-type ....................................... 435
  arch-charset ........................................ 434
  arch-document ....................................... 436
  arch-double ......................................... 435
  arch-foo ............................................ 435
  arch-foo-bar ........................................ 435
  arch-foo-baz ........................................ 435
  arch-long ............................................ 435
  arch-longdouble ...................................... 435
  arch-look ............................................ 435
  arch-name ............................................ 434
  arch-screen .......................................... 435
  arch-sharp ........................................... 435
  arch-short .......................................... 435
  arch-uchar .......................................... 435
arch-uint-type................................. 435
arch-uint16-type.............................. 436
arch-uint32-type.............................. 436
arch-uint64-type.............................. 436
arch-uint8-type.............................. 436
arch-ulong-type............................... 435
arch-ulonglong-type.......................... 435
arch-ushort-type.............................. 435
arch-void-type............................... 435
arch-wide.charset........................... 434
arch?........................................ 434
Architecture.disassemble..................... 387
Architecture.name............................ 387
attach........................................ 32
attachk...................................... 78
awatch........................................ 53

B
b (break)....................................... 46
backward-char (C-b)........................... 574
backward-delete-char (Rubout)................ 576
backward-kill-line (C-x Rubout).............. 577
backward-kill-word (M-DEL).................... 577
backward-word (M-b)......................... 574
beginning-of-history (M-c)................... 575
beginning-of-line (C-a)....................... 574
bell-style..................................... 564
bfd caching.................................... 245, 246
bind-tty-special-chars........................ 565
block-end...................................... 425
block-function................................ 425
block-global-block........................... 425
block-global?................................ 425
block-start.................................... 424
block-static-block........................... 425
block-static?................................ 425
block-superblock.............................. 425
block-symbols................................ 425
block-symbols-progress?....................... 425
block-valid?.................................. 424
Block.end..................................... 376
Block.function............................... 376
Block.global_block........................... 376
Block.is_global.............................. 377
Block.is_static.............................. 377
Block.is_valid............................... 376
Block.start.................................. 376
Block.static_block........................... 376
Block.superblock............................. 376
block?........................................ 424
BP_ACCESS_WATCHPOINT......................... 385, 381
BP_BREAKPOINT................................ 384, 430
BP_HARDWARE_WATCHPOINT....................... 385, 381
BP_READ_WATCHPOINT........................... 385, 381
BP_WATCHPOINT................................. 384, 430
break ........................................ 46
break ... task taskno (Ada) ................... 212
break ... thread threadno .................... 79
break, and Objective-C ....................... 198
break-range.................................... 290
breakpoint annotation ....................... 548
breakpoint-commands ......................... 433
breakpoint-condition ......................... 433
breakpoint-enabled?........................... 432
breakpoint-expression ....................... 432
breakpoint-hit-count ......................... 432
breakpoint-ignore-count ..................... 432
breakpoint-location ......................... 432
breakpoint-notifications ..................... 536
breakpoint-number............................ 431
breakpoint-silent?............................ 432
breakpoint-stop.............................. 433
breakpoint-task.............................. 433
breakpoint-thread............................ 432
breakpoint-type.............................. 432
breakpoint-valid?............................. 431
breakpoint-visible?........................... 432
Breakpoint._-init_-............................ 382
Breakpoint.commands ......................... 385
Breakpoint.condition ......................... 385
Breakpoint.delete............................. 384
Breakpoint.enabled........................... 384
Breakpoint.expression ....................... 385
Breakpoint.hit_count ......................... 385
Breakpoint.ignore_count...................... 384
Breakpoint.is_valid........................... 383
Breakpoint.location......................... 385
Breakpoint.number............................ 384
Breakpoint.silent............................ 384
Breakpoint.stop.............................. 383
Breakpoint.task.............................. 384
Breakpoint.temperature....................... 384
Breakpoint.thread............................ 384
Breakpoint.type.............................. 384
Breakpoint.visible........................... 384
breakpoint?.................................. 431
BreakpointEvent.breakpoint .................. 360
BreakpointEvent.breakpoints .................. 360
breakpoints................................. 431
breakpoints-invalid annotation ............. 547
bt (backtrace)............................... 94

C
c (continue).................................... 68
c (SingleKey TUI key)........................ 451
C-L............................................ 451
C-x 1.......................................... 450
C-x 2.......................................... 450
C-x a.......................................... 450
C-x A.......................................... 450
C-x C-a........................................ 450
C-x o.......................................... 450
C-x s.......................................... 450
<table>
<thead>
<tr>
<th>Command</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>call</td>
<td>229</td>
</tr>
<tr>
<td>call-last-kbd-macro (C-x e)</td>
<td>579</td>
</tr>
<tr>
<td>capitalize-word (M-c)</td>
<td>576</td>
</tr>
<tr>
<td>catch</td>
<td>55</td>
</tr>
<tr>
<td>catch assert</td>
<td>56</td>
</tr>
<tr>
<td>catch catch</td>
<td>55</td>
</tr>
<tr>
<td>catch exception</td>
<td>56</td>
</tr>
<tr>
<td>catch exception unhandled</td>
<td>56</td>
</tr>
<tr>
<td>catch exec</td>
<td>56</td>
</tr>
<tr>
<td>catch fork</td>
<td>58</td>
</tr>
<tr>
<td>catch load</td>
<td>58</td>
</tr>
<tr>
<td>catch rethrow</td>
<td>55</td>
</tr>
<tr>
<td>catch signal</td>
<td>58</td>
</tr>
<tr>
<td>catch syscall</td>
<td>56</td>
</tr>
<tr>
<td>catch throw</td>
<td>55</td>
</tr>
<tr>
<td>catch unload</td>
<td>58</td>
</tr>
<tr>
<td>catch vfork</td>
<td>58</td>
</tr>
<tr>
<td>cd</td>
<td>31</td>
</tr>
<tr>
<td>cd</td>
<td>107</td>
</tr>
<tr>
<td>character-search (C-J)</td>
<td>580</td>
</tr>
<tr>
<td>character-search-backward (M-C-J)</td>
<td>580</td>
</tr>
<tr>
<td>checkpoint</td>
<td>42</td>
</tr>
<tr>
<td>clear</td>
<td>59</td>
</tr>
<tr>
<td>clear, and Objective-C</td>
<td>198</td>
</tr>
<tr>
<td>clear-screen (C-l)</td>
<td>574</td>
</tr>
<tr>
<td>ClearObjFilesEvent.progspace</td>
<td>360</td>
</tr>
<tr>
<td>clone-inferior</td>
<td>34</td>
</tr>
<tr>
<td>collect (tracepoints)</td>
<td>169</td>
</tr>
<tr>
<td>Command__init__</td>
<td>362</td>
</tr>
<tr>
<td>Command.complete</td>
<td>363</td>
</tr>
<tr>
<td>Command.dont_repeat</td>
<td>363</td>
</tr>
<tr>
<td>Command.invoke</td>
<td>363</td>
</tr>
<tr>
<td>command?</td>
<td>414</td>
</tr>
<tr>
<td>COMMAND_BREAKPOINTS</td>
<td>364, 415</td>
</tr>
<tr>
<td>COMMAND_DATA</td>
<td>364, 415</td>
</tr>
<tr>
<td>COMMAND_FILES</td>
<td>364, 415</td>
</tr>
<tr>
<td>COMMAND_MAINTENANCE</td>
<td>365, 416</td>
</tr>
<tr>
<td>COMMAND_NONE</td>
<td>364, 415</td>
</tr>
<tr>
<td>COMMAND_OBSCURE</td>
<td>365, 416</td>
</tr>
<tr>
<td>COMMAND_RUNNING</td>
<td>364, 415</td>
</tr>
<tr>
<td>COMMAND_STACK</td>
<td>364, 415</td>
</tr>
<tr>
<td>COMMAND_STATUS</td>
<td>364, 415</td>
</tr>
<tr>
<td>COMMAND_SUPPORT</td>
<td>364, 415</td>
</tr>
<tr>
<td>COMMAND_TRACEPOINTS</td>
<td>364, 416</td>
</tr>
<tr>
<td>COMMAND_USER</td>
<td>364, 416</td>
</tr>
<tr>
<td>commands</td>
<td>62</td>
</tr>
<tr>
<td>commands annotation</td>
<td>546</td>
</tr>
<tr>
<td>comment-begin</td>
<td>565</td>
</tr>
<tr>
<td>compare-sections</td>
<td>124</td>
</tr>
<tr>
<td>compile code</td>
<td>230</td>
</tr>
<tr>
<td>compile file</td>
<td>231</td>
</tr>
<tr>
<td>compile</td>
<td>23</td>
</tr>
<tr>
<td>complete (TAB)</td>
<td>578</td>
</tr>
<tr>
<td>COMPLETE_COMMAND</td>
<td>365, 416</td>
</tr>
<tr>
<td>COMPLETE_EXPRESSION</td>
<td>365, 416</td>
</tr>
<tr>
<td>COMPLETE_FILENAME</td>
<td>365, 416</td>
</tr>
<tr>
<td>COMPLETE_LOCATION</td>
<td>365, 416</td>
</tr>
<tr>
<td>COMPLETE_NONE</td>
<td>365, 416</td>
</tr>
</tbody>
</table>

