HP-UX KWDB Kernel Debugger Guide

HP 9000 and Integrity Server Computer Systems

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Printing History

New editions of this manual will incorporate all material updated since the previous edition. The manual printing date and part number indicate its current edition. The printing date changes when a new edition is printed. (minor corrections that are incorporated at a reprinting do not cause the date to change.) The manual part number changes when extensive technical changes are incorporated.

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About This Document

This manual describes how to debug the HP-UX kernel and drivers and to analyze crash dumps and live systems.

The document printing date and part number indicate the document's current edition. The printing date will change when a new edition is printed. Minor changes may be made at reprint without changing the printing date. The document part number will change when extensive changes are made.

Document updates may be issued between editions to correct errors or document product changes. To ensure that you receive the updated or new editions, you should subscribe to the appropriate product support service. See your HP sales representative for details.

Intended Audience

This document is intended for HP-UX kernel/driver developers.

This document is not a tutorial.

New and Changed Documentation in This Edition

The manual name and part number have both been changed, so this becomes the first edition.

Publishing History

Table 1 Publishing History Details

Document Manufacturing Part Number	Operating Systems Supported	Publication Date
5971-4809	11.23	September 2004
5971-xxxx	11.23	May 2005
5971-xxxx	11.31	October 2006

What's in This Document

The *HP KWDB Kernel Debugger Guide* contains information on debugging:

- *Chapter 1, "Introduction,"* Summarizes what is in this document and provides overview information.
- *Chapter 2, "Setting Up KWDB for Remote Debugging,"* explains how to set up systems.
- *Chapter 3, "Getting Started with Remote Debugging,"* explains debugging sessions.
- *Chapter 4, "Command Reference,"* discusses KWDB and Q4 commands.
- *Chapter 5, "Analyzing Crash Dumps," s*hows how to analyze a crash dump.
- *Chapter 6, "Live Memory Analysis,"* explains live memory analysis.
- *Chapter 7, "KWDB PERL Programming Reference,"* explains how programs can be written in PERL to analyze crash dumps or live or remote systems.
- *Chapter 8, "Command Quick Reference,"* shows the KWDB commands for kernel debugging.
- *Chapter 9, "Troubleshooting,"* recognizing and resolving common problems.
- *Chapter 10, "Guide to Writing KWDB Compatible Code,"* shows how to write code that can be debugged using KWDB.
- "Glossary" — A comprehensive list of terms commonly used in *HP-UX Driver Development* documentation.

Typographical Conventions

This document uses the following conventions.

audit (5)	An HP-UX manpage. In this example, *audit* is the name and *5* is the section in the *HP-UX Reference*. On the web and on the Instant Information CD, it may be a hot link to the manpage itself. From the HP-UX command line, you can enter "`man audit`" or "`man 5 audit`" to view the manpage. See *man* (1).
Book Title	The title of a book. On the web and on the Instant Information CD, it may be a hot link to the book itself.
KeyCap	The name of a keyboard key. Note that **Return** and **Enter** both refer to the same key.
Emphasis	Text that is emphasized.
Bold	Text that is strongly emphasized.
Bold	The defined use of an important word or phrase.
`ComputerOut`	Text displayed by the computer.
`UserInput`	Commands and other text that you type.
`Command`	A command name or qualified command phrase.
`Variable`	The name of a variable that you may replace in a command or function or information in a display that represents several possible values.
`[ ]`	The contents are optional in formats and command descriptions. If the contents are a list separated by |, you must choose one of the items.
`{ }`	The contents are required in formats and command descriptions. If the contents are a list separated by |, you must choose one of the items.
...	The preceding element may be repeated an arbitrary number of times.

| Separates items in a list of choices.

HP-UX Release Name and Release Identifier

Each HP-UX 11i release has an associated release name and release identifier. The *uname* (1) command with the -r option returns the release identifier. This table shows the releases available for HP-UX 11i.

Table 2 HP-UX 11i Releases and Release Identifiers

Release Identifier	Release Name	Supported Processor Architecture
11.11	HP-UX 11i v1	PA-RISC
11.23	HP-UX 11i v2	PA-RISC, IA
11.31	HP-UX 11i v3	PA-RISC, IA

Related Documents

Other documents in this collection include:

- DDK FAQ
- *HP-UX Driver Development Getting Started Guide*
- *HP-UX Driver Development Reference Guide*

HP Encourages Your Comments

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Please include document title, manufacturing part number, and any comment, error found, or suggestion for improvement you have concerning this document. Also, please include what we did right so we can incorporate it into other documents.

Support/Compatibility Disclaimers

Since drivers function at the level of the kernel, Hewlett-Packard Company (HP) reminds you of the following:

- ❏ Adding your own driver to HP-UX requires relinking the driver into HP-UX. With each new release you should plan on recompiling your driver in order to reinstall it into the new HP-UX kernel. Many header files do not change. However, drivers typically use some header files that could change across releases (i.e., you can have some system dependencies).
- ❏ HP provides support services for HP products, including HP-UX. Products, including drivers, from non-HP parties receive no support, other than the support of those parts of a driver that rely on the documented behavior of supported HP products.
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  - HP hardware is not at fault; and
  - HP software (firmware) is not at fault by removing user-written kernel drivers.
- ❏ When HP hardware, software, and firmware are not at fault, you should seek help from the third party from whom you obtained software or hardware.

Reference Documentation

- **Hewlett-Packard Company**
  - *HP-UX Driver Development Reference Guide*
  - *HP-UX Driver Development Guide*

1 Introduction

Just as an application debugger is essential to the development, maintenance, and support of an application program, a kernel debugger is essential to the development, maintenance, and support of an operating system kernel. HP has made available KWDB, the HP-UX kernel debugger and crash analysis tool, to fulfill the needs of lab engineers and field engineers for a tool to provide a means to study the behavior of running systems and to analyze the crash dumps that may be generated when a system terminates.

Run KWDB in three ways:

1. As a remote system kernel debugger.
2. As an on-console or single-system kernel debugger.
3. As a crash dump/kernel memory analysis tool.

As a remote system kernel debugger, KWDB provides source level debugging, which includes access to symbols, variables, and source in addition to the basic features of providing stack traces, examination and modification of memory, control of execution through breakpoints and watchpoints. The remote method of debugging requires at least two systems, the system to debug, called the target, and the system, called the host, where entering the `kwdb` command and `kwdb` runs as a normal user application. This manual discusses how to set up the communication between these two systems, refer to *Chapter 2, "Setting Up KWDB for Remote Debugging."*

As an on-console kernel debugger, KWDB provides assembly level debugging, which although not as powerful as source level debugging still provides a set of debugging commands which allows control of breakpoints, examination and modification of memory, and stack tracing. These commands are documented in *Chapter 3, "Getting Started with Remote Debugging."*

The target will need to be booted with special flags to run KWDB as either a remote system debugger or as a single system debugger. These flags and the boot commands are documented in *Chapter 3, "Getting Started with Remote Debugging,"* as well as how to invoke the KWDB client to connect to the target system.

Although KWDB is based on GDB and KWDB has many of the same commands as GDB, it also supports a superset of commands provided by the HP-UX crash dump analyzer, Q4. *Chapter 3, "Getting Started with Remote Debugging,"* documents the commands available in KWDB.

As a crash dump analysis tool, KWDB allows extraction of information from a crash dump or from the memory devices, `/dev/mem` or `/dev/kmem`, of the local system. Using a local copy of the `vmunix` file KWDB has access to all the debug and symbol information available. Many scripts were developed to analyze crash dumps using Q4. These scripts can also be used by KWDB. *Chapter 4, "Command Reference,"* documents how to analyze crash dumps with KWDB. Since the system memory devices provides the super user with access to the same information on the system as a crash dump, it is easy to use KWDB to perform analysis of a live system, as documented in *Chapter 5, "Analyzing Crash Dumps."*

Chapter 6, "Live Memory Analysis," documents the script interface provided with KWDB. *Chapter 7, "KWDB PERL Programming Reference,"* and *Chapter 8, "Command Quick Reference,"* contain easy to use references. As a kernel engineer read *Chapter 9, "Troubleshooting,"* to better understand the KWDB dependencies in the kernel.

2 Setting Up KWDB for Remote Debugging

To use KWDB as remote kernel debugger at least two systems will be needed; the target system running the kernel that needs to be debugged, and the host system where the KWDB debugger runs as a normal user application. The KWDB debugger running as a user application is referred to as the “KWDB client”. Depending on the type of connection between host and target systems, a “communications server” may need to be run, in addition to KWDB.

This chapter describes how to set up the communication between the host system running KWDB and the target system running the kernel to be debugged. Refer to *Chapter 3, “Getting Started with Remote Debugging,”* for information on how to boot the target system and invoke KWDB to begin the debugging session.

KWDB Setup

KWDB supports two system architectures, PA-RISC and Itanium. On PA-RISC, a wide variety of HP-UX operating systems and machine classes are also supported. Setting up the connection between the target and the KWDB client will be done differently depending on the architecture, machine class and version of HP-UX on the target system. Therefore a need to identify each of these. Use KWDB to debug all HP-UX systems whose OS version is 11.10 and later. Kernels whose OS version is 10.0 to 11.0 were designed to be debugged with a different debugger known as NDDB. However, use KWDB to debug 11.0 and earlier kernels on PA-RISC S700/800 systems (with some limitations) using its nddb-compatibility mode.

There are at present six different methods by which KWDB can communicate with the target system it is debugging, and the details of KWDB setup will vary depending on the communication method chosen. Start by summarizing the different types of communication methods between the host and target machines.

Communication Methods

LAN Communication with Comm Server

This method is communication via a **Local Area Network** (LAN). It is generally the most common method since it is the fastest and most flexible. This method requires that a LAN card be installed on the target system that can be used exclusively by KWDB. This might require installation of an additional LAN card depending on the configuration of the system. It also requires that a communications server, usually referred to as a "comm" server run as a separate process on a machine on the same LAN subnet as the target system. This method of communication uses TCP/IP protocol for communication between KWDB client and communication server. The communication between communication server and target is through Ethernet layer LAN packets.

UDP Communication

This communication method is via the network using UDP/IP protocol. The requirements for UDP communication are the same as for LAN Communication previously described, except that no communications server is needed. This method of communication is supported by HP-UX kernels version 11.22 or later.

Dedicated Device Communication

There are two types of systems which make use of dedicated device communication for remote kernel debugging. They are explained in the following sections:

SUB/SINC The Superdome, Keystone, Matterhorn and Orca systems have a dedicated debugger device that can communicate with KWDB. Superdome, Keystone and Matterhorn systems use the SUB/SINC for all debugger communication.

SONIC LAN V-Class systems have a unique form of communication. The V-Class uses a special type of LAN card called SONIC LAN card for debugger communication. The V-Class system consists of a test station and various partitions. The KWDB communications server runs on the test station and communicates with the different partitions of the V-Class system using Ethernet layer LAN packets. The KWDB client running on a host system communicates with the communications server on the V-Class test station via TCP/IP.

Serial Communication

The serial communication method uses a direct RS-232 connection between the host and target machines. This requires close physical proximity between the host and target systems and is slow. It is not the communication method of choice, will (possibly) be used if an appropriate LAN card is not installed on the target system.

Lantron Serial Communication

This is an RS-232 connection between the target system and a Lantronix box. This method eliminates the need for close physical proximity between the host and target systems, but the connection is still slow.

Console Debugger Communication

This is communication via the target system's on-console debugger. KWDB on a host system can communicate with the on-console debugger on the target system if there is a remote console for the target system. If the target system is 11.11 or later, use the on-console debugger. This method of communication is slow.

