

# Debugging with GDB

This file documents the GNU debugger GDB.

This is the Tenth Edition, of *Debugging with GDB: the GNU Source-Level Debugger* for GDB (GDB) Version 13.0.50.20220510-git.

Copyright © 1988–2022 Free Software Foundation, Inc.

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 the Invariant Sections being “Free Software” and “Free Software Needs Free Documentation”, with the Front-Cover Texts being “A GNU Manual,” and with the Back-Cover Texts as in (a) below.

(a) The FSF’s Back-Cover Text is: “You are free to copy and modify this GNU Manual. Buying copies from GNU Press supports the FSF in developing GNU and promoting software freedom.”

Next: [Summary](#)   [\[Contents\]](#)[\[Index\]](#)

---

## Debugging with GDB

This file describes GDB, the GNU symbolic debugger.

This is the Tenth Edition, for GDB (GDB) Version 13.0.50.20220510-git.

Copyright (C) 1988–2022 Free Software Foundation, Inc.

This edition of the GDB manual is dedicated to the memory of Fred Fish. Fred was a long-standing contributor to GDB and to Free software in general. We will miss him.

- [Summary](#): Summary of GDB
- [Sample Session](#): A sample GDB session
- [Invocation](#): Getting in and out of GDB
- [Commands](#): GDB commands
- [Running](#): Running programs under GDB
- [Stopping](#): Stopping and continuing
- [Reverse Execution](#): Running programs backward
- [Process Record and Replay](#): Recording inferior’s execution and replaying it
- [Stack](#): Examining the stack
- [Source](#): Examining source files
- [Data](#): Examining data
- [Optimized Code](#): Debugging optimized code
- [Macros](#): Preprocessor Macros
- [Tracepoints](#): Debugging remote targets non-intrusively

- [Overlays](#): Debugging programs that use overlays
- [Languages](#): Using GDB with different languages
- [Symbols](#): Examining the symbol table
- [Altering](#): Altering execution
- [GDB Files](#): GDB files
- [Targets](#): Specifying a debugging target
- [Remote Debugging](#): Debugging remote programs
- [Configurations](#): Configuration-specific information
- [Controlling GDB](#): Controlling GDB
- [Extending GDB](#): Extending GDB
- [Interpreters](#): Command Interpreters
- [TUI](#): GDB Text User Interface
- [Emacs](#): Using GDB under GNU Emacs
- [GDB/MI](#): GDB's Machine Interface.
- [Annotations](#): GDB's annotation interface.
- [JIT Interface](#): Using the JIT debugging interface.
- [In-Process Agent](#): In-Process Agent
- [GDB Bugs](#): Reporting bugs in GDB
- [Command Line Editing](#): Command Line Editing
- [Using History Interactively](#): Using History Interactively
- [In Memoriam](#): In Memoriam
- [Formatting Documentation](#): How to format and print GDB documentation
- [Installing GDB](#): Installing GDB
- [Maintenance Commands](#): Maintenance Commands
- [Remote Protocol](#): GDB Remote Serial Protocol
- [Agent Expressions](#): The GDB Agent Expression Mechanism
- [Target Descriptions](#): How targets can describe themselves to GDB
- [Operating System Information](#): Getting additional information from the operating system
- [Trace File Format](#): GDB trace file format
- [Index Section Format](#): .gdb\_index section format
- [Debuginfod](#): Download debugging resources with debuginfod
- [Man Pages](#): Manual pages
- [Copying](#): GNU General Public License says how you can copy and share GDB
- [GNU Free Documentation License](#): The license for this documentation
- [Concept Index](#): Index of GDB concepts
- [Command and Variable](#): Index of GDB commands, variables, functions, and Python