**COMPLETE_SYMBOL** | 365, 416

**completion-display-width** | 565
**completion-ignore-case** | 565
**completion-map-case** | 565
**completion-prefix-display-length** | 565
**completion-query-items** | 565
**condition** | 61
**continue** | 68
**continue&** | 78
**convert-meta** | 565
**copy-backward-word ()** | 577
**copy-forward-word ()** | 578
**copy-region-as-kill ()** | 577
**core-file** | 238
**ctf** | 179
**Ctrl-o (operate-and-get-next)** | 19
**current-arch** | 434
**current-objfile** | 421
**current-progspace** | 419
**cwd** | 107

**D**

<table>
<thead>
<tr>
<th>Command</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>d (delete)</td>
<td>59</td>
</tr>
<tr>
<td>d (SingleKey TUI key)</td>
<td>451</td>
</tr>
<tr>
<td>data-directory</td>
<td>394</td>
</tr>
<tr>
<td>data-read-memory-bytes</td>
<td>536</td>
</tr>
<tr>
<td>debug_chaos</td>
<td>287</td>
</tr>
<tr>
<td>default-visualizer</td>
<td>410</td>
</tr>
<tr>
<td>define</td>
<td>316</td>
</tr>
<tr>
<td>delete</td>
<td>59</td>
</tr>
<tr>
<td>delete checkpoint checkpoint-id</td>
<td>42</td>
</tr>
<tr>
<td>delete display</td>
<td>124</td>
</tr>
<tr>
<td>delete mem</td>
<td>146</td>
</tr>
<tr>
<td>delete tracepoint</td>
<td>166</td>
</tr>
<tr>
<td>delete tvariable</td>
<td>168</td>
</tr>
<tr>
<td>delete-breakpoint!</td>
<td>431</td>
</tr>
<tr>
<td>delete-char (C-d)</td>
<td>576</td>
</tr>
<tr>
<td>delete-char-or-list ()</td>
<td>579</td>
</tr>
<tr>
<td>delete-horizontal-space ()</td>
<td>577</td>
</tr>
<tr>
<td>demangle</td>
<td>218</td>
</tr>
<tr>
<td>detach</td>
<td>33</td>
</tr>
<tr>
<td>detach (remote)</td>
<td>258</td>
</tr>
<tr>
<td>detach-inferiors info</td>
<td>35</td>
</tr>
<tr>
<td>digit-argument (M-O, M-I, , M---)</td>
<td>578</td>
</tr>
<tr>
<td>dir</td>
<td>106</td>
</tr>
<tr>
<td>directory</td>
<td>106</td>
</tr>
<tr>
<td>dis (disable)</td>
<td>60</td>
</tr>
<tr>
<td>disable</td>
<td>60</td>
</tr>
<tr>
<td>disable display</td>
<td>125</td>
</tr>
<tr>
<td>disable frame-filter</td>
<td>97</td>
</tr>
<tr>
<td>disable mem</td>
<td>146</td>
</tr>
<tr>
<td>disable pretty-printer</td>
<td>135</td>
</tr>
<tr>
<td>disable probes</td>
<td>66</td>
</tr>
<tr>
<td>disable tracepoint</td>
<td>166</td>
</tr>
<tr>
<td>disable type-printer</td>
<td>221</td>
</tr>
<tr>
<td>disable-completion</td>
<td>565</td>
</tr>
<tr>
<td>disassemble</td>
<td>109</td>
</tr>
<tr>
<td>Command</td>
<td>Page</td>
</tr>
<tr>
<td>----------------------------------------------</td>
<td>------</td>
</tr>
<tr>
<td>disconnect</td>
<td>258</td>
</tr>
<tr>
<td>display</td>
<td>124</td>
</tr>
<tr>
<td>do (down)</td>
<td>99</td>
</tr>
<tr>
<td>do-upper-case-version (M-a, M-b, M-x,...)</td>
<td>579</td>
</tr>
<tr>
<td>document</td>
<td>316</td>
</tr>
<tr>
<td>dont-repeat</td>
<td>316, 414</td>
</tr>
<tr>
<td>down</td>
<td>99</td>
</tr>
<tr>
<td>Down</td>
<td>451</td>
</tr>
<tr>
<td>down-silently</td>
<td>99</td>
</tr>
<tr>
<td>downcase-word (M-1)</td>
<td>576</td>
</tr>
<tr>
<td>dprintf</td>
<td>64</td>
</tr>
<tr>
<td>dprintf-style agent</td>
<td>64</td>
</tr>
<tr>
<td>dprintf-style call</td>
<td>64</td>
</tr>
<tr>
<td>dprintf-style gdb</td>
<td>64</td>
</tr>
<tr>
<td>dump</td>
<td>148</td>
</tr>
<tr>
<td>dump-functions ()</td>
<td>580</td>
</tr>
<tr>
<td>dump-macros ()</td>
<td>580</td>
</tr>
<tr>
<td>dump-variables ()</td>
<td>580</td>
</tr>
<tr>
<td>exec-file</td>
<td>237</td>
</tr>
<tr>
<td>exec-run-start-option</td>
<td>536</td>
</tr>
<tr>
<td>execute</td>
<td>393</td>
</tr>
<tr>
<td>exited annotation</td>
<td>547</td>
</tr>
<tr>
<td>ExitEvent</td>
<td>359</td>
</tr>
<tr>
<td>ExitEvent.exit_code</td>
<td>359</td>
</tr>
<tr>
<td>expand-tilde</td>
<td>566</td>
</tr>
<tr>
<td>explore</td>
<td>113</td>
</tr>
<tr>
<td>F</td>
<td></td>
</tr>
<tr>
<td>f (frame)</td>
<td>99</td>
</tr>
<tr>
<td>f (SingleKey TUI key)</td>
<td>451</td>
</tr>
<tr>
<td>fg (resume foreground execution)</td>
<td>68</td>
</tr>
<tr>
<td>field-artificial?</td>
<td>408</td>
</tr>
<tr>
<td>field-base-class?</td>
<td>408</td>
</tr>
<tr>
<td>field-hitspos</td>
<td>408</td>
</tr>
<tr>
<td>field-hitsize</td>
<td>408</td>
</tr>
<tr>
<td>field-enumval</td>
<td>408</td>
</tr>
<tr>
<td>field-name</td>
<td>408</td>
</tr>
<tr>
<td>field-type</td>
<td>408</td>
</tr>
<tr>
<td>field?</td>
<td>408</td>
</tr>
<tr>
<td>file</td>
<td>237</td>
</tr>
<tr>
<td>fin (finish)</td>
<td>69</td>
</tr>
<tr>
<td>find</td>
<td>153</td>
</tr>
<tr>
<td>find-rich-line</td>
<td>430</td>
</tr>
<tr>
<td>finish</td>
<td>69</td>
</tr>
<tr>
<td>finish%</td>
<td>78</td>
</tr>
<tr>
<td>FinishBreakpoint.<strong>init</strong></td>
<td>385</td>
</tr>
<tr>
<td>FinishBreakpoint.out_of_scope</td>
<td>386</td>
</tr>
<tr>
<td>FinishBreakpoint.return_value</td>
<td>386</td>
</tr>
<tr>
<td>flush_i_cache</td>
<td>273</td>
</tr>
<tr>
<td>flushregs</td>
<td>601</td>
</tr>
<tr>
<td>fo (forward-search)</td>
<td>105</td>
</tr>
<tr>
<td>focus</td>
<td>452</td>
</tr>
<tr>
<td>forward-backward-delete-char ()</td>
<td>576</td>
</tr>
<tr>
<td>forward-char (C-f)</td>
<td>574</td>
</tr>
<tr>
<td>forward-search</td>
<td>105</td>
</tr>
<tr>
<td>forward-search-history (C-a)</td>
<td>575</td>
</tr>
<tr>
<td>forward-word (M-f)</td>
<td>574</td>
</tr>
<tr>
<td>frame, command</td>
<td>94</td>
</tr>
<tr>
<td>frame, selecting</td>
<td>99</td>
</tr>
<tr>
<td>frame-arch</td>
<td>421</td>
</tr>
<tr>
<td>frame-block</td>
<td>423</td>
</tr>
<tr>
<td>frame-function</td>
<td>423</td>
</tr>
<tr>
<td>frame-name</td>
<td>421</td>
</tr>
<tr>
<td>frame-newer</td>
<td>423</td>
</tr>
<tr>
<td>frame-older</td>
<td>423</td>
</tr>
<tr>
<td>frame-pc</td>
<td>423</td>
</tr>
<tr>
<td>frame-read-register</td>
<td>423</td>
</tr>
<tr>
<td>frame-read-var</td>
<td>423</td>
</tr>
<tr>
<td>frame-sal</td>
<td>423</td>
</tr>
<tr>
<td>frame-select</td>
<td>423</td>
</tr>
<tr>
<td>frame-type</td>
<td>421</td>
</tr>
<tr>
<td>frame-unwind-stop-reason</td>
<td>422</td>
</tr>
<tr>
<td>frame-valid?</td>
<td>421</td>
</tr>
<tr>
<td>Frame.architecture</td>
<td>373</td>
</tr>
<tr>
<td>Frame.block</td>
<td>374</td>
</tr>
</tbody>
</table>
Debugging with GDB
<table>
<thead>
<tr>
<th>Command, Variable, and Function Index</th>
<th>751</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Type Code</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>VT_VOID</td>
<td>Type code for void (null) value.</td>
</tr>
<tr>
<td>VT_STRING</td>
<td>Type code for string.</td>
</tr>
<tr>
<td>VT_REF</td>
<td>Type code for reference.</td>
</tr>
<tr>
<td>VT_RANGE</td>
<td>Type code for range.</td>
</tr>
<tr>
<td>VT_PTR</td>
<td>Type code for pointer.</td>
</tr>
<tr>
<td>VT_METHODPTR</td>
<td>Type code for method pointer.</td>
</tr>
<tr>
<td>VT_METHOD</td>
<td>Type code for method.</td>
</tr>
<tr>
<td>VT_MEMBERPTR</td>
<td>Type code for member pointer.</td>
</tr>
<tr>
<td>VT_INTERNAL_FUNCTION</td>
<td>Type code for internal function.</td>
</tr>
<tr>
<td>VT_INT</td>
<td>Type code for int.</td>
</tr>
<tr>
<td>VT_FUNC</td>
<td>Type code for function.</td>
</tr>
<tr>
<td>VT_FLT</td>
<td>Type code for float.</td>
</tr>
<tr>
<td>VT_ENUM</td>
<td>Type code for enum.</td>
</tr>
<tr>
<td>VT_DECFLOAT</td>
<td>Type code for decimal float.</td>
</tr>
<tr>
<td>VT_CHAR</td>
<td>Type code for char.</td>
</tr>
<tr>
<td>VT_ARRAY</td>
<td>Type code for array.</td>
</tr>
<tr>
<td>VT_TYPE</td>
<td>Type code for type.</td>
</tr>
<tr>
<td>VT_BITSTRING</td>
<td>Type code for bit string.</td>
</tr>
<tr>
<td>VT_BOOL</td>
<td>Type code for boolean.</td>
</tr>
<tr>
<td>VT_COMPLEX</td>
<td>Type code for complex.</td>
</tr>
</tbody>
</table>