How to Select the Communication Method

The selection of communication method depends on the architecture, machine class and operating system version of the target. The following table shows communication methods supported by KWDB for different architecture, machine class and operating system versions. If there are more than one communication methods supported for a combination, they are listed in *Table 2-1, "Communication Methods for Remote Debugging,"* in the order of recommendation. Different notations used in this table are:

C — Console Debugger
D — Dedicated Device
L — LAN with Comm Server
S — Serial / Lantron Serial
U — UDP

Table 2-1 Communication Methods for Remote Debugging

Machine Class/Architecture	11.00	11.10	11.11	11.23	11.31
A Class	L	L	L, C	L, C, S, U	Not Supported
B Class	L	L	L, C	L, C, S, U	Not Supported
C Class	L	L	L, C	L, C, S, U	Not Supported
D Class	S	L	L, S, C	L, S, C	Not Supported
J Class (NonAstro)	L, S	L, S	L, S, C	L, S, C, U	Not Supported
J Class Astro	L	L	L, C	L, S, C, U	Not Supported
K Class	L	L	L, C	L, C	Not Supported

Table 2-1 Communication Methods for Remote Debugging (Continued)

Machine Class/Architecture	11.00	11.10	11.11	11.23	11.31
L Class	L	L	L, C	L, C, S, U	Not Supported
N Class	L	L	L, C	L, C, S, U	Not Supported
T Class	L	L	L, C	L, C	Not Supported
V Class	D	D	D	D	Not Supported
IPF	—	—	—	L, C, S, U	L, C, S, U
Superdome/Matterhorn/ Keystone/Orca	—	—	D, C	D, C	L, D, C, U
PA-RISC new non-cell platforms	—	—	L, C	L, C	L, C

NOTE To determine if a J Class system is Astro based or not, run the `ioscan` command. If the `ioscan` output contains a line for "System Bus Adapter" with "ioa" class, the system is Astro based.

If the machine type is a PA-RISC series 700 or 800, or IPF, the recommended communication method is LAN since it is the fastest. Use serial or Lantron serial only if it is impossible to obtain or install a LAN card that KWDB can use. For the PA-RISC 700/800 or IPF systems, also use Console Debugger Communication if the target's operating system is 11.11 or later. This has the advantage of requiring no special setup to be done (no LAN card installation or cable connections), the only requirement is that the target system must have a remote console implemented via a Lantronix box. The main disadvantage of this communication method is that it is very slow.

If a Superdome, Keystone, Matterhorn or Orca system, use SUB/SINC communication or Console Debugger Communication.

If a V-Class target system, use LAN communication via the SONIC LAN card. Other communication methods are not supported for V-Class.

Determining Machine Class and Operating System

Know the machine class and operating system on the target machine because that determines what kind of host/target communication to be used. On the target system find out the following; what architecture, PA-RISC or Itanium? What machine class? To determine this use the:

```
# model
```

command; a

```
19000/785/C3000
```

response shows that it is a model 9000, series 785 and is a PA-RISC C class machine; an

```
ia64 Intel MP Server
```

response shows that it is an IPF system

What version of the operating system do you have? To determine this, use the:

```
# uname -r
```

command; a

```
B.11.22
```

response shows the kernel is version HP-UX 11.22.

Set Up Instructions

The following sections explain set-up instructions for different communications methods.

LAN Communication with Comm Server

If the system is PA-RISC 700/800, or IPF, then LAN or UDP communication is the preferred method. This method of communication needs a LAN card on the target system dedicated for debugger communication. Determine what LAN cards are installed on the target machine and whether or not any of the LAN cards can be used by KWDB. If none of the LAN cards on the target machine can be used, install the appropriate type of card to use LAN communication. To determine what LAN cards are on the system and which LAN cards can be used by KWDB, and how to obtain the appropriate LAN card, refer to the *LAN Cards* section. For LAN communication with comm server, run a communications server. For instructions on how to run the communications server, refer to the section *KWDB Communications Server*.

UDP Communication

This method of communication is supported by HP-UX kernels version 11.22 or later. UDP communication needs a LAN card on the target dedicated for debugger communication. On PA-RISC systems KWDB can use **btlan** card and on IPF systems KWDB can use **btlan** card, **intl100** card, **igelan** card or **iether** card. To use this type of communication, determine what LAN cards are installed on the target machine and whether or not any of the LAN cards can be used by KWDB. If none of the LAN cards on the target machine can be used, then install the appropriate type of card for UDP communication. To determine what LAN cards are on the system, which LAN cards can be used by KWDB, and how to obtain the appropriate LAN card, refer to the *LAN Cards* section.

UDP protocol is used to communicate between the target and KWDB client, so no communication server is necessary. The target has to be assigned an IP address and gateway. This can be done automatically if a DHCP server is running on the network. Consult with the system administrator to check if DHCP server is running on the network.

Modify the file `/etc/rc.config.d/netconf` on the target system as shown in the following example:

```
# cat /etc/rc.config.d/netconf
```

...some lines omitted here...

```
INTERFACE_NAME[0]=lan1
IP_ADDRESS[0]=15.0.100.224
SUBNET_MASK[0]=255.255.252.0
BROADCAST_ADDRESS[0]=15.244.99.255
INTERFACE_STATE[0]=**
DHCP_ENABLE[0]=0
```

...some lines omitted here...

Change the file by removing the `IP_ADDRESS` value and setting `DHCP_ENABLE` to 1 as shown here:

```
# cat /etc/rc.config.d/netconf
```

```
INTERFACE NAME[0]=lan1
IP_ADDRESS[0]=
SUBNET_MASK[0]=255.255.252.0
BROADCAST_ADDRESS[0]=15.244.99.255
INTERFACE_STATE[0]=**
DHCP_ENABLE[0]=1
```

```
...some lines omitted here...
```

...some lines omitted here...

Reboot the target system and look at the IP_ADDRESS in the same file.

```
# cat /etc/rc.config.d/netconf

...some lines omitted here...
INTERFACE_NAME[0]=lan1
IP_ADDRESS[0]=15.244.99.231
SUBNET_MASK[0]=255.255.252.0
BROADCAST_ADDRESS[0]=15.244.99.255
INTERFACE_STATE[0]=**
DHCP_ENABLE[0]=1
```
...some lines omitted here...

If the DHCP server is running on the system an IP_ADDRESS will have been written into this file. In the previous example 15.244.99.231 is the IP address assigned by DHCP server for lan1.

If DHCP is not running on the network, obtain a valid IP address, and a valid gateway in order to use UDP communication. Its possible to get them from the system administrator. If not, "steal" an IP address and use the gateway from the target system by looking at the file /etc/rc.config.d/netconf. Search the netconf file and identify the LAN card KWDB will use. Refer to the *LAN Cards* section for more details on how to identify the LAN card KWDB will use. The IP address must be the one assigned to the LAN card that KWDB will use. Remove or comment out the corresponding entries from the file /etc/rc.config.d/netconf. Once the IP address and gateway are obtained, write them into the vmunix file that is to be run on the target system. For a PA-RISC system write the IP address to the symbol kgdb_udp_ip_addr; for an IPF system write the IP address to the symbol kdebug_udp_ip_addr. Write the gateway to the symbol kgdb_udp_gateway for PA-RISC and to the symbol kdebug_udp_gateway for an IPF system. Write the information into the vmunix file using KWDB or adb. Here is an example of writing IP address 0x0f0064e0 (15.0.100.224) to the symbol kdebug_udp_ip_addr for IPF kernel.

```
# kwdb -write /stand/vmunix

(kwdb) write 0x0f0064e0 at &kdebug_udp_ip_addr

Writing 4 bytes at 0xe00000010034f9ec in kernel file

Old value : 0x00000000

New value : 0x0f0064e0

(kwdb) quit
```

Once the information is written to the symbols reboot the kernel with the vmunix file that has been changed in order to use UDP communication. For instructions on booting the kernel and starting KWDB for UDP communication, refer to *Chapter 3, "Getting Started with Remote Debugging."* In KWDB 3.1.3, patching the vmunix for hardcoding the UPp IP address is supported through kwdb_config_kern_utility. This can be done by selecting the option "Set/Unset hardcoded IP address for UDP communication" in the main menu of kwdb_config_kern.

Dedicated Device Communication

There are two types of systems which make use of dedicated device communication for remote kernel debugging. They are explained in the following sections:

SUB/SINC If the target is a Superdome, Keystone, Matterhorn, or Orca, the SUB/SINC is used for all debugger communication. There is no need for a communications server or a special LAN card. Refer to *Chapter 3, "Getting Started with Remote Debugging."*

SONIC LAN The V-Class uses only LAN communication via the SONIC LAN card. Other forms of communication such as serial or Console Debugger communication are not supported. The OS version of the kernel must be 11.10 or later, nddb compatibility mode is not supported for the V-Class. The `kwdbd` communications server has to run on the V-Class test station. For instructions on running the `kwdbd` communications server, refer to the section *KWDB Communications Server*. For instructions on booting the kernel and starting KWDB for a V-Class, refer to *Chapter 3, "Getting Started with Remote Debugging."*

Serial/Lantron Serial Communication

If it is necessary to use an RS-232 serial connection, connect a cable directly between the host and target machine or from the target machine to a Lantronix box. No communications server is necessary if using a serial connection.

To set up RS-232 communications, perform the following steps:

1. Ensure the target contains an RS-232 card supported for debugger communications.

   To determine this, use the following rules:

   - For PA-RISC targets with kernel version 11.11 and earlier, KWDB only supports RS232 under Core I/O adapter. To determine if the system has a supported RS232 card use the command `ioscan -f` as shown in this example:

     ```
     # ioscan -f
     Class I  H/W Path  Driver      S/W State  H/W Type   Description
      ============================================================
                    .....Some lines omitted here.....

     ba    2  8/20      bus_adapter CLAIMED    BUS_NEXUS  Core I/O Adapter

                    .....Some lines omitted here....

     tty   1  8/20/2    asio0       CLAIMED    INTERFACE  Built-in RS-232C

                    .....Some lines omitted here.....
     ```

   - For PA-RISC targets with kernel version 11.20 and later, KWDB supports RS232 with driver `asio0`. To determine if the system has a supported RS232 card use the command `ioscan -fC tty`.

     The output of the command should show driver `asio` as shown here:

     ```
     # ioscan -fC tty
     Class     I  H/W Path  Driver  S/W State H/W Type   Description
     ===================================================================
     tty       0  8/16/4    asio0   CLAIMED   INTERFACE  Built-in RS-232C
     tty       1  8/20/2    asio0   CLAIMED   INTERFACE  Built-in RS-232C
     ```

     The driver cannot be of type mux2 (for example, PA-RISC K class has a mux2 driver and so cannot use serial communication). The "Driver" is the important column, information in other columns can vary. For example the "Description" column could show PCI Serial.

   - For Intel IPF systems, KWDB supports RS232 on all IPF systems.

2. Determine which RS-232 port will be dedicated to debugger communications on the target. KWDB will use the rules listed to select the port:

   - For PA-RISC targets, KWDB will choose the second port ("port B" or "serial 2") on the target for debugger communications if a second port exists.