[Index:](#)

data types

# Table of Contents

- [Summary of GDB](#)
  - [Free Software](#)
  - [Free Software Needs Free Documentation](#)
  - [Contributors to GDB](#)
- [1 A Sample GDB Session](#)
- [2 Getting In and Out of GDB](#)
  - [2.1 Invoking GDB](#)
    - [2.1.1 Choosing Files](#)
    - [2.1.2 Choosing Modes](#)
    - [2.1.3 What GDB Does During Startup](#)
    - [2.1.4 Initialization Files](#)
      - [2.1.4.1 Home directory early initialization files](#)
      - [2.1.4.2 System wide initialization files](#)
      - [2.1.4.3 Home directory initialization file](#)
      - [2.1.4.4 Local directory initialization file](#)
  - [2.2 Quitting GDB](#)
  - [2.3 Shell Commands](#)
  - [2.4 Logging Output](#)
- [3 GDB Commands](#)
  - [3.1 Command Syntax](#)
  - [3.2 Command Settings](#)
  - [3.3 Command Completion](#)
  - [3.4 Command options](#)
  - [3.5 Getting Help](#)
- [4 Running Programs Under GDB](#)
  - [4.1 Compiling for Debugging](#)
  - [4.2 Starting your Program](#)
  - [4.3 Your Program's Arguments](#)
  - [4.4 Your Program's Environment](#)
  - [4.5 Your Program's Working Directory](#)
  - [4.6 Your Program's Input and Output](#)
  - [4.7 Debugging an Already-running Process](#)
  - [4.8 Killing the Child Process](#)
  - [4.9 Debugging Multiple Inferiors Connections and Programs](#)
  - [4.10 Debugging Programs with Multiple Threads](#)
  - [4.11 Debugging Forks](#)
  - [4.12 Setting a \*Bookmark\* to Return to Later](#)
    - [4.12.1 A Non-obvious Benefit of Using Checkpoints](#)
- [5 Stopping and Continuing](#)
  - [5.1 Breakpoints, Watchpoints, and Catchpoints](#)
    - [5.1.1 Setting Breakpoints](#)
    - [5.1.2 Setting Watchpoints](#)
    - [5.1.3 Setting Catchpoints](#)
    - [5.1.4 Deleting Breakpoints](#)
    - [5.1.5 Disabling Breakpoints](#)
    - [5.1.6 Break Conditions](#)
    - [5.1.7 Breakpoint Command Lists](#)

- [5.1.8 Dynamic Printf](#)
  - [5.1.9 How to save breakpoints to a file](#)
  - [5.1.10 Static Probe Points](#)
  - [5.1.11 “Cannot insert breakpoints”](#)
  - [5.1.12 “Breakpoint address adjusted...”](#)
- [5.2 Continuing and Stepping](#)
- [5.3 Skipping Over Functions and Files](#)
- [5.4 Signals](#)
- [5.5 Stopping and Starting Multi-thread Programs](#)
  - [5.5.1 All-Stop Mode](#)
  - [5.5.2 Non-Stop Mode](#)
  - [5.5.3 Background Execution](#)
  - [5.5.4 Thread-Specific Breakpoints](#)
  - [5.5.5 Interrupted System Calls](#)
  - [5.5.6 Observer Mode](#)
- [6 Running programs backward](#)
- [7 Recording Inferior’s Execution and Replaying It](#)
- [8 Examining the Stack](#)
  - [8.1 Stack Frames](#)
  - [8.2 Backtraces](#)
  - [8.3 Selecting a Frame](#)
  - [8.4 Information About a Frame](#)
  - [8.5 Applying a Command to Several Frames.](#)
  - [8.6 Management of Frame Filters.](#)
- [9 Examining Source Files](#)
  - [9.1 Printing Source Lines](#)
  - [9.2 Specifying a Location](#)
    - [9.2.1 Linespec Locations](#)
    - [9.2.2 Explicit Locations](#)
    - [9.2.3 Address Locations](#)
  - [9.3 Editing Source Files](#)
    - [9.3.1 Choosing your Editor](#)
  - [9.4 Searching Source Files](#)
  - [9.5 Specifying Source Directories](#)
  - [9.6 Source and Machine Code](#)
  - [9.7 Disable Reading Source Code](#)
- [10 Examining Data](#)
  - [10.1 Expressions](#)
  - [10.2 Ambiguous Expressions](#)
  - [10.3 Program Variables](#)
  - [10.4 Artificial Arrays](#)
  - [10.5 Output Formats](#)
  - [10.6 Examining Memory](#)
  - [10.7 Memory Tagging](#)
  - [10.8 Automatic Display](#)
  - [10.9 Print Settings](#)
  - [10.10 Pretty Printing](#)
    - [10.10.1 Pretty-Printer Introduction](#)
    - [10.10.2 Pretty-Printer Example](#)
    - [10.10.3 Pretty-Printer Commands](#)
  - [10.11 Value History](#)
  - [10.12 Convenience Variables](#)