**H**

<table>
<thead>
<tr>
<th>Command</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>h (help)</td>
<td>Display help information.</td>
</tr>
<tr>
<td>handle</td>
<td>Command to handle an exception.</td>
</tr>
<tr>
<td>handle_exception</td>
<td>Command to handle an exception.</td>
</tr>
<tr>
<td>hbreak</td>
<td>Command to break instruction.</td>
</tr>
<tr>
<td>help</td>
<td>Command to display help information.</td>
</tr>
<tr>
<td>help function</td>
<td>Command to display help for a function.</td>
</tr>
<tr>
<td>help target</td>
<td>Command to display help for a target.</td>
</tr>
<tr>
<td>help user-defined</td>
<td>Command to display help for a user-defined function.</td>
</tr>
<tr>
<td>history-append</td>
<td>Command to append a command.</td>
</tr>
<tr>
<td>history-preserve-point</td>
<td>Command to preserve a point.</td>
</tr>
<tr>
<td>history-ref</td>
<td>Command to reference a history.</td>
</tr>
<tr>
<td>history-search-backward</td>
<td>Command to search backward in history.</td>
</tr>
<tr>
<td>history-search-forward</td>
<td>Command to search forward in history.</td>
</tr>
<tr>
<td>history-size</td>
<td>Command to display the size of the history.</td>
</tr>
<tr>
<td>hook</td>
<td>Command to set a hook.</td>
</tr>
<tr>
<td>hookpost</td>
<td>Command to post a hook.</td>
</tr>
<tr>
<td>horizontal-scroll-mode</td>
<td>Command to set the horizontal scroll mode.</td>
</tr>
<tr>
<td>host-config</td>
<td>Command to configure host settings.</td>
</tr>
</tbody>
</table>