- For PA-RISC targets it is possible to override KWDB's default selection rules and specify which serial port is to be used for debugging by using the `kwdb_config_kern` utility as explained in the *kwdb_config_kern Utility* section.
- For Intel IPF systems, KWDB will choose COM1 on the target for debugger communication.
- For HP IPF systems, KWDB will choose port 2 on the target for debugger communications if a second port exists.
- On IPF systems it is possible to change the default port that KWDB uses for serial communication on the target by using the `-z` option when booting the target system. On an Intel IPF target this option will cause port 2 to be selected and on an HP IPF target, this will cause port 1 to be selected. To override the default port if it is being used for another purpose such as a remote console. See *Chapter 3, "Getting Started with Remote Debugging,"* for information on booting the target system.

3. Set up the serial connection in either of two ways; connect the target and host machines directly, or connect the target machine to a Lantronix device. The advantage of connecting the target machine to a Lantronix device is that the host and target machines do not have to be physically connected, the host can be anywhere as long as it has access to the Lantronix device via the network.

Connecting the Target and Host Directly

The host and target must be close enough to connect a serial cable. Use a DB9 Female/Female null-modem cable to connect the host and target machines. This can be an off-the-shelf cable from a retail outlet.

Connect the serial cable between a serial port on the host and the serial port on the target determined in (step 2) of the Serial/Lantron Serial Communication section. Use port B or serial 2 on the host machine.

To specify the device file corresponding to the port (for example, `/dev/tty1p0`) the `target` command is invoked from KWDB client, as explained in *Chapter 3, "Getting Started with Remote Debugging."*

Connecting the Target to a Lantronix Device

If a Lantronix device is available, it can be connected to the serial port on the target, determined in (step 2) of the Serial/Lantronix Serial Communication section, to the Lantronix port instead of connecting the host and target directly.

Use the standard cable used for a remote console when connecting to a port on the Lantronix device. This can be an off-the-shelf cable from a retail outlet. Note the number of the Lantronix port that it's have connected to.

Set the speed of the Lantronix port that it's been connected to. Do this as superuser on the Lantronix device. If the target machine is a PA-RISC system set the speed of the serial port to 19200. If the target machine is an IPF system, set the speed of the serial port to 57600. For example if on a PA-RISC system and the port number is 14, configuration looks like:

```
LRS32F04:Telnet34>set pri
Password>
LRS32F04:Telnt34>>set port 14 speed 19200
LRS32F04:Telnt34>>show port 14

Port 14: Username:             Physical Port 14 (Idle)

   Char Size/Stop  Bits:8/1    Input Speed:      19200
   Flow Ctrl:          None    Output Speed:     19200
   Parity:             None    Modem Control: Disabled

   Access:           Remote    Local Switch:      None
   Backward:           None    Port Name:      Port_14
```

```
Break Ctrl:        Local    Session Limit:        4
Forward:            None    Terminal Type: Ansi(HP)
```

If the target machine uses a port on the Lantronix device for its remote console, the same port cannot be used, connect the second serial port of the target to a different port on the Lantronix. When issuing the commands to connect KWDB to the remote target, the name of the Lantronix device and the port number are needed. See *Chapter 3, "Getting Started with Remote Debugging."*

Console Debugger Communication

All HP-UX kernels version 11.11 or later have a debugger called the on-console or single system debugger embedded in the kernel which can be accessed via the system console. If the target system is 11.11 or later use the on-console debugger. The on-console debugger has a limited set of commands and allows assembly level debugging only. KWDB on a host system can communicate with the on-console debugger on the target system if there is a remote console for the target system. This allows for the use of the full set of KWDB commands with no extra communications setup. To do this, see *Chapter 3, "Getting Started with Remote Debugging."*

LAN Cards

If the target system is a PA-RISC Superdome, Keystone or Matterhorn this chapter can be skipped. These systems communicate with KWDB via a dedicated device. The V-Class target always uses the SONIC LAN card so the information in this chapter is not needed, however for the V-Class needed to run the `kwdbd` communications server on the test station. (See the section *KWDB Communications Server*.)

To use LAN communication between the host and target, there must be a LAN card on the target that is dedicated for use by KWDB. This dedicated LAN card can not be used for HP-UX networking, so it may be necessary to install an additional LAN card on the target system if networking is desired while debugging. KWDB does not support all LAN cards on all HP-UX systems so determine what LAN devices are installed in the target system. If the system is PA-RISC S700 or S800 series, see the *LAN Cards for the PA-RISC Architecture* section. If the system is IPF see the *LAN Cards for the IPF Architecture* section.

LAN Cards for the PA-RISC Architecture

To determine what LAN devices are installed on the target system, issue the command:

```
# ioscan -fC lan
```

See something like the following:

```
# ioscan -fC lan

Class  I  H/W Path   Driver S/W State  H/W Type  Description
===================================================================
lan    0  10/0/12/0  btlan  CLAIMED   INTERFACE  HP PCI 10/100Base-TX Core
lan    1  10/1/5/0   btlan  CLAIMED   INTERFACE  HP A5230A/B5509BA PCI 10/100Base-TX
Addon
```

The important things to look at in the output are the Driver column and the H/W Path column. The following drivers are supported by KWDB for LAN communication with comm server:

```
lan2
lan3
btlan
btlan3
btlan5
```

The following drivers are not supported by KWDB:

```
btlan4
btlan6
lan6
token2
```

KWDB supports only `btlan`, `btlan3`, and `btlan5` drivers for UDP communication. The output of the `ioscan` command shows that either the LAN card at hardware path 10/0/12/0 or the one at 10/1/5/0 can be used by KWDB. By default, KWDB will choose the first LAN card it is capable of using at the lowest hardware address. Therefore in the previous example, it will use the card at the hardware path 10/0/12/0. It is possible to configure the kernel to override the default rules for selecting a LAN card and use a specific hardware path using the `kwdb_config_kern` utility. See the *kwdb_config_kern Utility* section for information on `kwdb_config_kern`.

When the KWDB client is invoked later for LAN communication with comm server, you will need to know the Ethernet MAC address (or Station Address) of the LAN card that KWDB will use. To find this out, use the `lanscan` command:

```
# lanscan

Hardware  Station        Crd Hdw   Net-Interface  NM  MAC     HP-DLPI  DLPI
Path      Address        In# State  Name  PPA     ID  Type    Support  Mjr#
10/0/12/0 0x001083F94458  0   UP    lan0 snap0    1   ETHER    Yes     119
10/1/5/0  0x001083F6AF66  1   UP    lan1 snap1    2   ETHER    Yes     119
```

In the example, the Ethernet MAC address to use when invoking KWDB is `0x001083F94458` because it corresponds to the hardware path of the LAN card that KWDB will use.

Not all drivers are supported on all classes of machines on all versions of HP-UX. Which drivers are supported depends on the version of the operating system (which was previously obtained with the `uname -r` command) and the class of machine (which was previously obtained with the `model` command).

The later the release of HP-UX, the more types of LAN drivers are supported. The following *Table 2-2, "LAN Drivers for 11.10 or Later,"* gives an estimate of what LAN drivers are supported on version 11.10 or later

Table 2-2 LAN Drivers for 11.10 or Later

Machine Class	lan2	lan3	btlan	btlan3	btlan5
A			X	X	X
B			X	X	X
C	X		X	X	X
D (low end)	X				
D (high end)					
IPF			X	X	X
J (non-astro)	X				
J (astro)			X	X	X
K	X	X			
L			X	X	X
N			X	X	X
R	X				
T		X			

The following *Table 2-3, "LAN Drivers for 11.0,"* gives an estimate of what LAN drivers are supported on version 11.0. Support for the `btlan` drivers on 11.0 *requires* that the patch **PHKL_18543** be installed on the system.

Table 2-3 LAN Drivers for 11.0

Machine Class	lan2	lan3	btlan	btlan3	btlan5
A			X	X	X
B			X	X	X
C			X	X	X
D (low end)					
D (high end)					
J (non-astro)			X	X	X
J (astro)					
K		X			
L			X	X	X
N			X	X	X
R					
T		X			

The following *Table 2-4, "LAN Drivers for 10.20 and 10.30,"* gives an estimate of what LAN drivers are supported on versions 10.20 and 10.30

Table 2-4 LAN Drivers for 10.20 and 10.30

Machine Class	lan2	lan3	btlan	btlan3	btlan5
A					
B					
C					
D (low end)					
D (high end)					
IPF					
J (non-astro)					
J (astro)					
K		X			
L					
N					

Table 2-4 LAN Drivers for 10.20 and 10.30 (Continued)

Machine Class	lan2	lan3	btlan	btlan3	btlan5
R					
T		X			

LAN Card Selection Rules for 11.10 and 11.11

The rules for selecting LAN cards for OS version 11.10 and 11.11 are:

1. KWDB uses the supported PCI **btlan** card at the lowest hardware address.
2. If there is no supported PCI **btlan** card then it chooses an NIO LAN card with a `lan3` driver.
3. If there is neither a supported PCI `btlan` or an NIO LAN card, it chooses a LASI LAN card with a `lan2` driver.

LAN Card Selection Rules for 11.23 and Later

The rules for selecting LAN cards for OS version 11.23 and later are:

1. KWDB uses the supported PCI **btlan** card.
2. If there is no supported PCI **btlan** card then it chooses an **intl100** card.
3. If there is not **btlan** or **intl100** card then it chooses **igelan** card.
4. If there is no **btlan** or **intl100** or **igelan** card then it chooses ieither card.

If there are multiple cards of the same type KWDB chooses the card at the lowest hardware address.

LAN Card Selection Rules for 11.31 and Later

The 11.31 version of the kernel debugger implements a *preference ordering* for LAN drivers. When booted with a specific preference order, the kernel debugger attempts to *steal* a LAN card belonging to that driver. If, however, no card of that specified driver is found, or could not be claimed due to a hardware problem or if no cable is connected to the card, the kernel debugger detects that condition, and attempts to select another card belonging to the next driver in the *preference list*. The search continues till a LAN card is found. If the user wishes, he can abort this behavior by pressing control C at the system console after the search for a card for the initially preferred driver is completed. The preference list for LAN drivers in 11.31 kernels is::

1. **btlan:** by default -dlan or -dudp would attempt to select a btlan card. If -dlan.btlan is specified, btlan card is searched for.
2. **igelan:** If no btlan card is found, kernel debugger attempts to take an igelan card.
3. **intl100:** If there is no btlan or igelan card, kernel debugger attempts to choose an intl100 card.
4. **iether:** If there is no btlan or igelan or intl100 card, then kernel debugger attempts to choose an iether card.

If booted with -dlan.igelan, the preference list is igelan, btlan, intl100, iether. Likewise, if booted with -dlan.intl100, then preference order is intl100, btlan, igelan, iether, and if booted with -dlan.iether, then preference order is iether, btlan, igelan, and int100.

Which LAN Card to Install

If the machine does not have a LAN card that KWDB can use, the system administrator will need to install one. For the `lan2` driver, install a card that supports NIO LAN (sometimes referred to as HP-PB) on the system. For the `lan3` driver, install a card that supports LASI 10BaseT LAN on the system. For any `btlan` driver, install a card that supports PCI 10/100 BaseT LAN on the system. See the *How to Obtain a LAN Card* section for information on purchasing LAN cards for the target system.

NOTE Multiport **btlan** cards are not supported by KWDB in operating systems prior to the 11.31 release. In 11.31, 4 port btlan cards are supported by KWDB on both PA-Risc and IPF platforms.

LAN Cards for the IPF Architecture

Selecting LAN cards for the IPF architecture is simpler than it is for PA-RISC. For the IPF architecture, use a **btlan** card, a built-in **intl100** card, an add-on **intl100** card, an **igelan** card, or an **iether** card.