- [10.13 Convenience Functions](#)
- [10.14 Registers](#)
- [10.15 Floating Point Hardware](#)
- [10.16 Vector Unit](#)
- [10.17 Operating System Auxiliary Information](#)
- [10.18 Memory Region Attributes](#)
  - [10.18.1 Attributes](#)
    - [10.18.1.1 Memory Access Mode](#)
    - [10.18.1.2 Memory Access Size](#)
    - [10.18.1.3 Data Cache](#)
  - [10.18.2 Memory Access Checking](#)
- [10.19 Copy Between Memory and a File](#)
- [10.20 How to Produce a Core File from Your Program](#)
- [10.21 Character Sets](#)
- [10.22 Caching Data of Targets](#)
- [10.23 Search Memory](#)
- [10.24 Value Sizes](#)
- [11 Debugging Optimized Code](#)
  - [11.1 Inline Functions](#)
  - [11.2 Tail Call Frames](#)
- [12 C Preprocessor Macros](#)
- [13 Tracepoints](#)
  - [13.1 Commands to Set Tracepoints](#)
    - [13.1.1 Create and Delete Tracepoints](#)
    - [13.1.2 Enable and Disable Tracepoints](#)
    - [13.1.3 Tracepoint Passcounts](#)
    - [13.1.4 Tracepoint Conditions](#)
    - [13.1.5 Trace State Variables](#)
    - [13.1.6 Tracepoint Action Lists](#)
    - [13.1.7 Listing Tracepoints](#)
    - [13.1.8 Listing Static Tracepoint Markers](#)
    - [13.1.9 Starting and Stopping Trace Experiments](#)
    - [13.1.10 Tracepoint Restrictions](#)
  - [13.2 Using the Collected Data](#)
    - [13.2.1 tfind \*n\*](#)
    - [13.2.2 tdump](#)
    - [13.2.3 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 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 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 GDB and C](#)
    - [15.4.1.7 GDB Features for C++](#)
    - [15.4.1.8 Decimal Floating Point format](#)
  - [15.4.2 D](#)
  - [15.4.3 Go](#)
  - [15.4.4 Objective-C](#)
    - [15.4.4.1 Method Names in Commands](#)
    - [15.4.4.2 The Print Command With Objective-C](#)
  - [15.4.5 OpenCL C](#)
    - [15.4.5.1 OpenCL C Datatypes](#)
    - [15.4.5.2 OpenCL C Expressions](#)
    - [15.4.5.3 OpenCL C Operators](#)
  - [15.4.6 Fortran](#)
    - [15.4.6.1 Fortran Types](#)
    - [15.4.6.2 Fortran Operators and Expressions](#)
    - [15.4.6.3 Fortran Intrinsics](#)
    - [15.4.6.4 Special Fortran Commands](#)
  - [15.4.7 Pascal](#)
  - [15.4.8 Rust](#)
  - [15.4.9 Modula-2](#)
    - [15.4.9.1 Operators](#)
    - [15.4.9.2 Built-in Functions and Procedures](#)
    - [15.4.9.3 Constants](#)
    - [15.4.9.4 Modula-2 Types](#)
    - [15.4.9.5 Modula-2 Defaults](#)
    - [15.4.9.6 Deviations from Standard Modula-2](#)
    - [15.4.9.7 Modula-2 Type and Range Checks](#)
    - [15.4.9.8 The Scope Operators :: and .](#)
    - [15.4.9.9 GDB and Modula-2](#)
  - [15.4.10 Ada](#)
    - [15.4.10.1 Introduction](#)
    - [15.4.10.2 Omissions from Ada](#)
    - [15.4.10.3 Additions to Ada](#)
    - [15.4.10.4 Overloading support for Ada](#)
    - [15.4.10.5 Stopping at the Very Beginning](#)
    - [15.4.10.6 Ada Exceptions](#)
    - [15.4.10.7 Extensions for Ada Tasks](#)
    - [15.4.10.8 Tasking Support when Debugging Core Files](#)
    - [15.4.10.9 Tasking Support when using the Ravenscar Profile](#)
    - [15.4.10.10 Ada Source Character Set](#)
    - [15.4.10.11 Known Peculiarities of Ada Mode](#)
- [15.5 Unsupported Languages](#)
- [16 Examining the Symbol Table](#)
- [17 Altering Execution](#)