**I**

<table>
<thead>
<tr>
<th>Command</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>i (info)</td>
<td>Display information about a target or thread.</td>
</tr>
<tr>
<td>if</td>
<td>Command to display information about a file.</td>
</tr>
<tr>
<td>ignore</td>
<td>Command to ignore a warning.</td>
</tr>
<tr>
<td>inferior info</td>
<td>Command to display information about an inferior.</td>
</tr>
<tr>
<td>Inferior.is_valid</td>
<td>Command to check if an inferior is valid.</td>
</tr>
<tr>
<td>Inferior.num</td>
<td>Command to display the number of inferiors.</td>
</tr>
<tr>
<td>Inferior.pid</td>
<td>Command to display the process ID.</td>
</tr>
<tr>
<td>Inferior.read_memory</td>
<td>Command to read memory.</td>
</tr>
<tr>
<td>Inferior.search_memory</td>
<td>Command to search memory.</td>
</tr>
<tr>
<td>Inferior.threads</td>
<td>Command to display the threads of an inferior.</td>
</tr>
<tr>
<td>Inferior.wasAttached</td>
<td>Command to check if an inferior was attached.</td>
</tr>
<tr>
<td>Inferior.write_memory</td>
<td>Command to write memory.</td>
</tr>
<tr>
<td>InferiorCallPostEvent.address</td>
<td>Command to set a call post event.</td>
</tr>
<tr>
<td>InferiorCallPostEvent.ptid</td>
<td>Command to set a call post event.</td>
</tr>
<tr>
<td>InferiorCallPreEvent.address</td>
<td>Command to set a call pre event.</td>
</tr>
<tr>
<td>InferiorCallPreEvent.ptid</td>
<td>Command to set a call pre event.</td>
</tr>
<tr>
<td>InferiorThread.is_exited</td>
<td>Command to check if a thread is exited.</td>
</tr>
<tr>
<td>InferiorThread.is_running</td>
<td>362</td>
</tr>
<tr>
<td>--------------------------</td>
<td>-----</td>
</tr>
<tr>
<td>InferiorThread.is_stopped</td>
<td>362</td>
</tr>
<tr>
<td>InferiorThread.is_valid</td>
<td>362</td>
</tr>
<tr>
<td>InferiorThread.name</td>
<td>361</td>
</tr>
<tr>
<td>InferiorThread.num</td>
<td>362</td>
</tr>
<tr>
<td>InferiorThread.ptid</td>
<td>362</td>
</tr>
<tr>
<td>InferiorThread.switch</td>
<td>362</td>
</tr>
<tr>
<td>info</td>
<td></td>
</tr>
<tr>
<td>info address</td>
<td>218</td>
</tr>
<tr>
<td>info all-registers</td>
<td>141</td>
</tr>
<tr>
<td>info args</td>
<td>100</td>
</tr>
<tr>
<td>info auto-load</td>
<td>303</td>
</tr>
<tr>
<td>info auto-load gdb-scripts</td>
<td>321</td>
</tr>
<tr>
<td>info auto-load guile-scripts</td>
<td>440</td>
</tr>
<tr>
<td>info auto-load libthread-db</td>
<td>305</td>
</tr>
<tr>
<td>info auto-load local-gdbinit</td>
<td>304</td>
</tr>
<tr>
<td>info auto-load python-scripts</td>
<td>388</td>
</tr>
<tr>
<td>info auxv</td>
<td>144</td>
</tr>
<tr>
<td>info breakpoints</td>
<td>48</td>
</tr>
<tr>
<td>info checkpoints</td>
<td>42</td>
</tr>
<tr>
<td>info classes</td>
<td>222</td>
</tr>
<tr>
<td>info common</td>
<td>200</td>
</tr>
<tr>
<td>info copying</td>
<td>24</td>
</tr>
<tr>
<td>info dcache</td>
<td>153</td>
</tr>
<tr>
<td>info display</td>
<td>125</td>
</tr>
<tr>
<td>info dll</td>
<td>242</td>
</tr>
<tr>
<td>info dos</td>
<td>277</td>
</tr>
<tr>
<td>info exceptions</td>
<td>210</td>
</tr>
<tr>
<td>info extensions</td>
<td>189</td>
</tr>
<tr>
<td>info f (info frame)</td>
<td>100</td>
</tr>
<tr>
<td>info files</td>
<td>240</td>
</tr>
<tr>
<td>info float</td>
<td>143</td>
</tr>
<tr>
<td>info frame</td>
<td>100</td>
</tr>
<tr>
<td>info frame, show the source language</td>
<td>189</td>
</tr>
<tr>
<td>info frame-filter</td>
<td>97</td>
</tr>
<tr>
<td>info functions</td>
<td>221</td>
</tr>
<tr>
<td>info handle</td>
<td>73</td>
</tr>
<tr>
<td>info inferiors</td>
<td>34</td>
</tr>
<tr>
<td>info io_registers, AVR</td>
<td>291</td>
</tr>
<tr>
<td>info line</td>
<td>108</td>
</tr>
<tr>
<td>info line, and Objective-C</td>
<td>198</td>
</tr>
<tr>
<td>info locals</td>
<td>100</td>
</tr>
<tr>
<td>info macro</td>
<td>159</td>
</tr>
<tr>
<td>info macros</td>
<td>159</td>
</tr>
<tr>
<td>info mem</td>
<td>146</td>
</tr>
<tr>
<td>info meminfo</td>
<td>277</td>
</tr>
<tr>
<td>info os</td>
<td>144</td>
</tr>
<tr>
<td>info os cpus</td>
<td>144</td>
</tr>
<tr>
<td>info os files</td>
<td>144</td>
</tr>
<tr>
<td>info os modules</td>
<td>144</td>
</tr>
<tr>
<td>info os msg</td>
<td>144</td>
</tr>
<tr>
<td>info os processes</td>
<td>145</td>
</tr>
<tr>
<td>info os progroups</td>
<td>145</td>
</tr>
<tr>
<td>info os semaphores</td>
<td>145</td>
</tr>
<tr>
<td>info os shm</td>
<td>145</td>
</tr>
<tr>
<td>info os sockets</td>
<td>145</td>
</tr>
<tr>
<td>info os threads</td>
<td>145</td>
</tr>
<tr>
<td>info pidlist</td>
<td>277</td>
</tr>
<tr>
<td>info pretty-printer</td>
<td>134</td>
</tr>
<tr>
<td>info probes</td>
<td>66</td>
</tr>
<tr>
<td>info proc</td>
<td>276</td>
</tr>
<tr>
<td>info program</td>
<td>45</td>
</tr>
<tr>
<td>info record</td>
<td>89</td>
</tr>
<tr>
<td>info registers</td>
<td>141</td>
</tr>
<tr>
<td>info scope</td>
<td>221</td>
</tr>
<tr>
<td>info selectors</td>
<td>222</td>
</tr>
<tr>
<td>info serial</td>
<td>279</td>
</tr>
<tr>
<td>info set</td>
<td>23</td>
</tr>
<tr>
<td>info thread</td>
<td>32</td>
</tr>
<tr>
<td>info threads</td>
<td>37</td>
</tr>
<tr>
<td>info tp [n...]</td>
<td>170</td>
</tr>
<tr>
<td>info tracepoints [n...]</td>
<td>170</td>
</tr>
<tr>
<td>info variables</td>
<td>168</td>
</tr>
<tr>
<td>info type-printers</td>
<td>220</td>
</tr>
<tr>
<td>info types</td>
<td>220</td>
</tr>
<tr>
<td>info variables</td>
<td>222</td>
</tr>
<tr>
<td>info vector</td>
<td>143</td>
</tr>
<tr>
<td>info w32</td>
<td>279</td>
</tr>
<tr>
<td>info warranty</td>
<td>24</td>
</tr>
<tr>
<td>info watchpoints [n...]</td>
<td>53</td>
</tr>
<tr>
<td>info win</td>
<td>452</td>
</tr>
<tr>
<td>info-gdb-mi-command</td>
<td>536</td>
</tr>
<tr>
<td>init-if-undefined</td>
<td>137</td>
</tr>
<tr>
<td>input-meta</td>
<td>566</td>
</tr>
<tr>
<td>input-port</td>
<td>437</td>
</tr>
<tr>
<td>insert-comment (M-#)</td>
<td>580</td>
</tr>
<tr>
<td>insert-completions (M-*)</td>
<td>578</td>
</tr>
<tr>
<td>inspect</td>
<td>113</td>
</tr>
<tr>
<td>instantiate on type_printer</td>
<td>341</td>
</tr>
<tr>
<td>interpreter-exec</td>
<td>447</td>
</tr>
<tr>
<td>interrupt</td>
<td>79</td>
</tr>
<tr>
<td>isearch-terminators</td>
<td>566</td>
</tr>
<tr>
<td>iterator-list</td>
<td>440</td>
</tr>
<tr>
<td>iterator-filter</td>
<td>440</td>
</tr>
<tr>
<td>iterator-for-each</td>
<td>440</td>
</tr>
<tr>
<td>iterator-map</td>
<td>440</td>
</tr>
<tr>
<td>iterator-next!</td>
<td>439</td>
</tr>
<tr>
<td>iterator-object</td>
<td>439</td>
</tr>
<tr>
<td>iterator-progress</td>
<td>439</td>
</tr>
<tr>
<td>iterator-until</td>
<td>440</td>
</tr>
<tr>
<td>iterator?</td>
<td>439</td>
</tr>
</tbody>
</table>
**J**

<table>
<thead>
<tr>
<th>j (jump)</th>
<th>226</th>
</tr>
</thead>
<tbody>
<tr>
<td>jit-reader-load</td>
<td>551</td>
</tr>
<tr>
<td>jit-reader-unload</td>
<td>551</td>
</tr>
<tr>
<td>jump</td>
<td>226</td>
</tr>
<tr>
<td>jump, and Objective-C</td>
<td>198</td>
</tr>
</tbody>
</table>

**K**

| KeyboardInterrupt | 327 |
| keymap | 567 |
| kill | 33 |
| kill inferiors info | 35 |
| kill-line (C-k) | 577 |
| kill-region () | 577 |
| kill-whole-line () | 577 |
| kill-word (M-d) | 577 |
| kvm | 275 |

**L**

<table>
<thead>
<tr>
<th>1 (list)</th>
<th>101</th>
</tr>
</thead>
<tbody>
<tr>
<td>language-option</td>
<td>536</td>
</tr>
<tr>
<td>layout</td>
<td>452</td>
</tr>
<tr>
<td>lazy-string-&gt;value</td>
<td>434</td>
</tr>
<tr>
<td>lazy-string-address</td>
<td>434</td>
</tr>
<tr>
<td>lazy-string-encoding</td>
<td>434</td>
</tr>
<tr>
<td>lazy-string-length</td>
<td>434</td>
</tr>
<tr>
<td>lazy-string-type</td>
<td>434</td>
</tr>
<tr>
<td>lazy-string?</td>
<td>434</td>
</tr>
<tr>
<td>LazyString.address</td>
<td>386</td>
</tr>
<tr>
<td>LazyString.encoding</td>
<td>386</td>
</tr>
<tr>
<td>LazyString.length</td>
<td>386</td>
</tr>
<tr>
<td>LazyString.type</td>
<td>387</td>
</tr>
<tr>
<td>LazyString.value</td>
<td>386</td>
</tr>
<tr>
<td>left</td>
<td>451</td>
</tr>
<tr>
<td>LineTable_has_line</td>
<td>382</td>
</tr>
<tr>
<td>LineTable.line</td>
<td>382</td>
</tr>
<tr>
<td>LineTable.source_lines</td>
<td>382</td>
</tr>
<tr>
<td>LineTableEntry.line</td>
<td>381</td>
</tr>
<tr>
<td>LineTableEntry.pc</td>
<td>382</td>
</tr>
<tr>
<td>list</td>
<td>101</td>
</tr>
<tr>
<td>list, and Objective-C</td>
<td>198</td>
</tr>
<tr>
<td>load filename</td>
<td>255</td>
</tr>
<tr>
<td>lookup-block</td>
<td>425</td>
</tr>
<tr>
<td>lookup-global-symbol</td>
<td>427</td>
</tr>
<tr>
<td>lookup-symbol</td>
<td>427</td>
</tr>
<tr>
<td>lookup-type</td>
<td>404</td>
</tr>
<tr>
<td>loop_break</td>
<td>319</td>
</tr>
<tr>
<td>loop_continue</td>
<td>319</td>
</tr>
</tbody>
</table>