The rules for IPF are summarized in *Table 2-5, "LAN Cards/IPF Version."*:

Table 2-5 LAN Cards/IPF Version

Machine Class/Kernel Version	btlan	intl100	igelan	iether
IPF/pre 11.22	X			
IPF 11.22	X	X		
IPF 11.23 or later	X	X	X	X

If the kernel is earlier than version 11.22, then KWDB uses the **btlan** card with lowest hardware address. Add a **btlan** card to the system, because they are not standard on IPF systems. Even if the system has a **btlan** card, the `ioscan` command will probably not show it because `btlan` drivers are not usually built into the IPF kernel.

If the kernel version is 11.22 KWDB will select the **btlan** card with lowest hardware address. If there is no **btlan** card installed on the system KWDB will select the **intl100** card with the lowest hardware address.

If the kernel version is 11.23 or later KWDB will select the **btlan**, **intl100**, **igelan** or **iether** card in the order. It is possible to select a particular type of card for KWDB communication by specifying it along with -d boot option. For instance, -dlan.btlan will select the **btlan** card, `-dlan.intl100` will select the **intl100** card, `-dlan.igelan` will select the **igelan** card and `-dlan.iether` will select the **iether** card. If there are multiple cards of the same type specified the card with lowest hardware address will be selected.

If the target system is an Intel IPF system, use the `kwdb_config_kern` utility to select the hardware address of the LAN card to be used. See the *kwdb_config_kern Utility* section for information.

To find the hardware address of the LAN devices on the target system, issue the command:

```
# ioscan -fC lan
```

Results are like the following:

```
# ioscan -fC lan
Class  I  H/W Path    Driver  S/W State H/W Type     Description
=============================================================================
lan    0  0/16/1/5/0  intl100 CLAIMED   INTERFACE    Intel PCI Pro 10/100Tx Server
Adapter
```

How to Obtain a LAN Card

If the target Operating System version is 11.31 or later, the kernel debugger supports the following set of cards. Kernel debugger does detect any other card (that is not specified in the list below) during its hardware scan, but does not select them for kernel debugging.

Table 2-6 Description of LAN cards supported by kernel debugger in HPUX 11.31

Card (driver) type	PCI ID		PCI Subsystem ID		Description
	Vendor ID	Device ID	Vendor ID	Device ID	
btlan	0x1011	0x0019	0x103c	0x104f	HP PCI 10/100Base-TX 21143 (btlan) 1 port adapter - core
	0x1011	0x0019	0x103c	0x1066	HP PCI 10/100Base-TX 21143 (btlan) 1 port adapter - addon Part no: A5230A/B5509BA
	0x1011	0x0019	0x103c	0x125a	HP PCI 10/100Base-TX 21143 (btlan) 4 port adapter - addon. Part no: A5506B
igelan	0x14e4	0x1644	0x103c	0x12a4	HP Gigabit Ethernet NIC bmc5700 adapter - core
	0x14e4	0x1645	0x103c	0x128a	HP Gigabit Ethernet NIC bmc5701/TX adapter - addon. Part no: A6825-60101
	0x14e4	0x16a7	0x103c	0x12a5	HP Gigabit Ethernet NIC bmc5703/TX adapter - addon
	0x14e4	0x1648	0x103c	0x12a6	HP Gigabit Ethernet NIC bmc5704/TX adapter - addon
	0x14e4	0x1645	0x103c	0x12ca	HP BCM95703C30 PCI/PCI-X 1000-BaseT FC/GigE Combo adapter in core for Kona IPF
	0x14e4	0x1645	0x103c	0x1328	HP PCI-X 1000Base-T Dual-port Built-in (igelan) adapter in core for Hurricane/Kona IPF Blades
	0x14e4	0x1645	0x103c	0x12c1	HP A7109-60001 PCI (igelan) 1000Base-T Core

Table 2-6 Description of LAN cards supported by kernel debugger in HPUX 11.31

Card (driver) type	PCI ID		PCI Subsystem ID		Description
	Vendor ID	Device ID	Vendor ID	Device ID	
iether	0x8086	0x100e	0x103c	0x12a6	Intel PCI 1000 Base dual port Anvik2/T (iether) adapter. Part no: A7012-60001
	0x8086	0x1079	0x103c	0x1274	Intel PCI Kenai-32 (iether) adapter
	0x8086	0x1079	0x103c	0x12d1	HP AB290-60001 U320/1000Base-T SCSI Combo (iether) adapter - in core for Mittlehorn IPF
	0x8086	0x1079	0x103c	0x12d3	HP AB545A-60001 dual/Anvik2 4-port 1000B-T (iether) adapter - in core for Mittlehorn IPF
intl100	0x8086	0x1229	0x103c	0x3000	Intel PCI Pro 10/100Tx Server (intl100) adapter - core
	0x8086	0x1229	0x103c	0x1280	Intel PCI Pro 10/100Tx Server (intl100) adapter - adapter

If the target system is IPF or a PA-RISC system with support for the `btlan` driver, obtain and install a PCI 10/100 LAN B5509BA 10BaseT and 100BaseT RJ45 UTP, half-size PCI Universal Card. To obtain this card, contact an HP support representative or visit the following web site:

`http://www.hp.com/workstations/products/accessories/unix/io_cards/b5509ba/summary.html`

If the target system is IPF and the OS version is 11.22 or later, KWDB supports the intl100 driver and the Intel 100+ PCI **Network Interface Card** (NIC) can be used, which can be obtained from a retail outlet.

It might be difficult to obtain LAN cards for older systems which only support the `lan2` or `lan3` drivers. Contact an HP support representative for assistance.

KWDB Communications Server

If using a LAN connection between the host and target system, and the target is PA-RISC S700/800, IPF, or V-Class, also run the communications server. The communications server runs as a daemon process. For PA-RISC S700/800 and IPF the system it runs on must be on the same LAN subnet as the LAN card on the target system. To determine this, run the `ping` command with the `-o` option on the system the communications server will run on. An example, if the target system is named target1, run.

```
ping -o target1
```

Then **Ctrl-c** after a few seconds to stop the `ping` command. If the `ping` command prints only two systems after the **Ctrl-c** they are on the same subnet.

```
# ping -o target1
PING target1.aa.bb.com: 64 byte packets
64 bytes from 11.0.99.222: icmp_seq=0. time=0. ms
^C
----target1.aa.bb.com PING Statistics----
1 packets transmitted, 1 packets received, 0% packet loss
round-trip (ms)  min/avg/max = 1/1/1
1 packets sent via:
        11.0.99.222     - target1.aa.bb.com
        11.0.100.111    - system1.aa.bb.com
#
```

For V-Class targets, the communications server *must* run on the V-Class test station.

Which Communications Server to Use

Use one of two communications servers depending on the version of HP-UX on the target system. If using version 11.10 or later, use `kwdbd`. If using version 11.0 or earlier on a PA-RISC S700/800 target use `nddbcs`. Debugging a V-Class with KWDB on an OS earlier than 11.10 is not supported.

How to Start the Communications Server

Both `kwdbd` and `nddbcs` are installed in `/usr/contrib/kwdb/bin`. The syntax for starting the communications server is either:

```
# /usr/contrib/kwdb/bin/kwdb [options]
```

or

```
# /usr/contrib/kwdb/bin/nddbcs [options]
```

The options may be any of the following:

`-d`

Execute the communications server in a daemon process.

`-f` *device*

Specify a device for LAN communications with the target systems. This parameter has a different syntax depending on the OS version. For 10.20 and earlier the format is `-f/dev/lan`<number> where <number> is 0, 1 and so forth. For example, `-f/dev/lan0`. For OS versions 10.30 and later the format is `-flan`<number> where <number> is 0, 1 and so forth. The default device is `/dev/lan0`, or `flan0`, depending on the version of the operating system. For a V-Class, the device file depends on the type of test station. If the test station is a 712, then use `lan1`. If the test station is a B-Class, then use `lan0`. Otherwise consult with the system administrator to determine the device to specify for the V-Class. More than one device may be specified, each preceded by `-f`. It might be necessary to specify more than one device if the machine on which the communications server runs has more than one `lan` device in `/dev`. To determine this, use the command:

```
# ls /dev/lan*
```

If the command showed `/dev/lan0` and `/dev/lan1` for example, then specify both `lan0` and `lan1` for the `-f` option.

How to Ensure Communications Server is Running

If running `kwdbd`, issue the command:

```
# ps -ef | grep kwdbd
```

If running `nddbcs`, use the command:

```
# ps -ef | grep nddbcs
```

Communications Server Log Files

The KWDB communications servers log information about host/target connections in a log file. For the `kwdbd` communication server the log file is `/var/opt/kwdb/kwdbd.log`. For the `nddbcs` communication server, the log file is `/var/opt/nddb/nddb_error_log`.

If there are problems connecting to a target machine and have verified that both target and communication server are in the same subnet, the appropriate communications server is running and the log file does not contain any possible errors, verify LAN connectivity between communication server and the target using the command:

```
# linkloop <ethernet_MAC_address>
```

Where `ethernet_MAC_address` is the ethernet MAC address of the target LAN card. Make sure that the target system is up and running, when the `linkloop` command is run.

Starting Communications Server at Boot Time

Arrange to start the `kwdbd` communication server at boot time by editing the file `/usr/contrib/kwdb/newconfig/etc/rc.config.d/kwdbd`.

Change the value of `KWDBD_START` from 0 to 1, and change `KWDBD_RS` to contain the `-f` option. Comments in this file are self explanatory.

Communications Server Configuration File

Make connecting to the target system more user friendly by editing the file `/etc/opt/kwdb/kwdbd.conf`. This file provides a correlation between the Ethernet MAC address of the target system and the name of the target system. It also allows defining of a default target machine. When invoking KWDB to connect to the target system, ordinarily specify the Ethernet MAC address of the LAN card on the target system. (See *Chapter 3, "Getting Started with Remote Debugging,"* for a description of how to connect to the target system.)

If the `kwdbd.conf` file is edited to correlate the machine name with the Ethernet MAC address, specify the machine name instead of the Ethernet MAC address when using KWDB's `target` command. This file contains self-explanatory comments. The format of the file is as follows:

```
#       Uncomment and edit as appropriate for the system:

#       Directive  Machine name       Ethernet address
#       ---------  ------------       -----------------
#
#       map        cheetah            0x0800099a1234
#       map        panther            0x0800099b5678
#       default    cheetah

        map        uxho0325           0x080009932b50
        map        nddb6              0x080009419358

        default    nddb6
```

The previous example specifies that the machine `uxho0325` has the Ethernet MAC address `0x080009932b50` and the default machine to connect to is `nddb6`. Set the file permission of `kwdb.conf` to world-writable by system administrator, so the users can edit this file to add new entries.

kwdb_config_kern Utility

It is possible to modify the vmunix kernel to change the communications device that KWDB uses on the target system using a script called kwdb_config_kern. This can be done for PA-RISC and Intel IPF target systems (this utility does not function on HP IPF systems). Also, this utility can be used to turn early boot code debugging on or off. This utility works only on kernels whose OS version is 11.10 or later. for options that require patching of vmunix, it must be run on the target system, and the system must be rebooted with the same vmunix kernel that has been modified for the changes to take effect. To execute kwdb_config_kern, enter:

```
# kwdb_config_kern kernel_file
```

Where kernel_file is the kernel file, usually vmunix, that runs on the target system.