- [17.1 Assignment to Variables](#)
- [17.2 Continuing at a Different Address](#)
- [17.3 Giving your Program a Signal](#)
- [17.4 Returning from a Function](#)
- [17.5 Calling Program Functions](#)
  - [17.5.1 Calling functions with no debug info](#)
- [17.6 Patching Programs](#)
- [17.7 Compiling and injecting code in GDB](#)
  - [17.7.1 Compilation options for the compile command](#)
  - [17.7.2 Caveats when using the compile command](#)
  - [17.7.3 Compiler search for the compile command](#)
- [18 GDB Files](#)
  - [18.1 Commands to Specify Files](#)
  - [18.2 File Caching](#)
  - [18.3 Debugging Information in Separate Files](#)
  - [18.4 Debugging information in a special section](#)
  - [18.5 Index Files Speed Up GDB](#)
    - [18.5.1 Automatic symbol index cache](#)
  - [18.6 Errors Reading Symbol Files](#)
  - [18.7 GDB Data Files](#)
- [19 Specifying a Debugging Target](#)
  - [19.1 Active Targets](#)
  - [19.2 Commands for Managing Targets](#)
  - [19.3 Choosing Target Byte Order](#)
- [20 Debugging Remote Programs](#)
  - [20.1 Connecting to a Remote Target](#)
    - [20.1.1 Types of Remote Connections](#)
    - [20.1.2 Host and Target Files](#)
    - [20.1.3 Remote Connection Commands](#)
  - [20.2 Sending files to a remote system](#)
  - [20.3 Using the gdbserver Program](#)
    - [20.3.1 Running gdbserver](#)
      - [20.3.1.1 Attaching to a Running Program](#)
      - [20.3.1.2 TCP port allocation lifecycle of gdbserver](#)
      - [20.3.1.3 Other Command-Line Arguments for gdbserver](#)
    - [20.3.2 Connecting to gdbserver](#)
    - [20.3.3 Monitor Commands for gdbserver](#)
    - [20.3.4 Tracepoints support in gdbserver](#)
  - [20.4 Remote Configuration](#)
  - [20.5 Implementing a Remote Stub](#)
    - [20.5.1 What the Stub Can Do for You](#)
    - [20.5.2 What You Must Do for the Stub](#)
    - [20.5.3 Putting it All Together](#)
- [21 Configuration-Specific Information](#)
  - [21.1 Native](#)
    - [21.1.1 BSD libkvm Interface](#)
    - [21.1.2 Process Information](#)
    - [21.1.3 Features for Debugging DJGPP Programs](#)
    - [21.1.4 Features for Debugging MS Windows PE Executables](#)
      - [21.1.4.1 Support for DLLs without Debugging Symbols](#)
      - [21.1.4.2 DLL Name Prefixes](#)
      - [21.1.4.3 Working with Minimal Symbols](#)