**M**

<table>
<thead>
<tr>
<th>macro define</th>
<th>159</th>
</tr>
</thead>
<tbody>
<tr>
<td>macro exp1</td>
<td>159</td>
</tr>
<tr>
<td>macro expand</td>
<td>159</td>
</tr>
<tr>
<td>macro list</td>
<td>160</td>
</tr>
<tr>
<td>macro undef</td>
<td>160</td>
</tr>
<tr>
<td>maint ada set ignore-descriptive-types ...</td>
<td>215</td>
</tr>
<tr>
<td>maint ada show ignore-descriptive-types ...</td>
<td>215</td>
</tr>
<tr>
<td>maint agent</td>
<td>597</td>
</tr>
<tr>
<td>maint agent-eval</td>
<td>597</td>
</tr>
<tr>
<td>maint agent-printf</td>
<td>597</td>
</tr>
<tr>
<td>maint btrace clear</td>
<td>598</td>
</tr>
<tr>
<td>maint btrace clear-packet-history</td>
<td>598</td>
</tr>
<tr>
<td>maint btrace packet-history</td>
<td>597</td>
</tr>
<tr>
<td>maint check-psymtabs</td>
<td>599</td>
</tr>
<tr>
<td>maint check-symtabs</td>
<td>599</td>
</tr>
<tr>
<td>maint cplus first_component</td>
<td>599</td>
</tr>
<tr>
<td>maint cplus namespace</td>
<td>599</td>
</tr>
<tr>
<td>maint demangler-warning</td>
<td>599</td>
</tr>
<tr>
<td>maint deprecate</td>
<td>599</td>
</tr>
<tr>
<td>maint dump-me</td>
<td>599</td>
</tr>
<tr>
<td>maint expand-symtabs</td>
<td>599</td>
</tr>
<tr>
<td>maint flush-symbol-cache</td>
<td>224</td>
</tr>
<tr>
<td>maint info bfd</td>
<td>245</td>
</tr>
<tr>
<td>maint info breakpoints</td>
<td>597</td>
</tr>
<tr>
<td>maint info btrace</td>
<td>597</td>
</tr>
<tr>
<td>maint info program-spaces</td>
<td>35</td>
</tr>
<tr>
<td>maint info psymtabs</td>
<td>223</td>
</tr>
<tr>
<td>maint info sections</td>
<td>240</td>
</tr>
<tr>
<td>maint info sol-threads</td>
<td>37</td>
</tr>
<tr>
<td>maint info symtabs</td>
<td>223</td>
</tr>
<tr>
<td>maint internal-error</td>
<td>599</td>
</tr>
<tr>
<td>maint internal-warning</td>
<td>599</td>
</tr>
<tr>
<td>maint packet</td>
<td>600</td>
</tr>
<tr>
<td>maint print architecture</td>
<td>600</td>
</tr>
<tr>
<td>maint print c-tdesc</td>
<td>600</td>
</tr>
<tr>
<td>maint print cooked-registers</td>
<td>601</td>
</tr>
<tr>
<td>maint print dummy-frames</td>
<td>600</td>
</tr>
<tr>
<td>maint print msymbs</td>
<td>222</td>
</tr>
<tr>
<td>maint print objfiles</td>
<td>601</td>
</tr>
<tr>
<td>maint print symbols</td>
<td>222</td>
</tr>
<tr>
<td>maint print raw-registers</td>
<td>601</td>
</tr>
<tr>
<td>maint print reggroups</td>
<td>601</td>
</tr>
<tr>
<td>maint print register-groups</td>
<td>601</td>
</tr>
<tr>
<td>maint print registers</td>
<td>601</td>
</tr>
<tr>
<td>maint print remote-registers</td>
<td>601</td>
</tr>
<tr>
<td>maint print section-scripts</td>
<td>601</td>
</tr>
<tr>
<td>maint print statistics</td>
<td>602</td>
</tr>
<tr>
<td>maint print symbol-cache</td>
<td>224</td>
</tr>
<tr>
<td>maint print symbol-cache-statistics</td>
<td>224</td>
</tr>
<tr>
<td>maint print symbols</td>
<td>222</td>
</tr>
<tr>
<td>maint print target-stack</td>
<td>602</td>
</tr>
<tr>
<td>maint print type</td>
<td>602</td>
</tr>
<tr>
<td>maint print unwind, HPPA</td>
<td>295</td>
</tr>
<tr>
<td>maint print user-registers</td>
<td>601</td>
</tr>
<tr>
<td>maint set bfd-sharing</td>
<td>245</td>
</tr>
<tr>
<td>maint set btrace pt skip-pad</td>
<td>598</td>
</tr>
<tr>
<td>maint set catch-demangler-crashes</td>
<td>599</td>
</tr>
<tr>
<td>maint set demangler-warning</td>
<td>600</td>
</tr>
<tr>
<td>maint set dwarf always-disassemble</td>
<td>602</td>
</tr>
<tr>
<td>maint set dwarf max-cache-age</td>
<td>602</td>
</tr>
<tr>
<td>maint set internal-error</td>
<td>600</td>
</tr>
<tr>
<td>maint set internal-warning</td>
<td>600</td>
</tr>
<tr>
<td>maint set per-command</td>
<td>604</td>
</tr>
</tbody>
</table>
PARAM_FILENAME .......................... 367, 419
PARAM_INTEGER .......................... 367
PARAM_OPTIONAL_FILENAME .......... 367, 419
PARAM_STRING .......................... 367, 419
PARAM_STRING_NOESCAPE .......... 367, 419
PARAM_UINT8 .......................... 367, 418
PARAM_UINT8_UNSIGNED .......... 368, 419
PARAM_UINT8_UNSIGNED_EXTENDED ... 419
PARAM_UINT16 .......................... 419
PARAM_UINT16_UNSIGNED .......... 368, 419
PARAM_UINT16_UNSIGNED_EXTENDED ... 419
PARAM_UINT32 .......................... 419
PARAM_UINT32_UNSIGNED .......... 368, 419
PARAM_UINT32_UNSIGNED_EXTENDED ... 419
PARAM_UINT64 .......................... 419
PARAM_UINT64_UNSIGNED .......... 368, 419
PARAM_UINT64_UNSIGNED_EXTENDED ... 419
PARAM_ZINT8 .......................... 419
PARAM_ZINT8_UNSIGNED .......... 368, 419
PARAM_ZINT8_UNSIGNED_EXTENDED ... 419
PARAM_ZINT16 .......................... 419
PARAM_ZINT16_UNSIGNED .......... 368, 419
PARAM_ZINT16_UNSIGNED_EXTENDED ... 419
PARAM_ZINT32 .......................... 419
PARAM_ZINT32_UNSIGNED .......... 368, 419
PARAM_ZINT32_UNSIGNED_EXTENDED ... 419
PARAM_ZINT64 .......................... 419
PARAM_ZINT64_UNSIGNED .......... 368, 419
PARAM_ZINT64_UNSIGNED_EXTENDED ... 419
print ................................... 418
print-object ............................ 198
progspace-objfiles .................... 420
progspace-pretty-printers ........... 420
progspace-valid? ....................... 419
Progspace_FILENAME ..................... 369
Progspace_filename .................... 369
Progspace_frame filters ............... 369
Progspace.pretty_printers .......... 369
Progspace.type_printers .............. 369
progspace? ............................ 419
progspace? ............................ 419
progspace? ............................ 419
prompt annotation ..................... 546
prompt-for-continue annotation ..... 546
ptype .................................. 219
puts ................................... 272
pwd .................................... 31
py ..................................... 322
python ................................ 322, 535
python-interactive .................... 322
Q
q (quit) ................................ 17
q (SingleKey TUI key) ................. 451
query annotation ....................... 546
queue-signal .......................... 227
quit ................................... 547
quoted-insert (C-q or C-v) .......... 576
R
r (run) ................................ 26
r (SingleKey TUI key) ................. 451
rbreak ................................ 47
rc (reverse-continue) ................. 83
re-read-init-file (C-x C-r) .......... 579
readnow ............................ 238
rec .................................... 85
rec btrace ............................ 85
rec btrace bts ......................... 85
rec btrace pt .......................... 85
rec bs ................................ 85
rec del ................................ 89
rec full ................................ 85
rec function-call-history ............ 90
rec instruction-history .............. 89
rec pt ................................ 85
rec s .................................. 86
recognize on type_recognizer ........ 341
record ............................. 85
record btrace ........................ 85
record btrace bts .................... 85
record btrace pt ...................... 85
record bs ................................ 85
record delete ......................... 89
record full ............................ 85
record function-call-history ........ 90
record goto ........................... 86
record instruction-history .......... 89
## Debugging with GDB