The system displays a self explanatory menu of options:

```
kwdb_config_kern version 3.1.1 --KWDB target kernel configurator.
KWDB kernel configuration Main Menu.


1. Set/unset hardcoded communication device for host to target communication.
   (to be used prior to booting).
2. Turn on or off lan or serial port based boottime debugging.
   (to be used prior to booting).
3. Initialize the kernel debugger at runtime.
4. Display connection status of the kernel debugger.
5. Set/unset the IP address for UDP/IP communication.
0. Exit kwdb_config_kern.


Choose an action by number from the above list.
```

If #1, kwdb_config_kern is chosen, it can scan the system and present a list of communications devices, or an option that will allow the hardware path of the communications device to be entered directly. The hardware path must appear exactly as it is shown by the ioscan or lanscan commands, for example; 8/0/1/0. The hardware path for both serial and LAN communication can be changed.

If the early boot code debugging option (option #2) is selected, a prompt to enter “yes” or “no” to turn it on or off. The kwdb_config_kern script will modify the vmunix kernel, for the changes to take effect, reboot the target system using this kernel.

If #3 option is selected, kwdb_config_kern would initialize the kernel debugger at runtime. This feature is available for 11.31 kernels and beyond. Currently runtime initialization of kernel debugger is possible for sub/sync based remote debugger and console debugger only. If option #4 is selected, kwdb_config_kern displays the kernel debugger connection status. If the target kernel was booted without any kernel debugger options, then it prints Kernel debugger is not initialized, otherwise, if booted with any of the kernel debugging options, it prints the type of communication. This option can be used to determine the MAC address of the LAN card or the UDP IP address being used for *boot-nowait* mode of kernel debugging when debugging with LAN or UDP modes respectively. Usage of options #3 and #4 does not require booting of the target system.

If #5 is selected, `kwdb_config_kern` allows the user to hardcode the vmunix with an IP address for UDP based communication. Once this is done, for changes to take effect, the target system has to be rebooted. Option #5 would not be printed for operating system versions prior to 11.22, because UDP-based remote debugging was not supported in those kernels.

kwdbctl Utility

The kwdbctl utility allows you to query and to control the state of the kernel debugger in a native system. This utility has the capability to set dynamically attributes inside kernel debugger stub, and also to print the hw_path of the kernel debugger remote communication device. This utility has support for online initialization of the kernel debugger through lan, sub/sync, and console modes of communication. It prints the output in machine readable format. This utility should be used as a superuser.

Usage

```
kwdbctl -v
kwdbctl -q | -m
kwdbctl -i <connection>
kwdbctl -d | -D
kwdbctl -s attribute=value
```

The various options supported by kwdbctl are:

- `-v`: print version information and then exit.
- `-q`: queries kernel debugger parameters on native system

  If the kernel is booted with option for debugging with LAN ,then `kwdbctl -q` gives the details of LAN card selected for communication with the host and also prints the MAC address of the LAN card which can be used for connecting from the remote system.
- `-m`: same as `-q`, prints output in machine readable format
- `-i` *`connection`*: initializes native system for kernel debugging with the specified connection. The *`connection`* can be one of the following:
  - For cell platforms: "sub" or "console" or "lan" or "crash"
  - For non-cell platforms: "console" or "lan" or "crash"
- `-d`: destroys kernel debugger from native system
- `-D`: force destroys the kernel debugger from native system, and any breakpoints that were set by the client (if any attached), are removed from the target memory.
- `-s` <attrib>=<value>: set attributes inside the kernel debugger.

Supported attributes:

nodeconfig:

value can be 1 (kernel debugger cannot be deconfigured)

value can 0 (kernel debugger can be deconfigured). When turned on, the debugger would fail the cell OLD requests if its remote communication device belongs to the cell being OLD'd.

pci_ola_card_claim:

value can be 1 (pre-initialize stub for remote debugging upon a future PCI OLA)

value can be 0 (to un-init a pre-initialized stub).

To configure for crashtime waiting after system boot.

crash_wait_timeout:

value can be 1 (enable timeout for crashtime remote attachment for 5 mins).

3 Getting Started with Remote Debugging

KWDB uses two primary systems during a remote debugging session:

1. The host system, which runs the KWDB debugger client.
2. The target system, which runs the kernel to be debugged.

KWDB can debug three types of target HP-UX operating systems: 32 bit PA-RISC, 64 bit PA-RISC and IPF. The host system where KWDB runs need not match the target system in terms of architecture or operating system version. Whether the host system is 32 bit PA-RISC, 64 bit PA-RISC or IPF, debug any kind of target. The only limitation is that if the host system is PA-RISC it's operating system must be version 10.20 or later.

Because the kernel itself is being debugged, KWDB cannot run on the system that is being debugged. Instead, it is a remote debugger which runs on a separate system (referred to as the "host" system) and communicates with the system being debugged (referred to as the "target" system). There are at present six different methods by which KWDB can communicate with the target system it is debugging:

1. LAN Communication with Comm Server — Communication via a **Local Area Network** (LAN). This usually may require that an additional LAN card be installed on the target system. It also requires that a communications server run as a separate process.
2. Serial Communication — A direct RS-232 connection between the host and target machines. This requires close physical proximity between the host and target machines and is slow.
3. Lantron Serial Communication — This is an RS-232 connection between the target system and a Lantronix box. This eliminates the need for close physical proximity between the host and target systems but the connection is still slow.
4. Dedicated Device Communication:

   SUB/SINC: The Superdome, Keystone, Matterhorn and Orca systems have a dedicated debugger device that can communicate with KWDB. They use the SUB/SINC for debugger communication.

   SONIC LAN: V-Class systems have a special type of LAN card called SONIC LAN for debugger communication.
5. Communication via the Target system's console debugger — If the target system has a remote console and the operating system is version 11.11 or later, use this communication method.
6. UDP Communication — Communication using UDP between host and target systems. This usually may require that an additional LAN card be installed on the target system. The OS version of the kernel must be 11.22 or later.

This chapter assumes that any special setup and installation required to use the above communication methods has already been done. For setup and installation instructions and more detail about the communication methods, refer to *Chapter 2, "Setting Up KWDB for Remote Debugging."*

To use KWDB to debug the kernel, the kernel's version must be 11.10 or later. However, KWDB can be used to debug 11.0 and older kernels (with some limitations) using its nddb-compatibility mode (NDDB is the name of a previous HP kernel debugger). Chapter 2, "Setting Up KWDB for Remote Debugging," on page 19 describes how to do this. The remainder of this chapter describes how to boot the target kernel and invoke KWDB for remote debugging depending on the type of target machine being debugged and the communication method used.

Before Starting a KWDB Debug Section

To use KWDB, the following is needed:

- Host system, with KWDB installed.
- Target system, booted for debugging. If the target operating system version is 11.31 and beyond, kernel debugging can be achieved without having to boot the kernel debugger options.
- If using LAN communications with comm server, a communications server, on which the communications daemon *kwdbd* is running. This must be on the same subnet as the target system. The host system itself can be used as communication server provided the target system is on the same subnet.
- Copy of the kernel that's to be debugged must reside on both the host and target systems. Any source files that are to be symbolically debugged must also be present on the host. Copy those files to the host system.
- Edit `/etc/opt/kwdbd/kwdbd.conf` to add the name of the machine along with its ethernet MAC address, so that *kwdbd* can find the test machine by name.

Starting KWDB Debug Session

To start a KWDB kernel debugging session, start KWDB on the host system, boot the target system, and attach the host debugger client to the target system.

The following sections describe the processes to establish a KWDB debugging session:

- *Starting the KWDB Debugger on the HOST system*
- *Booting and Attaching the Target System for Debugging*
- *Booting the kernel without debugger options and initializing kernel debugger later (for Operating Systems starting from 11.31 and beyond)*

Starting the KWDB Debugger

Start KWDB on a copy of the target kernel executable file on the host system. The KWDB run string syntax is:

```
kwdb kernel_file
```

where *kernel_file* specifies the pathname of the host's copy of the target's kernel file.

As mentioned earlier, this kernel file must be the same as the kernel file booted on the target system. If doing source level debugging, have the source files that were compiled with debug flags present on the host system. If the source files are not in the default path searched by KWDB, tell KWDB where to find them by using the KWDB command:

```
dir path-name
```

where *path-name* is the directory path to the location of the source files.

KWDB supports the following interfaces:

- Default command line interface.
- The DDD interface, a widely used free software graphical user interface for GDB.

To start KWDB in XDB compatibility mode, which allows for use of XDB commands, use the `-xdb` option. The following example shows how to start KWDB in XDB compatibility mode.

```
% kwdb -xdb vmunix
```

To start KWDB with the DDD interface, use the following example:

```
% ddd -debugger kwdb vmunix
```

To automatically execute KWDB commands on each invocation of the debugger, enter commands into one of the KWDB init files, `$HOME/.kwdbinit` and `./.kwdbinit` (where . refers to the current directory from which KWDB is run). The commands in `$HOME/.kwdbinit` will be executed first followed by those in `./.kwdbinit`

Booting and Attaching the Target System for Debugging

To prepare for a debugging session, reboot the target system or attach to a running kernel on the target, if debugging has been previously enabled. In either case, the target must have KWDB debugging enabled before attaching the target with the KWDB client on the host system. This is normally done by booting the target using the flags defined in the subsections of this chapter.

Methods of Booting Target System

Select one of the two different methods to boot the target for debugging:

1. Boot-and-wait for client connection.
2. Boot-without-wait for client connection.

The method selected determines “the first breakpoint” and when to attach the host to the target for debugging.

- ❏ Boot-and-wait for Client Connection

  The first breakpoint is the place at which the target kernel is positioned after establishing the connection. Ordinarily, when the kernel is booted with a boot flag for boot-and-wait that enables debugging, the kernel will stop early in the boot process and print the message `waiting for kernel debugger to attach`. It is at that point that the KWDB `target` and `attach` commands are issued on the host system. When the target is booted to wait for a debugger client to attach, the target is positioned at KWDB’s initial connection point. Begin issuing KWDB commands to set breakpoints, examine registers and memory etc. In order for the kernel to continue the boot process, enter the KWDB `continue` command which can be abbreviated as “c”. The point in the bootup sequence at which this first breakpoint occurs may vary by target platform and kernel capability. If the platform has early boot code debugging capability, KWDB normally connects at the end of routine `monarch_init()`, early in real-mode initialization. Targets debugged via PCI LAN currently attach later, during virtual-mode I/O configuration. For 11.31 and beyond, it is possible to debug the kernel much earlier (as mentioned above).

- ❏ Boot-without-wait for Client Connection

  The target system can be booted with a boot flag for boot-without-wait that enables debugging. In this method target system does not stop and wait for the KWDB target and attach commands; instead it completes the boot process. Attach KWDB to the target system at any time using the `target` and `attach` commands.

NOTE If the code needed to debug is only executed during bootup time before the first breakpoint, KWDB cannot be used to examine the code. This includes portions of the code for `$locore`, `realmain()`, and `monarch_init()`.

The commands and process used to boot and attach the host to the target depend on the following factors:

- Type of target system; S700/S800, V-Class, Superdome, Keystone, Matterhorn, Orca, IPF.
- Communication method: LAN with comm server, RS-232, Lantron serial, SUB/SINC, Console, UDP.
- Type of attachment: boot-and-wait or attach to a running kernel.
- In pre 11.31 Operating Systems, the initial breakpoint is at kernel’s kgdb_break for PA kernels and kdebug_kern_break for IPF kernels. In 11.31 kernels, initial breakpoint is very early in the kernel boot - for sub/sync communication on cell platforms, the kernel can be debugged from the very first function of the kernel, for other remote communications it can be debugged after the 10th function of the kernel on IPF and 18th function on PA-RISC.