- [21.1.5 Commands Specific to GNU Hurd Systems](#)
  - [21.1.6 Darwin](#)
  - [21.1.7 FreeBSD](#)
  - [21.2 Embedded Operating Systems](#)
  - [21.3 Embedded Processors](#)
    - [21.3.1 Synopsys ARC](#)
    - [21.3.2 ARM](#)
    - [21.3.3 BPF](#)
    - [21.3.4 M68k](#)
    - [21.3.5 MicroBlaze](#)
    - [21.3.6 MIPS Embedded](#)
    - [21.3.7 OpenRISC 1000](#)
    - [21.3.8 PowerPC Embedded](#)
    - [21.3.9 Atmel AVR](#)
    - [21.3.10 CRIS](#)
    - [21.3.11 Renesas Super-H](#)
  - [21.4 Architectures](#)
    - [21.4.1 AArch64](#)
      - [21.4.1.1 AArch64 SVE.](#)
      - [21.4.1.2 AArch64 Pointer Authentication.](#)
      - [21.4.1.3 AArch64 Memory Tagging Extension.](#)
    - [21.4.2 x86 Architecture-specific Issues](#)
      - [21.4.2.1 Intel Memory Protection Extensions \(MPX\).](#)
    - [21.4.3 Alpha](#)
    - [21.4.4 MIPS](#)
    - [21.4.5 HPPA](#)
    - [21.4.6 PowerPC](#)
    - [21.4.7 Nios II](#)
    - [21.4.8 Sparc64](#)
      - [21.4.8.1 ADI Support](#)
    - [21.4.9 S12Z](#)
- [22 Controlling GDB](#)
  - [22.1 Prompt](#)
  - [22.2 Command Editing](#)
  - [22.3 Command History](#)
  - [22.4 Screen Size](#)
  - [22.5 Output Styling](#)
  - [22.6 Numbers](#)
  - [22.7 Configuring the Current ABI](#)
  - [22.8 Automatically loading associated files](#)
    - [22.8.1 Automatically loading init file in the current directory](#)
    - [22.8.2 Automatically loading thread debugging library](#)
    - [22.8.3 Security restriction for auto-loading](#)
    - [22.8.4 Displaying files tried for auto-load](#)
  - [22.9 Optional Warnings and Messages](#)
  - [22.10 Optional Messages about Internal Happenings](#)
  - [22.11 Other Miscellaneous Settings](#)
- [23 Extending GDB](#)
  - [23.1 Canned Sequences of Commands](#)
    - [23.1.1 User-defined Commands](#)
    - [23.1.2 User-defined Command Hooks](#)
    - [23.1.3 Command Files](#)



- [23.1.4 Commands for Controlled Output](#)
- [23.1.5 Controlling auto-loading native GDB scripts](#)
- [23.2 Command Aliases](#)
  - [23.2.1 Default Arguments](#)
- [23.3 Extending GDB using Python](#)
  - [23.3.1 Python Commands](#)
  - [23.3.2 Python API](#)
    - [23.3.2.1 Basic Python](#)
    - [23.3.2.2 Exception Handling](#)
    - [23.3.2.3 Values From Inferior](#)
    - [23.3.2.4 Types In Python](#)
    - [23.3.2.5 Pretty Printing API](#)
    - [23.3.2.6 Selecting Pretty-Printers](#)
    - [23.3.2.7 Writing a Pretty-Printer](#)
    - [23.3.2.8 Type Printing API](#)
    - [23.3.2.9 Filtering Frames](#)
    - [23.3.2.10 Decorating Frames](#)
    - [23.3.2.11 Writing a Frame Filter](#)
    - [23.3.2.12 Unwinding Frames in Python](#)
    - [23.3.2.13 Xmethods In Python](#)
    - [23.3.2.14 Xmethod API](#)
    - [23.3.2.15 Writing an Xmethod](#)
    - [23.3.2.16 Inferiors In Python](#)
    - [23.3.2.17 Events In Python](#)
    - [23.3.2.18 Threads In Python](#)
    - [23.3.2.19 Recordings In Python](#)
    - [23.3.2.20 CLI Commands In Python](#)
    - [23.3.2.21 GDB/MI Commands In Python](#)
    - [23.3.2.22 Parameters In Python](#)
    - [23.3.2.23 Writing new convenience functions](#)
    - [23.3.2.24 Program Spaces In Python](#)
    - [23.3.2.25 Objfiles In Python](#)
    - [23.3.2.26 Accessing inferior stack frames from Python](#)
    - [23.3.2.27 Accessing blocks from Python](#)
    - [23.3.2.28 Python representation of Symbols](#)
    - [23.3.2.29 Symbol table representation in Python](#)
    - [23.3.2.30 Manipulating line tables using Python](#)
    - [23.3.2.31 Manipulating breakpoints using Python](#)
    - [23.3.2.32 Finish Breakpoints](#)
    - [23.3.2.33 Python representation of lazy strings](#)
    - [23.3.2.34 Python representation of architectures](#)
    - [23.3.2.35 Registers In Python](#)
    - [23.3.2.36 Connections In Python](#)
    - [23.3.2.37 Implementing new TUI windows](#)
  - [23.3.3 Python Auto-loading](#)
  - [23.3.4 Python modules](#)
    - [23.3.4.1 gdb.printing](#)
    - [23.3.4.2 gdb.types](#)
    - [23.3.4.3 gdb.prompt](#)
- [23.4 Extending GDB using Guile](#)
  - [23.4.1 Guile Introduction](#)
  - [23.4.2 Guile Commands](#)