<table>
<thead>
<tr>
<th>Command</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>record pt</td>
<td>85</td>
</tr>
<tr>
<td>record restore</td>
<td>87</td>
</tr>
<tr>
<td>record save</td>
<td>87</td>
</tr>
<tr>
<td>record stop</td>
<td>86</td>
</tr>
<tr>
<td>redraw-current-line ()</td>
<td>574</td>
</tr>
<tr>
<td>refresh</td>
<td>452</td>
</tr>
<tr>
<td>register-breakpoint!</td>
<td>431</td>
</tr>
<tr>
<td>register-command!</td>
<td>413</td>
</tr>
<tr>
<td>register-parameter!</td>
<td>418</td>
</tr>
<tr>
<td>register_xmethod_matcher</td>
<td>354</td>
</tr>
<tr>
<td>RegisterChangedEventArgs.frame</td>
<td>361</td>
</tr>
<tr>
<td>RegisterChangedEventArgs.regnum</td>
<td>361</td>
</tr>
<tr>
<td>remote delete</td>
<td>250</td>
</tr>
<tr>
<td>remote get</td>
<td>250</td>
</tr>
<tr>
<td>remote put</td>
<td>250</td>
</tr>
<tr>
<td>remove-inferiors</td>
<td>34</td>
</tr>
<tr>
<td>remove-symbol-file</td>
<td>239</td>
</tr>
<tr>
<td>restart checkpoint-id</td>
<td>42</td>
</tr>
<tr>
<td>restore</td>
<td>148</td>
</tr>
<tr>
<td>RET (repeat last command)</td>
<td>19</td>
</tr>
<tr>
<td>return</td>
<td>228</td>
</tr>
<tr>
<td>reverse-continue</td>
<td>83</td>
</tr>
<tr>
<td>reverse-finish</td>
<td>84</td>
</tr>
<tr>
<td>reverse-next</td>
<td>84</td>
</tr>
<tr>
<td>reverse-nexti</td>
<td>84</td>
</tr>
<tr>
<td>reverse-search</td>
<td>105</td>
</tr>
<tr>
<td>reverse-search-history (C-r)</td>
<td>575</td>
</tr>
<tr>
<td>reverse-step</td>
<td>83</td>
</tr>
<tr>
<td>reverse-stepi</td>
<td>83</td>
</tr>
<tr>
<td>revert-all-at-newline</td>
<td>568</td>
</tr>
<tr>
<td>revert-line (M-r)</td>
<td>579</td>
</tr>
<tr>
<td>Right</td>
<td>451</td>
</tr>
<tr>
<td>rn (reverse-next)</td>
<td>84</td>
</tr>
<tr>
<td>rni (reverse-nexti)</td>
<td>84</td>
</tr>
<tr>
<td>rs (step)</td>
<td>83</td>
</tr>
<tr>
<td>rsi (reverse-stepi)</td>
<td>83</td>
</tr>
<tr>
<td>run</td>
<td>26</td>
</tr>
<tr>
<td>run&amp;</td>
<td>78</td>
</tr>
<tr>
<td>rwatch</td>
<td>53</td>
</tr>
</tbody>
</table>

### S

<table>
<thead>
<tr>
<th>Command</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>s (SingleKey TUI key)</td>
<td>451</td>
</tr>
<tr>
<td>s (step)</td>
<td>68</td>
</tr>
<tr>
<td>sal-last</td>
<td>430</td>
</tr>
<tr>
<td>sal-line</td>
<td>429</td>
</tr>
<tr>
<td>sal-pc</td>
<td>430</td>
</tr>
<tr>
<td>sal-syntab</td>
<td>429</td>
</tr>
<tr>
<td>sal-valid?</td>
<td>429</td>
</tr>
<tr>
<td>sal?</td>
<td>429</td>
</tr>
<tr>
<td>save breakpoints</td>
<td>65</td>
</tr>
<tr>
<td>save gdb-index</td>
<td>250</td>
</tr>
<tr>
<td>save tracepoints</td>
<td>178</td>
</tr>
<tr>
<td>save-tracepoints</td>
<td>178</td>
</tr>
<tr>
<td>sdireset</td>
<td>287</td>
</tr>
<tr>
<td>sdstatus</td>
<td>287</td>
</tr>
<tr>
<td>search</td>
<td>105</td>
</tr>
<tr>
<td>section</td>
<td>240</td>
</tr>
</tbody>
</table>

### Other Commands

- set debug hppa
- set debug auto-load
- set debug aarch64
- set data-directory
- set cp-abi
- set confirm
- set complaints
- set com3irq
- set com2irq
- set com2base
- set com1irq
- set com1base
- set coerce-float-to-double
- set charset
- set breakpoint pending
- set breakpoint auto-hw
- set breakpoint condition-evaluation
- set breakpoint always-inserted
- set breakpoint auto-load
- set breakpoint auto-load gdb-scripts
- set breakpoint auto-load guile-scripts
- set breakpoint auto-load libthread-db
- set breakpoint auto-load local-gdbinit
- set breakpoint auto-load off
- set breakpoint auto-load ldscripts
- set breakpoint auto-load python-scripts
- set breakpoint auto-load safe-path
- set breakpoint auto-load scripts-directory
- set breakpoint auto-load symbol-file
- set breakpoint auto-load watchpoints
- set breakpoint case-sensitive
- set breakpoint charset
- set breakpoint check range
- set breakpoint check type
- set breakpoint circular-trace-buffer
- set breakpoint code-cache
- set breakpoint coerce-float-to-double
- set breakpoint com1base
- set breakpoint com1irq
- set breakpoint com2base
- set breakpoint com2irq
- set breakpoint com3base
- set breakpoint com3irq
- set breakpoint com4base
- set breakpoint com4irq
- set breakpoint complaints
- set breakpoint confirm
- set breakpoint cp-abi
- set breakpoint cygwin-exceptions
- set breakpoint data-directory
- set breakpoint dcaching cache
- set breakpoint dcaching cache size
- set breakpoint debug
- set breakpoint debug aarch64
- set breakpoint debug auto-load
- set breakpoint debug bfd-cache level
- set breakpoint debug darwin
- set breakpoint debug entry-values
- set breakpoint debug hppa
<table>
<thead>
<tr>
<th>Command</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>set debug libthread-db</td>
<td>39</td>
</tr>
<tr>
<td>set debug mach-o</td>
<td>285</td>
</tr>
<tr>
<td>set debug mips</td>
<td>295</td>
</tr>
<tr>
<td>set debug monitor</td>
<td>255</td>
</tr>
<tr>
<td>set debug nios2</td>
<td>296</td>
</tr>
<tr>
<td>set debug-file-directory</td>
<td>247</td>
</tr>
<tr>
<td>set debugevents</td>
<td>280</td>
</tr>
<tr>
<td>set debugexceptions</td>
<td>280</td>
</tr>
<tr>
<td>set debugexec</td>
<td>280</td>
</tr>
<tr>
<td>set debugmemory</td>
<td>280</td>
</tr>
<tr>
<td>set default-collect</td>
<td>170</td>
</tr>
<tr>
<td>set demangle-style</td>
<td>132</td>
</tr>
<tr>
<td>set detach-on-fork</td>
<td>40</td>
</tr>
<tr>
<td>set directories</td>
<td>107</td>
</tr>
<tr>
<td>set disable-randomization</td>
<td>29</td>
</tr>
<tr>
<td>set disassemble-next-line</td>
<td>112</td>
</tr>
<tr>
<td>set disassembly-flavor</td>
<td>111</td>
</tr>
<tr>
<td>set disconnected-printf</td>
<td>65</td>
</tr>
<tr>
<td>set disconnected-tracing</td>
<td>172</td>
</tr>
<tr>
<td>set displaced-stepping</td>
<td>598</td>
</tr>
<tr>
<td>set editing</td>
<td>297</td>
</tr>
<tr>
<td>set endian</td>
<td>256</td>
</tr>
<tr>
<td>set environment</td>
<td>30</td>
</tr>
<tr>
<td>set exceptions, Hurd command</td>
<td>283</td>
</tr>
<tr>
<td>set exec-direction</td>
<td>84</td>
</tr>
<tr>
<td>set exec-done-display</td>
<td>308</td>
</tr>
<tr>
<td>set exec-wrapper</td>
<td>27</td>
</tr>
<tr>
<td>set extended-prompt</td>
<td>297</td>
</tr>
<tr>
<td>set extension-language</td>
<td>189</td>
</tr>
<tr>
<td>set follow-exec-mode</td>
<td>41</td>
</tr>
<tr>
<td>set follow-fork-mode</td>
<td>40</td>
</tr>
<tr>
<td>set frame-filter priority</td>
<td>98</td>
</tr>
<tr>
<td>set gnu-target</td>
<td>254</td>
</tr>
<tr>
<td>set guile print-stack</td>
<td>396</td>
</tr>
<tr>
<td>set hash, for remote monitors</td>
<td>255</td>
</tr>
<tr>
<td>set height</td>
<td>300</td>
</tr>
<tr>
<td>set history expansion</td>
<td>299</td>
</tr>
<tr>
<td>set history filename</td>
<td>298</td>
</tr>
<tr>
<td>set history remove-duplicates</td>
<td>298</td>
</tr>
<tr>
<td>set history save</td>
<td>298</td>
</tr>
<tr>
<td>set history size</td>
<td>298</td>
</tr>
<tr>
<td>set host-charset</td>
<td>150</td>
</tr>
<tr>
<td>set inferior-tty</td>
<td>32</td>
</tr>
<tr>
<td>set input-radix</td>
<td>300</td>
</tr>
<tr>
<td>set interactive-mode</td>
<td>313</td>
</tr>
<tr>
<td>set language</td>
<td>188</td>
</tr>
<tr>
<td>set libthread-db-search-path</td>
<td>39</td>
</tr>
<tr>
<td>set listsize</td>
<td>101</td>
</tr>
<tr>
<td>set logging</td>
<td>18</td>
</tr>
<tr>
<td>set mach-exceptions</td>
<td>285</td>
</tr>
<tr>
<td>set max-completions</td>
<td>20</td>
</tr>
<tr>
<td>set max-user-call-depth</td>
<td>316</td>
</tr>
<tr>
<td>set mem inaccessible-by-default</td>
<td>147</td>
</tr>
<tr>
<td>set mips abi</td>
<td>294</td>
</tr>
<tr>
<td>set mips compression</td>
<td>294</td>
</tr>
<tr>
<td>set mips mask-address</td>
<td>294</td>
</tr>
<tr>
<td>set mipsfpu</td>
<td>288</td>
</tr>
<tr>
<td>set monitor-prompt, MIPS remote</td>
<td>289</td>
</tr>
</tbody>
</table>
show auto-load libthread-db
show auto-load local-gdbinit
show auto-load python-scripts
show auto-load safe-path
show auto-load scripts-directory
show auto-load solib-add
show backtrace
show basename-may-differ
show breakpoint always-inserted
show breakpoint auto-hw
show breakpoint condition-evaluation
show breakpoint pending
show can-use-hw-watchpoints
show case-sensitive
show charset
show check range
show check type
show circular-trace-buffer
show code-cache
show coerce-float-to-double
show com1base
show com1irq
show com2base
show com2irq
show com3base
show com3irq
show configuration
show confirm
show convenience
show copying
show cp-abi
show cygwin-exceptions
show data-directory
show dcache line-size
show dcache size
show debug
show debug auto-load
show debug bfd-cache
show debug darwin
show debug entry-values
show debug libthread-db
show debug mach-o
show debug mips
show debug monitor
show debug nios2
show debug-file-directory
show default-collect
show detach-on-fork
show directories
show disassemble-next-line
show disassemble-flavor
show disconnected-dprintf
show disconnected-tracing
show displaced-stepping