For console debugger, kernel can be debugged after kernel's in-core symbol table is created (which is after the 4th function of the kernel boot process). If console target mode of remote communication is used, remote source level debugging can be achieved from that point onwards. For other remote communications (lan, udp, serial), kernel debugger's routine for the first breakpoint is kwdb_boot_init() on PA-RISC (which is called at the end of monarch_init() - which is the 18th function called from realmain calllist during boot), and kwdb_boot_init_lan_serial() on IPF (which is called after ACPI subsystem is initialized - which is the 10th function called from sysinit calllist).

The kernel debugger's routine for the first breakpoint is kwdb_boot_init() on PA-RISC (which is called at the end of monarch_init()) and kwdb_boot_init_lan_serial() on IPF.

The following sections describe the procedures for specific configurations.

Debugging Superdome/Matterhorn/Keystone/Orca with Firmware sub/sync

For a PA system, boot the target machine to ISL, and enter one of the following at the ISL> prompt:

```
ISL> hpux -f0x8002 kernel_file
```

For 11.31 and beyond, users can use a more friendly command from the ISL. This is a platform-independent method:

```
ISL> hpux kernel_file kwdb_flags=sub
```

```
(for backward compatability reasons, bothe the -f and kwdb_flags method work)
```

(Boot-and-wait) The kernel stops and waits for a client connection during the bootup sequence, rather than booting up normally.

For pre 11.31 kernels,

```
ISL> hpux -f0x8000 kernel_file
```

For 11.31 and beyond, users can use the platform independent kwdb_flags environment variable from ISL:

```
ISL> hpux kernel_file kwdb_flags=sub.nowait
```

(Boot-without-wait) Attach the debugger client to the target at a later time.

For an IPF system boot the target as follows:

```
HPUX > boot kernel_file -dsub
```

(Boot-and-wait) The kernel stops and waits for a client connection during the bootup sequence, rather than booting up normally.

```
HPUX > boot kernel_file -d0x41
```

(Boot-without-wait) Attach the debugger client to the target at a later time. For 11.31 kernels, the platform independent kwdb_flags environment variable method works on IPF also.

After booting the target, run KWDB on the host system as follows:

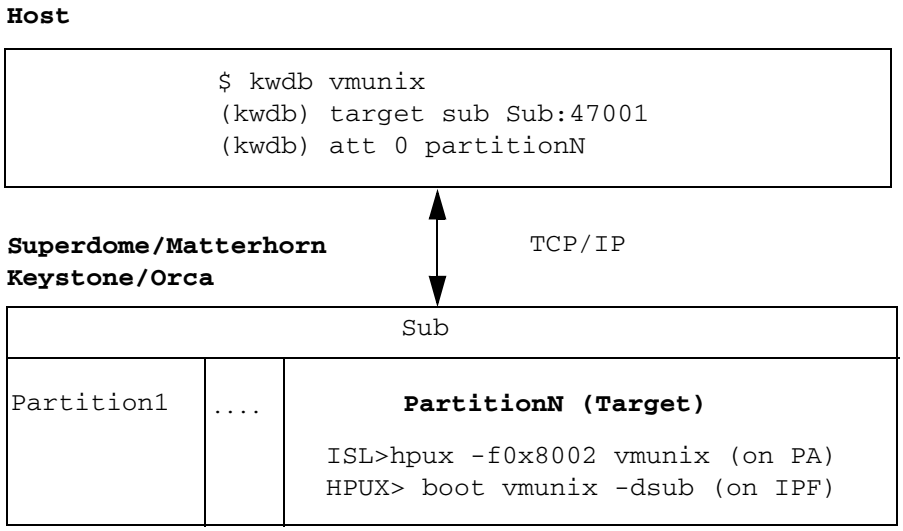
```
$ kwdb kernel_file
(kwdb) target sub name_of_sub[:47001]
(kwdb) attach 0 partition_name
```

kernel_file	Specifies the name of the host's copy of the kernel executable file booted on the target.
name_of_sub	Specifies the name of sub for Superdome communication.
:47001	Specifies the port number. This value is included only if file /etc/services on the host does not define service *kwdbd* as TCP port 47001.

partition_name Specifies the name of the partition to debug. This name is case sensitive. If the partition name contains white space, it must be surrounded by double quotes.

This is shown in *Figure 3-1, "Debugging Superdome/Matterhorn/Keystone/Orca Target."*

Figure 3-1 Debugging Superdome/Matterhorn/Keystone/Orca Target



From 11.31 and beyond, all cell based machines (both PA-RISC Matterhorns, Keystones, and Superdomes and IPF Orca, Eiger etc) support LAN based remote debugging also. The steps and procedure for LAN based remote debugging on the cell based platforms is same as that for non-cell platforms (PA-RISC S700/S800 N/L-class boxes, PA-RISC Mt Hamilton class of boxes, and IPF non-cell boxes). Refer to "Debugging S700/S7800 Target Using LAN" on page 49 for more details.

Debugging V-Class Target Using LAN

Boot the target machine to the `Command:` prompt and enter one of the following:

`Command: boot pri -f0x8002` *`kernel_file`*

(Boot-and-wait) The kernel stops and waits for a client connection during the boot up sequence, rather than booting up as usual.

`Command: boot pri -f0x8000` *`kernel_file`*

(Boot-without-wait) Attach the debugger client to the target at a later time.

On the target, *`kernel_file`* is usually `/stand/vmunix`

After booting the target, run KWDB on the host system as follows:

```
$kwdb kernel_file
(kwdb) target pa_kern test_station[:47001]
(kwdb) attach 0 target_id
```

`kernel_file` Specifies the name of the host's copy of the kernel executable file booted on the target.

`test_station` Specifies the name of the V-Class test station for the target, where *`kwdbd`* is running.

`:47001` Specifies the port number. This value is needed only if file `/etc/services` on the host does not define service `kwdbd` as TCP port 47001. Starting with 11.31, this port number need not be given if the `/etc/services` on the host does not have an entry for kwdbd. In case there is no entry for kwdbd in the `/etc/services` file for kwdbd service then the port 1127 will be used by default for talking to the communication server.

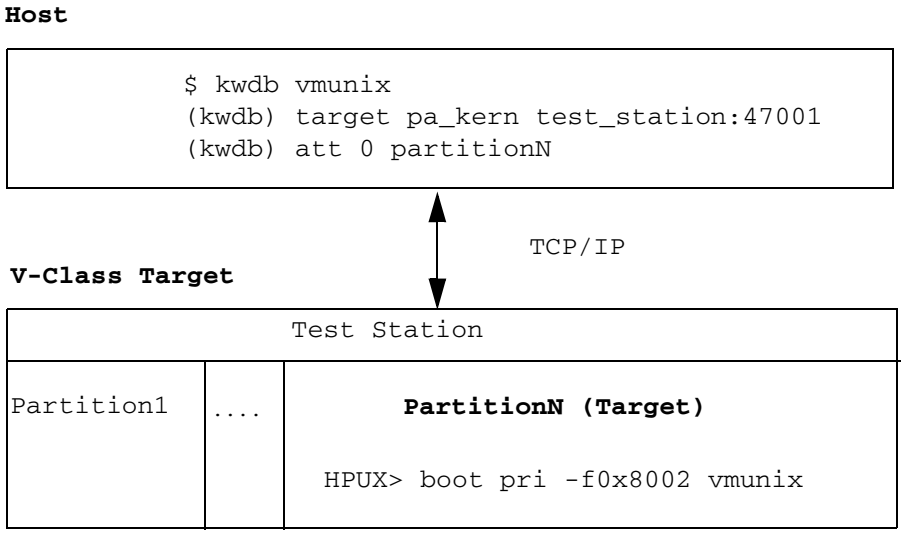
target_id => sonic-mac-address | *mnemonic-identifier*

For example, *target_id* can be either *sonic-mac-address* or *mnemonic-identifier*.

- The "sonic-mac-address" is ethernet MAC address (or station address) of the SONIC LAN card in the target. The station address is a sequence of 12 hexadecimal digits preceded by the string "`0x`". For example, `0x0060b0079447`.
- The "mnemonic-identifier" is a name for the target's SONIC LAN card, often the target system's name, as given by the `kwdbd` configuration file, `kwdbd.conf`, on `comm_server`. See the *Chapter 2, "Setting Up KWDB for Remote Debugging,"* for more information.

This is shown in *Figure 3-2, "Debugging V-Class Target."*

Figure 3-2 Debugging V-Class Target



Debugging S700/S7800 Target Using LAN

Boot the target machine to ISL, and enter one of the following at the ISL> prompt:

For pre 11.31 kernels,

`ISL> hpux -f0xc003` *kernel_file*

For 11.31 and beyond, users can use a more user friendly command from the ISL. This is a platform independent method:

```
ISL> hpux kernel_file kwdb_flags=lan.[driver]
```

(Boot-and-wait) The kernel stops and waits for a client connection during the bootup sequence, rather than booting up normally. In 11.31, the *driver* option lets the user specify which LAN driver would be his *most preferred* one whose cards are to be used for kernel debugging. The driver names can be btlan, igelan, intl100, and iether. Preference of the lan drivers is discussed in detail in "LAN Card Selection Rules for 11.31 and Later" on page 32.

In 11.31, it is also possible to specify the driver name through the -f option as follows:

```
ISL> hpux -f0x10c003 kernel_file (for specifying btlan driver, same as 0xc003)

ISL> hpux -f0x20c003 kernel_file (for specifying igelan driver)

ISL> hpux -f0x40c003 kernel_file (for specifying intl100 driver)

ISL> hpux -f0x80c003 kernel_file (for specifying iether driver)
```

(Boot-without-wait) Attach the debugger client to the target at a later time.

For pre 11.31 kernels,

```
ISL> hpux -f0xc001 kernel_file
```

For 11.31 and beyond, the platform independent environment variable method can be used:

```
ISL> hpux kernel_file kwdb_flags=lan.[driver.[nowait]]
```

In 11.31 the driver specification is optional. See "LAN Card Selection Rules for 11.31 and Later" on page 32.

On the target, *kernel_file* is usually `/stand/vmunix`.

After booting the target, run `kwdb` on the host system as follows:

```
$ kwdb kernel_file
(kwdb) target pa_kern comm_server[:47001]
(kwdb) attach 0 target_id
```

kernel_file — Specifies the name of the host's copy of the kernel executable file booted on the target.

comm_server — Specifies the name of the system where `kwdbd` is running for the target. This can be any system running `kwdbd` on the LAN subnet to which the target's debugger LAN card is cabled. The target and `comm_server` has to be in the same LAN subnet.

`:47001` — Specifies the port number. This value is needed only if file `/etc/services` on the host does not define service `kwdbd` as TCP port 47001. Starting with 11.31, this port number need not be specified even if the `/etc/services` on the host does not define the service `kwdbd` as TCP port 47001. When no entry is present in the `/etc/services` file for `kwdbd` service, the `kwdbd` has been enhanced to use the default port of 1127.