- [23.4.3 Guile API](#)
  - [23.4.3.1 Basic Guile](#)
  - [23.4.3.2 Guile Configuration](#)
  - [23.4.3.3 GDB Scheme Data Types](#)
  - [23.4.3.4 Guile Exception Handling](#)
  - [23.4.3.5 Values From Inferior In Guile](#)
  - [23.4.3.6 Arithmetic In Guile](#)
  - [23.4.3.7 Types In Guile](#)
  - [23.4.3.8 Guile Pretty Printing API](#)
  - [23.4.3.9 Selecting Guile Pretty-Printers](#)
  - [23.4.3.10 Writing a Guile Pretty-Printer](#)
  - [23.4.3.11 Commands In Guile](#)
  - [23.4.3.12 Parameters In Guile](#)
  - [23.4.3.13 Program Spaces In Guile](#)
  - [23.4.3.14 Objfiles In Guile](#)
  - [23.4.3.15 Accessing inferior stack frames from Guile.](#)
  - [23.4.3.16 Accessing blocks from Guile.](#)
  - [23.4.3.17 Guile representation of Symbols.](#)
  - [23.4.3.18 Symbol table representation in Guile.](#)
  - [23.4.3.19 Manipulating breakpoints using Guile](#)
  - [23.4.3.20 Guile representation of lazy strings.](#)
  - [23.4.3.21 Guile representation of architectures](#)
  - [23.4.3.22 Disassembly In Guile](#)
  - [23.4.3.23 I/O Ports in Guile](#)
  - [23.4.3.24 Memory Ports in Guile](#)
  - [23.4.3.25 Iterators In Guile](#)
- [23.4.4 Guile Auto-loading](#)
- [23.4.5 Guile Modules](#)
  - [23.4.5.1 Guile Printing Module](#)
  - [23.4.5.2 Guile Types Module](#)
- [23.5 Auto-loading extensions](#)
  - [23.5.1 The `objfile-gdb.ext` file](#)
  - [23.5.2 The `.debug\_gdb\_scripts` section](#)
    - [23.5.2.1 Script File Entries](#)
    - [23.5.2.2 Script Text Entries](#)
  - [23.5.3 Which flavor to choose?](#)
- [23.6 Multiple Extension Languages](#)
  - [23.6.1 Python comes first](#)
- [24 Command Interpreters](#)
- [25 GDB Text User Interface](#)
  - [25.1 TUI Overview](#)
  - [25.2 TUI Key Bindings](#)
  - [25.3 TUI Single Key Mode](#)
  - [25.4 TUI Mouse Support](#)
  - [25.5 TUI-specific Commands](#)
  - [25.6 TUI Configuration Variables](#)
- [26 Using GDB under GNU Emacs](#)
- [27 The GDB/MI Interface](#)
  - [Function and Purpose](#)
  - [Notation and Terminology](#)
  - [27.1 GDB/MI General Design](#)
    - [27.1.1 Context management](#)