set syn-garbage-limit, MIPS remote
set symroot
set target-charset
set target-file-system-kind
(set unix|dos-based|auto)
set target-wide-charset
set task, Hurd command
set tcp
set thread, Hurd command
set timeout
set trace-buffer-size
set trace-commands
set trace-notes
set trace-stop-notes
set trace-user
set trust-readonly-sections
set tui active-border-mode
set tui border-kind
set tui border-mode
set unwind-on-terminating-exception
set unwindsignal
set use-coredump-filter
set variable
set verbose
set watchdog
set width
set write
set-breakpoint-condition!
set-breakpoint-enabled!
set-breakpoint-hit-count!
set-breakpoint-ignore-count!
set-breakpoint-silent!
set-breakpoint-stop!
set-breakpoint-task!
set-breakpoint-thread!
set-iterator-progress!
set-mark (C=0)
set-memory-port-read-buffer-size!
set-memory-port-write-buffer-size!
set-objfile-pretty-printers!
set-parameter-value!
set-pretty-printer-enabled!
set-pretty-printers!
set-progspace-pretty-printers!
set_debug_traps
share
sharedlibrary
shell
show
show ada trust-PAD-over-XVS.
show agent
show annotate
show architecture
show args
show arm
show auto-load
show auto-load gdb-scripts
show auto-load guile-scripts

Debugging with GDB

show auto-load libthread-db
show auto-load local-gdbinit
show auto-load python-scripts
show auto-load safe-path
show auto-load scripts-directory
show auto-load solib-add
show backtrace
show basename-may-differ
show breakpoint always-inserted
show breakpoint auto-hw
show breakpoint condition-evaluation
show breakpoint pending
show can-use-hw-watchpoints
show case-sensitive
show charset
show check range
show check type
show circular-trace-buffer
show code-cache
show coerce-float-to-double
show com1base
show com1irq
show com2base
show com2irq
show com3base
show com3irq
show configuration
show confirm
show convenience
show copying
show cp-abi
show cygwin-exceptions
show data-directory
show dcache line-size
show dcache size
show debug
show debug auto-load
show debug bfd-cache
show debug darwin
show debug entry-values
show debug libthread-db
show debug mach-o
show debug mips
show debug monitor
show debug nios2
show debug-file-directory
show default-collect
show detach-on-fork
show directories
show disassemble-next-line
show disassemble-flavor
show disconnected-dprintf
show disconnected-tracing
show displaced-stepping

set syn-garbage-limit, MIPS remote
set symroot
set target-charset
set target-file-system-kind
(set unix|dos-based|auto)
set target-wide-charset
set task, Hurd command
set tcp
set thread, Hurd command
set timeout
set trace-buffer-size
set trace-commands
set trace-notes
set trace-stop-notes
set trace-user
set trust-readonly-sections
set tui active-border-mode
set tui border-kind
set tui border-mode
set unwind-on-terminating-exception
set unwindsignal
set use-coredump-filter
set variable
set verbose
set watchdog
set width
set write
set-breakpoint-condition!
set-breakpoint-enabled!
set-breakpoint-hit-count!
set-breakpoint-ignore-count!
set-breakpoint-silent!
set-breakpoint-stop!
set-breakpoint-task!
set-breakpoint-thread!
set-iterator-progress!
set-mark (C=0)
set-memory-port-read-buffer-size!
set-memory-port-write-buffer-size!
set-objfile-pretty-printers!
set-parameter-value!
set-pretty-printer-enabled!
set-pretty-printers!
set-progspace-pretty-printers!
set_debug_traps
share
sharedlibrary
shell
show
show ada trust-PAD-over-XVS.
show agent
show annotate
show architecture
show args
show arm
show auto-load
show auto-load gdb-scripts
show auto-load guile-scripts

show auto-load libthread-db
show auto-load local-gdbinit
show auto-load python-scripts
show auto-load safe-path
show auto-load scripts-directory
show auto-load solib-add
show backtrace
show basename-may-differ
show breakpoint always-inserted
show breakpoint auto-hw
show breakpoint condition-evaluation
show breakpoint pending
show can-use-hw-watchpoints
show case-sensitive
show charset
show check range
show check type
show circular-trace-buffer
show code-cache
show coerce-float-to-double
show com1base
show com1irq
show com2base
show com2irq
show com3base
show com3irq
show configuration
show confirm
show convenience
show copying
show cp-abi
show cygwin-exceptions
show data-directory
show dcache line-size
show dcache size
show debug
show debug auto-load
show debug bfd-cache
show debug darwin
show debug entry-values
show debug libthread-db
show debug mach-o
show debug mips
show debug monitor
show debug nios2
show debug-file-directory
show default-collect
show detach-on-fork
show directories
show disassemble-next-line
show disassemble-flavor
show disconnected-dprintf
show disconnected-tracing
show displaced-stepping

set syn-garbage-limit, MIPS remote
set symroot
set target-charset
set target-file-system-kind
(set unix|dos-based|auto)
set target-wide-charset
set task, Hurd command
set tcp
set thread, Hurd command
set timeout
set trace-buffer-size
set trace-commands
set trace-notes
set trace-stop-notes
set trace-user
set trust-readonly-sections
set tui active-border-mode
set tui border-kind
set tui border-mode
set unwind-on-terminating-exception
set unwindsignal
set use-coredump-filter
set variable
set verbose
set watchdog
set width
set write
set-breakpoint-condition!
set-breakpoint-enabled!
set-breakpoint-hit-count!
set-breakpoint-ignore-count!
set-breakpoint-silent!
set-breakpoint-stop!
set-breakpoint-task!
set-breakpoint-thread!
set-iterator-progress!
set-mark (C=0)
set-memory-port-read-buffer-size!
set-memory-port-write-buffer-size!
set-objfile-pretty-printers!
set-parameter-value!
set-pretty-printer-enabled!
set-pretty-printers!
set-progspace-pretty-printers!
set_debug_traps
share
sharedlibrary
shell
show
show ada trust-PAD-over-XVS.
show agent
show annotate
show architecture
show args
show arm
show auto-load
show auto-load gdb-scripts
show auto-load guile-scripts