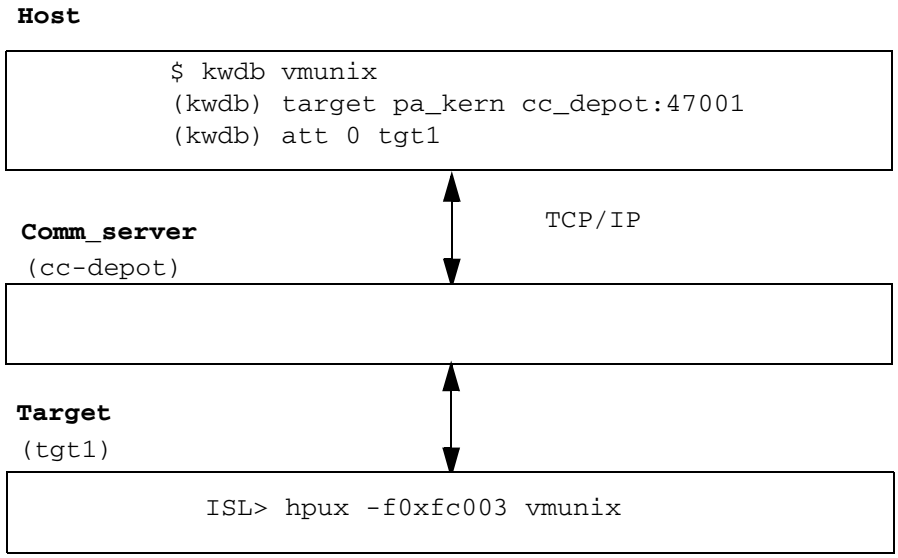
target_id => lan-mac-address | *mnemonic-identifier*

For example, *target_id* can be either *lan-mac-address* or *mnemonic-identifier*.

- The "lan-mac-address" is the Ethernet LAN MAC address of the LAN card used for debugger communications in the target system. The MAC address is a sequence of 12 hexadecimal digits preceded by the string "`0x`", as reported by the *lanscan* (1M) command on the target (if a driver had bound to the card). For example, `0x0060b0079447`. Some kernels will print this value along with the `waiting for kernel debugger to attach` message. If not, see *Chapter 2, "Setting Up KWDB for Remote Debugging,"* for instructions on how to determine this value.
- In 11.31, for boot-without mode of kernel debugging, it is possible to query the target kernel for getting the *lan-mac-address*. The user can either use the kwdb_config_kern utility as discussed in "LAN Card Selection Rules for 11.31 and Later" on page 32, or use `kwdbctl -q` in order to obtain the *lan-mac-address* of the LAN card which is being used by the kernel debugger.
- The "mnemonic-identifier" is a name for the target LAN card, often the target system's name, as given by the `kwdbd` configuration file `kwdbd.conf` on `comm_server`. See the *Chapter 2, "Setting Up KWDB for Remote Debugging,"* for more information.

This is shown in *Figure 3-3, "Debugging S700/S800 PA Target Using LAN."*

Figure 3-3 Debugging S700/S800 PA Target Using LAN



Debugging IPF Target Using LAN

Boot the target machine to ISL, and enter the following at the boot prompt:

For pre 11.31 kernels,

```
HPUX> boot kernel_file -dlan
```

For 11.31 and beyond, users can use a more friendly command from the HPUX boot loader prompt:

```
HPUX> boot kernel_file kwdb_flags=lan.[driver]
```

(Boot-and-wait) The kernel stops and waits for a client connection during the bootup sequence, rather than booting up normally. In 11.31, the *driver* option lets the user specify which LAN driver would be his *most preferred* one whose cards are to be used for kernel debugging. The driver names can be btlan, igelan, intl100, and iether. Preference of the lan drivers is discussed in detail in "LAN Card Selection Rules for 11.31 and Later" on page 32.

(Boot-and-wait) The kernel stops and waits for a client connection during the bootup sequence, rather than booting up normally. It is possible to specify the type of LAN card for KWDB on HP-UX kernel version 11.23 or later by using the option `-dlan.intl100` for **intl100** card, `-dlan.igelan` for **igelan** card, or `-dlan.iether` for **iether** card.

For pre 11.31 kernels,

```
HPUX> boot kernel_file -d0x111
```

For 11.31 and beyond, users can use a more friendly command:

```
HPUX> boot kernel_file -dlan.[driver.]nowait
```

or

```
HPUX> boot kernel_file kwdb_flags=lan.[driver.]nowait
```

(Boot-without-wait) Attach the debugger client to the target at a later time. On the target, `kernel_file` is usually `/stand/vmunix`.

For HP IPF systems, a **btlan** card is normally used by KWDB for LAN communication between host and target systems. It is possible to select the **intl100** card for communication on pre HP-UX 11.23 kernels by booting the target using the `-z` option.

After booting the target, run kwdb on the host system as follows:

```
$ kwdb kernel_file
(kwdb) target ia64_kern comm_server[:47001]
(kwdb) attach 0 target_id
```

kernel_file Specifies the name of the host's copy of the kernel executable file booted on the target.

comm_server Specifies the name of the system where kwdbd is running for the target. This can be any system running kwdbd on the LAN subnet to which the target's debugger LAN card is cabled. The target and comm_server has to be in the same LAN subnet.

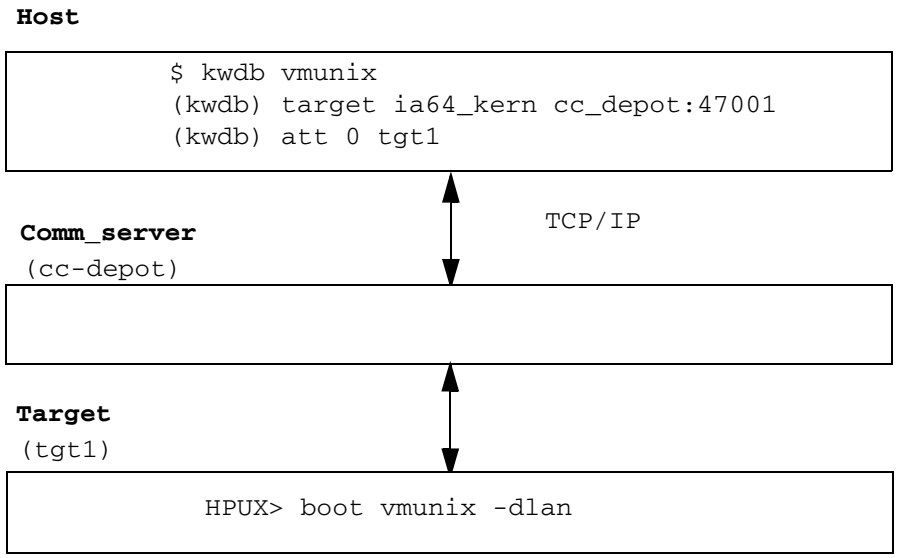
:47001 Specifies the port number. This value is needed only if file /etc/services on the host does not define service kwdbd as TCP port 47001. Starting with 11.31, this port number need not be specified if the file /etc/services on the host does not define the service kwdbd as TCP port 47001. When no entry is present in the /etc/services file for kwdbd service), the kwdbd has been enhanced to use the default port of 1127.

target_id => lan-mac-address | *mnemonic-identifier* is either *lan-mac-address* or *mnemonic-identifier*.

- The "lan-mac-address" is the Ethernet LAN MAC address (or test address) of the LAN card used for debugger communications in the target system. The test address is a sequence of 12 hexadecimal digits preceded by the string "0x", as reported by the *lanscan* (1M) command on the target (if a driver had bound to the card). For example, 0x0060b0079447. The kernels will print this value along with the waiting for kernel debugger to attach message.
- In 11.31, for boot-without mode of kernel debugging, it is possible to query the target kernel for getting the *lan-mac-address*. The user can either use the kwdb_config_kern utility as discussed in "kwdb_config_kern Utility" on page 40, or use kwdbctl -q in order to obtain the *lan-mac-address* of the LAN card which is being used by the kernel debugger.
- The "mnemonic-identifier" is a mnemonic identifier for the target LAN card, often the target system's name, as given by the kwdbd configuration file kwdbd.conf on comm_server. See the *Chapter 2, "Setting Up KWDB for Remote Debugging,"* for more information.

This is shown in *Figure 3-4, "Debugging IPF Target Using LAN."*

Figure 3-4 Debugging IPF Target Using LAN



Debugging S700/S800 Target Using RS-232

Boot the target machine to ISL and enter one of the following at the ISL> prompt:

```
ISL> hpux -f0x8003 kernel_file
```

(Boot-and-wait) The kernel stops and waits for a client connection during the bootup sequence, rather than booting up normally.

```
ISL> hpux -f0x8001 kernel_file
```

(Boot-without-wait) Attach the debugging client to the target at a later time.

On the target, `kernel_file` is usually `/stand/vmunix`. After booting the target, run `kwdb` on the host system as follows:

```
$ kwdb kernel_file
(kwdb) target serial [device_file] [baud_rate]
(kwdb) attach 0
```

kernel_file Specifies the name of the host's copy of the kernel executable file booted on the target.

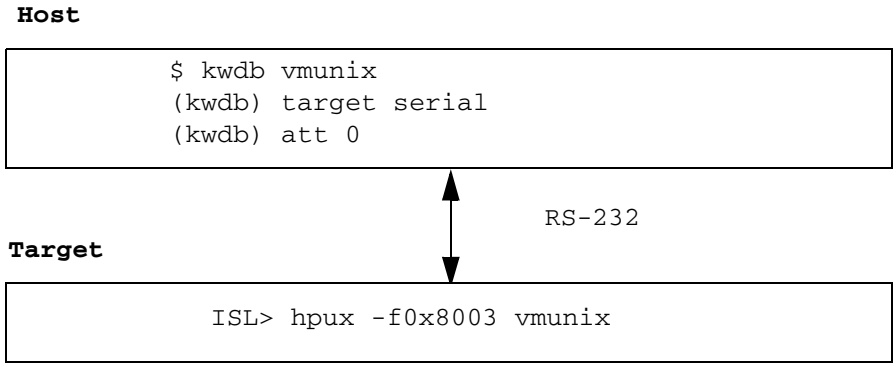
device_file Specifies the name of the host RS-232 device file to use for communicating with the target. This device file describes the host's serial port that is cabled to the target. If this parameter is not given, the default is `/dev/tty1p0` (which is the second serial port for many S700 platforms).

baud_rate Specifies the baud rate. This value must match the value used by the target kernel. The default baud rate for PA targets is 19200.

NOTE In Operating System 11.31 and beyond, on PA-RISC, serial communication is supported only for built-in PCI serial cards. The kernel debugger in these platforms does not make use of the built-in serial cards on PA-RISC boxes.

This is shown in *Figure 3-5, "Debugging S700/S800 PA Target Using a Serial Connection."*

Figure 3-5 Debugging S700/S800 PA Target Using a Serial Connection



Debugging IPF Target Using RS-232

Boot the target machine and enter the following at the boot prompt:

For pre 11.31 kernels,

```
HPUX> boot kernel_file -dserial
```

For 11.31 kernels and beyond, you can specify which serial card you want to use - the built-in one or the PCI serial one (if present)

For selecting builtin serial cards:

```
HPUX> boot kernel_file -dserial
```

or

```
HPUX> boot kernel_file kwdb_flags=serial
```

For selecting PCI serial cards:

```
HPUX> boot kernel_file -dserial.pci
```

or

```
HPUX> boot kernel_file kwdb_flags=serial.pci
```

(Boot-and-wait) The kernel stops and waits for a client connection during the bootup sequence, rather than booting up normally.

For pre 11.31 kernels,

```
HPUX> boot kernel_file -d0x121
```

For 11.31 kernels and beyond, you could specify the nowait tag to specify whether the kernel should wait or not:

```
HPUX> boot kernel_file -dserial.[pci.]nowait
```

or

```
HPUX> boot kernel_file kwdb_flags=serial.[pci.]nowait
```

(Boot-without-wait) Attach the debugger client to the target at a later time. On the target, *kernel_file* is usually `/stand/vmunix`.