- [27.1.1.1 Threads and Frames](#)
  - [27.1.1.2 Language](#)
  - [27.1.2 Asynchronous command execution and non-stop mode](#)
  - [27.1.3 Thread groups](#)
- [27.2 GDB/MI Command Syntax](#)
  - [27.2.1 GDB/MI Input Syntax](#)
  - [27.2.2 GDB/MI Output Syntax](#)
- [27.3 GDB/MI Compatibility with CLI](#)
- [27.4 GDB/MI Development and Front Ends](#)
- [27.5 GDB/MI Output Records](#)
  - [27.5.1 GDB/MI Result Records](#)
  - [27.5.2 GDB/MI Stream Records](#)
  - [27.5.3 GDB/MI Async Records](#)
  - [27.5.4 GDB/MI Breakpoint Information](#)
  - [27.5.5 GDB/MI Frame Information](#)
  - [27.5.6 GDB/MI Thread Information](#)
  - [27.5.7 GDB/MI Ada Exception Information](#)
- [27.6 Simple Examples of GDB/MI Interaction](#)
- [27.7 GDB/MI Command Description Format](#)
- [27.8 GDB/MI Breakpoint Commands](#)
- [27.9 GDB/MI Catchpoint Commands](#)
  - [27.9.1 Shared Library GDB/MI Catchpoints](#)
  - [27.9.2 Ada Exception GDB/MI Catchpoints](#)
  - [27.9.3 C++ Exception GDB/MI Catchpoints](#)
- [27.10 GDB/MI Program Context](#)
- [27.11 GDB/MI Thread Commands](#)
- [27.12 GDB/MI Ada Tasking Commands](#)
- [27.13 GDB/MI Program Execution](#)
- [27.14 GDB/MI Stack Manipulation Commands](#)
- [27.15 GDB/MI Variable Objects](#)
- [27.16 GDB/MI Data Manipulation](#)
- [27.17 GDB/MI Tracepoint Commands](#)
- [27.18 GDB/MI Symbol Query Commands](#)
- [27.19 GDB/MI File Commands](#)
- [27.20 GDB/MI Target Manipulation Commands](#)
- [27.21 GDB/MI File Transfer Commands](#)
- [27.22 Ada Exceptions GDB/MI Commands](#)
- [27.23 GDB/MI Support Commands](#)
- [27.24 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](#)
    - [32.4.3 Commands For Changing Text](#)
    - [32.4.4 Killing And Yanking](#)
    - [32.4.5 Specifying Numeric Arguments](#)
    - [32.4.6 Letting Readline Type For You](#)
    - [32.4.7 Keyboard Macros](#)
    - [32.4.8 Some Miscellaneous Commands](#)
  - [32.5 Readline vi Mode](#)
- [33 Using History Interactively](#)
  - [33.1 History Expansion](#)
    - [33.1.1 Event Designators](#)
    - [33.1.2 Word Designators](#)
    - [33.1.3 Modifiers](#)
- [Appendix A In Memoriam](#)
- [Appendix B Formatting Documentation](#)
- [Appendix C Installing GDB](#)
  - [C.1 Requirements for Building GDB](#)
  - [C.2 Invoking the GDB configure Script](#)
  - [C.3 Compiling GDB in Another Directory](#)
  - [C.4 Specifying Names for Hosts and Targets](#)
  - [C.5 configure Options](#)
  - [C.6 System-wide configuration and settings](#)
    - [C.6.1 Installed System-wide Configuration Scripts](#)
- [Appendix D Maintenance Commands](#)
- [Appendix E GDB Remote Serial Protocol](#)
  - [E.1 Overview](#)
  - [E.2 Packets](#)
  - [E.3 Stop Reply Packets](#)
  - [E.4 General Query Packets](#)