show auto-load libthread-db
show auto-load local-gdbinit
show auto-load python-scripts
show auto-load safe-path
show auto-load scripts-directory
show auto-load solib-add
show backtrace
show basename-may-differ
show breakpoint always-inserted
show breakpoint auto-hw
show breakpoint condition-evaluation
show breakpoint pending
show can-use-hw-watchpoints
show case-sensitive
show charset
show check range
show check type
show circular-trace-buffer
show code-cache
show coerce-float-to-double
show com1base
show com1irq
show com2base
show com2irq
show com3base
show com3irq
show configuration
show confirm
show convenience
show copying
show cp-abi
show cygwin-exceptions
show data-directory
show dcache line-size
show dcache size
show debug
show debug auto-load
show debug bfd-cache
show debug darwin
show debug entry-values
show debug libthread-db
show debug mach-o
show debug mips
show debug monitor
show debug nios2
show debug-file-directory
show default-collect
show detach-on-fork
show directories
show disassemble-next-line
show disassemble-flavor
show disconnected-dprintf
show disconnected-tracing
show displaced-stepping
<table>
<thead>
<tr>
<th>Command</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>show editing</td>
<td>298</td>
</tr>
<tr>
<td>show exceptions, Hurd command</td>
<td>283</td>
</tr>
<tr>
<td>show exec-done-display</td>
<td>308</td>
</tr>
<tr>
<td>show extended-prompt</td>
<td>297</td>
</tr>
<tr>
<td>show follow-fork-mode</td>
<td>40</td>
</tr>
<tr>
<td>show frame-filter priority</td>
<td>98</td>
</tr>
<tr>
<td>show gnutarget</td>
<td>254</td>
</tr>
<tr>
<td>show hash, for remote monitors</td>
<td>305</td>
</tr>
<tr>
<td>show height</td>
<td>300</td>
</tr>
<tr>
<td>show history</td>
<td>299</td>
</tr>
<tr>
<td>show host-charset</td>
<td>150</td>
</tr>
<tr>
<td>show inferior-tty</td>
<td>32</td>
</tr>
<tr>
<td>show input-radix</td>
<td>301</td>
</tr>
<tr>
<td>show interactive-mode</td>
<td>313</td>
</tr>
<tr>
<td>show language</td>
<td>189</td>
</tr>
<tr>
<td>show libthread-db-search-path</td>
<td>39</td>
</tr>
<tr>
<td>show listsize</td>
<td>101</td>
</tr>
<tr>
<td>show logging</td>
<td>18</td>
</tr>
<tr>
<td>show mach-exceptions</td>
<td>285</td>
</tr>
<tr>
<td>show max-completions</td>
<td>20</td>
</tr>
<tr>
<td>show max-user-call-depth</td>
<td>316</td>
</tr>
<tr>
<td>show mem inaccessible-by-default</td>
<td>147</td>
</tr>
<tr>
<td>show mips abi</td>
<td>294</td>
</tr>
<tr>
<td>show mips compression</td>
<td>294</td>
</tr>
<tr>
<td>show mips mask-address</td>
<td>294</td>
</tr>
<tr>
<td>show mipsfpu</td>
<td>288</td>
</tr>
<tr>
<td>show monitor-prompt, MIPS remote</td>
<td>289</td>
</tr>
<tr>
<td>show monitor-warnings, MIPS remote</td>
<td>290</td>
</tr>
<tr>
<td>show mpx bound</td>
<td>293</td>
</tr>
<tr>
<td>show multiple-symbols</td>
<td>117</td>
</tr>
<tr>
<td>show new-console</td>
<td>280</td>
</tr>
<tr>
<td>show new-group</td>
<td>280</td>
</tr>
<tr>
<td>show non-stop</td>
<td>77</td>
</tr>
<tr>
<td>show opaque-type-resolution</td>
<td>222</td>
</tr>
<tr>
<td>show osabi</td>
<td>301</td>
</tr>
<tr>
<td>show output-radix</td>
<td>301</td>
</tr>
<tr>
<td>show overload-resolution</td>
<td>196</td>
</tr>
<tr>
<td>show pagination</td>
<td>300</td>
</tr>
<tr>
<td>show paths</td>
<td>30</td>
</tr>
<tr>
<td>show print</td>
<td>126</td>
</tr>
<tr>
<td>show print inferior-events</td>
<td>35</td>
</tr>
<tr>
<td>show print symbol-loading</td>
<td>222</td>
</tr>
<tr>
<td>show print thread-events</td>
<td>38</td>
</tr>
<tr>
<td>show print type methods</td>
<td>217</td>
</tr>
<tr>
<td>show print type typedefs</td>
<td>218</td>
</tr>
<tr>
<td>show processor</td>
<td>253</td>
</tr>
<tr>
<td>show procsfs-file</td>
<td>277</td>
</tr>
<tr>
<td>show procsfs-trace</td>
<td>276</td>
</tr>
<tr>
<td>show prompt</td>
<td>297</td>
</tr>
<tr>
<td>show radix</td>
<td>301</td>
</tr>
<tr>
<td>show range-stepping</td>
<td>71</td>
</tr>
<tr>
<td>show ravenscar task-switching</td>
<td>213</td>
</tr>
<tr>
<td>show record</td>
<td>90</td>
</tr>
<tr>
<td>show record btrace</td>
<td>88</td>
</tr>
<tr>
<td>show record full</td>
<td>87</td>
</tr>
<tr>
<td>show remote</td>
<td>264</td>
</tr>
<tr>
<td>show remote system-call-allowed</td>
<td>665</td>
</tr>
</tbody>
</table>

show remote-mips64-transfers-32bit-regs | 295 |
show remotecache                   | 152 |
show remoteflow                     | 265 |
show retransmit-timeout            | 289 |
show script-extension              | 315 |
show sh calling-convention         | 292 |
show shell                        | 280 |
show signal-thread                 | 282 |
show signals, Hurd command         | 282 |
show sigs, Hurd command            | 282 |
show sigthread                     | 282 |
show solib-search-path             | 244 |
show spu                          | 296 |
show stack-cache                   | 152 |
show stop-on-solib-events          | 243 |
show stopped, Hurd command         | 283 |
show struct-convention             | 292 |
show substitute-path               | 108 |
show syn-garbage-limit, MIPS remote | 289 |
show sysroot                       | 244 |
show target-charset                | 150 |
show target-file-system-kind       | 244 |
show target-wide-charset           | 150 |
show task, Hurd commands           | 283 |
show tcp                          | 266 |
show thread, Hurd command          | 284 |
show timeout                      | 289 |
show trace-buffer-size             | 173 |
show trace-notes                   | 174 |
show trace-stop-notes              | 174 |
show trace-user                    | 174 |
show unwind-on-terminating-exception | 230 |
show unwindsignal                  | 229 |
show user                         | 316 |
show values                       | 136 |
show verbose                      | 307 |
show version                      | 24  |
show warranty                     | 24  |
show width                        | 300 |
show write                        | 230 |
show all-if-ambiguous             | 568 |
show all-if-unmodified            | 568 |
show si (stepi)                   | 70  |
signal                           | 227 |
signal annotation                 | 548 |
signal-name annotation            | 547 |
signal-name-end annotation        | 547 |
signal-string annotation          | 547 |
signal-string-end annotation      | 547 |
SignalEvent.stop_signal           | 360 |
signalled annotation              | 547 |
silent                            | 63  |
sim, a command                    | 285 |
skip delete                       | 72  |
skip disable                      | 72  |
skip enable                       | 72  |
skip file                         | 72  |
symbol-variable?

tfile

tcatch

T

tab-insert (M-TAB)

tabset

target

target ctf

target ddb port

target lsi port

target mips port

target pmon port

target record

target record-btrace

target record-full

target tfile

target-config
	
task (Ada)

tbreak

tdump

teval (tracepoints)
tfile
tfind
Debugging with GDB

W
w (SingleKey TUI key) ........................................ 451
watch ......................................................... 52
watchpoint annotation ...................................... 548
whatis ......................................................... 218
where ......................................................... 95
while ......................................................... 319
while-stepping (tracepoints) ............................... 170
winheight .................................................. 453
WP_ACCESS ................................................. 383, 431
WP_READ .................................................. 383, 431
WP_WRITE .................................................. 383, 431

X
x (examine memory) ........................................ 122
x(examine), and info line ................................... 108
XMethod.__init__ ........................................... 353
XMethodMatcher.__init__ ................................... 353
XMethodMatcher.match ...................................... 354
XMethodWorker.__call__ .................................... 354
XMethodWorker.get_arg_types ............................. 354
XMethodWorker.get_result_type .......................... 354

Y
yank (C-y) .................................................... 578
yank-last-arg (M-. or M-_) ................................. 578
yank-nth-arg (M-C-y) ....................................... 575
yank-pop (M-y) ............................................. 578
The body of this manual is set in cmr10 at 10.95pt,
with headings in cmb10 at 10.95pt
and examples in cmtt10 at 10.95pt.
cmti10 at 10.95pt,
cmb10 at 10.95pt, and
cmsl10 at 10.95pt
are used for emphasis.