- [E.5 Architecture-Specific Protocol Details](#)
  - [E.5.1 ARM-specific Protocol Details](#)
    - [E.5.1.1 ARM Breakpoint Kinds](#)
    - [E.5.1.2 ARM Memory Tag Types](#)
  - [E.5.2 MIPS-specific Protocol Details](#)
    - [E.5.2.1 MIPS Register Packet Format](#)
    - [E.5.2.2 MIPS Breakpoint Kinds](#)
- [E.6 Tracepoint Packets](#)
  - [E.6.1 Relocate instruction reply packet](#)
- [E.7 Host I/O Packets](#)
- [E.8 Interrupts](#)
- [E.9 Notification Packets](#)
- [E.10 Remote Protocol Support for Non-Stop Mode](#)
- [E.11 Packet Acknowledgment](#)
- [E.12 Examples](#)
- [E.13 File-I/O Remote Protocol Extension](#)
  - [E.13.1 File-I/O Overview](#)
  - [E.13.2 Protocol Basics](#)
  - [E.13.3 The F Request Packet](#)
  - [E.13.4 The F Reply Packet](#)
  - [E.13.5 The 'Ctrl-C' Message](#)
  - [E.13.6 Console I/O](#)
  - [E.13.7 List of Supported Calls](#)
    - [open](#)
    - [close](#)
    - [read](#)
    - [write](#)
    - [lseek](#)
    - [rename](#)
    - [unlink](#)
    - [stat/fstat](#)
    - [gettimeofday](#)
    - [isatty](#)
    - [system](#)
  - [E.13.8 Protocol-specific Representation of Datatypes](#)
    - [Integral Datatypes](#)
    - [Pointer Values](#)
    - [Memory Transfer](#)
    - [struct stat](#)
    - [struct timeval](#)
  - [E.13.9 Constants](#)
    - [Open Flags](#)
    - [mode\\_t Values](#)
    - [Errno Values](#)
    - [Lseek Flags](#)
    - [Limits](#)
  - [E.13.10 File-I/O Examples](#)
- [E.14 Library List Format](#)
- [E.15 Library List Format for SVR4 Targets](#)
- [E.16 Memory Map Format](#)
- [E.17 Thread List Format](#)
- [E.18 Traceframe Info Format](#)

- [E.19 Branch Trace Format](#)
  - [E.20 Branch Trace Configuration Format](#)
- [Appendix F The GDB Agent Expression Mechanism](#)
  - [F.1 General Bytecode Design](#)
  - [F.2 Bytecode Descriptions](#)
  - [F.3 Using Agent Expressions](#)
  - [F.4 Varying Target Capabilities](#)
  - [F.5 Rationale](#)
- [Appendix G Target Descriptions](#)
  - [G.1 Retrieving Descriptions](#)
  - [G.2 Target Description Format](#)
    - [G.2.1 Inclusion](#)
    - [G.2.2 Architecture](#)
    - [G.2.3 OS ABI](#)
    - [G.2.4 Compatible Architecture](#)
    - [G.2.5 Features](#)
    - [G.2.6 Types](#)
    - [G.2.7 Registers](#)
  - [G.3 Predefined Target Types](#)
  - [G.4 Enum Target Types](#)
  - [G.5 Standard Target Features](#)
    - [G.5.1 AArch64 Features](#)
    - [G.5.2 ARC Features](#)
    - [G.5.3 ARM Features](#)
    - [G.5.4 i386 Features](#)
    - [G.5.5 LoongArch Features](#)
    - [G.5.6 MicroBlaze Features](#)
    - [G.5.7 MIPS Features](#)
    - [G.5.8 M68K Features](#)
    - [G.5.9 NDS32 Features](#)
    - [G.5.10 Nios II Features](#)
    - [G.5.11 Openrisc 1000 Features](#)
    - [G.5.12 PowerPC Features](#)
    - [G.5.13 RISC-V Features](#)
    - [G.5.14 RX Features](#)
    - [G.5.15 S/390 and System z Features](#)
    - [G.5.16 Sparc Features](#)
    - [G.5.17 TMS320C6x Features](#)
- [Appendix H Operating System Information](#)
  - [H.1 Process list](#)
- [Appendix I Trace File Format](#)
- [Appendix J .gdb index section format](#)
- [Appendix K Download debugging resources with Debuginfod](#)
  - [K.1 Debuginfod Settings](#)
- [Appendix L Manual pages](#)
- [Appendix M GNU GENERAL PUBLIC LICENSE](#)
- [Appendix N GNU Free Documentation License](#)
- [Concept Index](#)
- [Command, Variable, and Function Index](#)