Target system's COM1 port is used for serial communication between host and target systems. It is possible to select COM2 port on target system for serial communication by booting the target using `-z` option.

After booting the target, run `kwdb` on the host system as follows:

```
$ kwdb kernel_file
(kwdb) target serial [device_file] [baud_rate]
(kwdb) attach 0
```

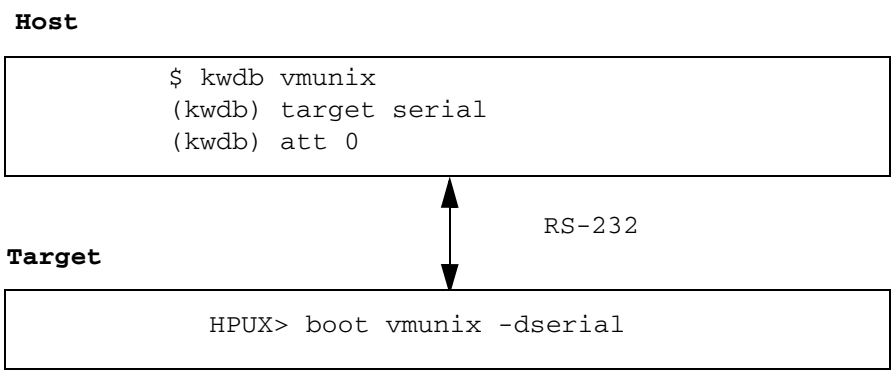
kernel_file Specifies the name of the host's copy of the kernel executable file booted on the target.

device_file Specifies the name of the host RS-232 device file to use for communicating with the target. This device file describes the host's serial port that is cabled to the target. If this parameter is not given, the default is `/dev/tty1p0` (which is the second serial port for many S700 platforms).

baud_rate Specifies the baud rate. This value must match the value used by the target kernel. The default baud rate for IPF targets is 57600.

This is shown in *Figure 3-6, "Debugging IPF Target Using a Serial Connection."*

Figure 3-6 Debugging IPF Target Using a Serial Connection



Debugging S700/S800 Target Using Lantron Serial

Boot the target machine to ISL and enter one of the following at the ISL> prompt:

```
ISL> hpux -f0x8003 kernel_file
```

(Boot-and-wait) The kernel stops and waits for a client connection during the bootup sequence, rather than booting up normally.

```
ISL> hpux -f0x8001 kernel_file
```

(Boot-without-wait) Attach to the target at a later time.

After booting the target, run `kwdb` on the host system as follows:

```
$ kwdb kernel_file
(kwdb) target lantron_serial lantron_name:30nn
(kwdb) attach 0
```

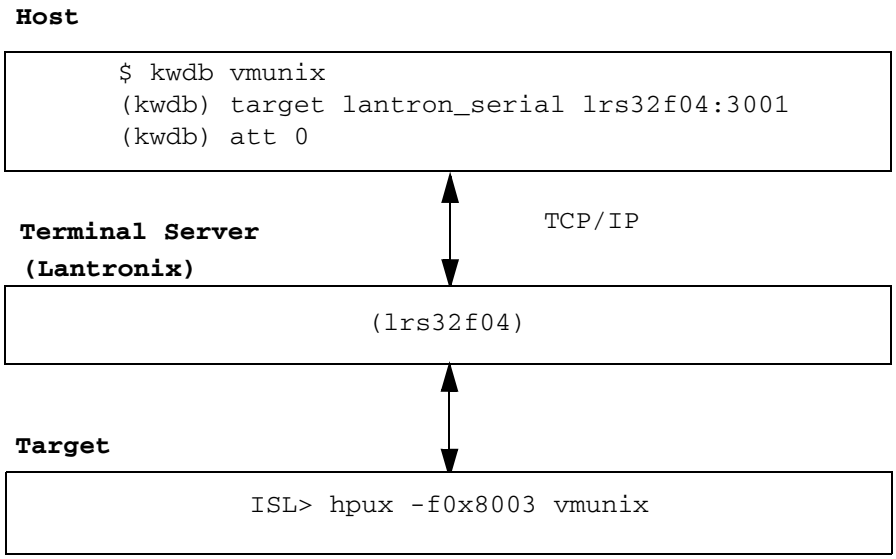
kernel_file Specifies the name of the host's copy of the kernel executable file booted on the target.

lantron_name Specifies the name of the terminal server such as Lantronix box which is connected to the target.

30nn Needed to bind a TCP session to the lantron. *nn* is the number of physical port on the Lantronix box that the serial cable from the target is plugged in to.

This is shown in *Figure 3-7, "Debugging S700/S800 PA Target Using Lantron Serial."*

Figure 3-7 Debugging S700/S800 PA Target Using Lantron Serial



Debugging IPF Target Using Lantron Serial

Boot the target machine to ISL and enter one of the following at the boot prompt:

```
HPUX> boot kernel_file -dserial
```

(Boot-and-wait) The kernel stops and waits for a client connection during the bootup sequence, rather than booting up normally.

```
HPUX> boot kernel_file -d0x121
```

(Boot-without-wait) Attach the debugger client to the target at a later time.

For Intel IPF target system COM1 port is used for serial communication between host and target systems through Lantronix. For HP IPF target system COM2 port is used for serial communication between host and target systems through Lantronix. It is possible to select COM2 port on the Intel IPF target system for communication by booting the target using the `-z` option. It is possible to select COM1 port on HP IPF target system for communication by booting the target using the `-z` option. After booting the target, run `kwdb` on the host system as follows:

```
$ kwdb kernel_file
(kwdb) target lantron_serial lantron_name:30nn
(kwdb) attach 0
```

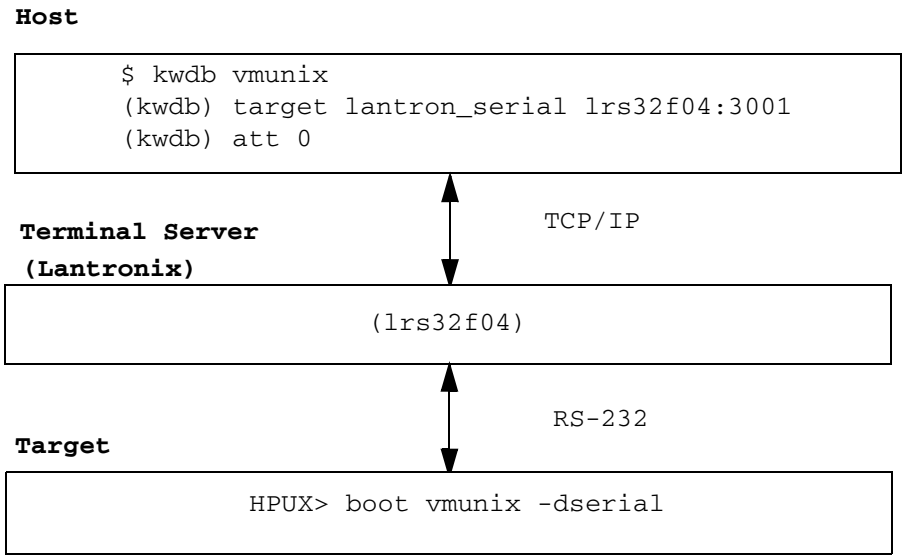
kernel_file Specifies the name of the host's copy of the kernel executable file booted on the target.

lantron_name Specifies the name of the terminal server such as Lantronix box which is connected to the target.

:30nn Needed to bind a TCP session to the lantron. *nn* is the number of the physical port on the Lantronix box that the serial cable from the target is plugged in to.

This is shown in *Figure 3-8, "Debugging IPF Target Using Lantron Serial."*

Figure 3-8 Debugging IPF Target Using Lantron Serial

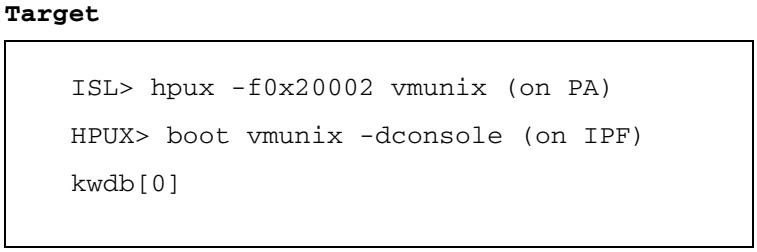


Debugging Targets Using Remote Console

Every HP-UX kernel 11.11 and later has a built-in debugger that can be accessed from the system console. This is commonly referred to as the “on-console” debugger. This is also called “single system debugger” as the debugging on the target system itself.

This is shown in *Figure 3-9, “Assembly Level Debugging PA/IPF Target Using On-Console Debugger.”*

Figure 3-9 Assembly Level Debugging PA/IPF Target Using On-Console Debugger



For an IPF system, boot the target machine to ISL and enter the following at the boot prompt:

For pre 11.31 kernels,

`HPUX> boot` *`kernel_file`* `-dconsole`

For 11.31 and beyond,

`HPUX> boot` *`kernel_file`* `-dconsole`

or

`HPUX> boot` *`kernel_file`* `kwdb_flags=console`

(Boot-and-wait) The kernel stops and waits at `kwdb[0]` prompt. Where *`kernel_file`* is usually `/stand/vmunix`.

For pre 11.31 kernels,

```
HPUX> boot kernel_file -d0x181
```

For 11.31 and beyond,

```
HPUX> boot kernel_file -dconsole.nowait
```

or

```
HPUX> boot kernel_file kwdb_flags=console.nowait
```

(Boot-without-wait) System boots up normally and can be interrupted to get `kwdb[0]` prompt for debugging the system at a later time by pressing **Ctrl-x**.

For an S700/S800 PA system, boot the target as follows:

For pre 11.31 kernels,

```
ISL> hpux -f0x20002 kernel_file
```

For 11.31 and beyond,

```
ISL> hpux -f0x20002 kernel_file
```

or

```
ISL> hpux kernel_file kwdb_flags=console
```

(Boot-and-wait) The kernel stops and waits at `kwdb[0]` prompt.

For pre 11.31 kernels,

```
ISL> hpux -f0x20000 kernel_file
```

For 11.31 and beyond,

```
ISL> hpux -f0x20000 kernel_file
```

or

```
ISL> hpux kernel_file kwdb_flags=console.nowait
```

(Boot-without-wait) The flag `0x20000` is used if stop on boot is not desired. System boots up normally and can be interrupted to get `kwdb[0]` prompt for debugging the system at a later time by pressing **Ctrl-x**.

This debugger has the advantage of requiring no communications setup since it runs on the target system itself, but it has a limited set of commands. The list of commands supported on a single system (on-console) debugger will be described in the *Chapter 4, "Command Reference."* The on-console debugger only allows assembly level debugging.

Use `kwdb` on a host system in conjunction with the on-console debugger on the target system to provide symbolic debugging through remote console. Use the full set of KWDB commands with no extra communications setup as long as there is a remote console for the target system that is implemented via a Lantronix box.

Using Console Target for Targets with Latronix Console

After booting the target to the `kwdb[0]` prompt and disconnecting from the remote console run KWDB on the host system as follows:

```
$ kwdb kernel_file
(kwdb) target console lantron_name:20nn
```

kernel_file Specifies the name of the host's copy of the kernel executable file booted on the target.

lantron_name Specifies the name of the terminal server such as Lantronix box which is connected to the target.

`:20nn` Needed to bind a TCP session to the lantron. *nn* is the number of physical port on the Lantronix box that the serial cable from the target is plugged in to.

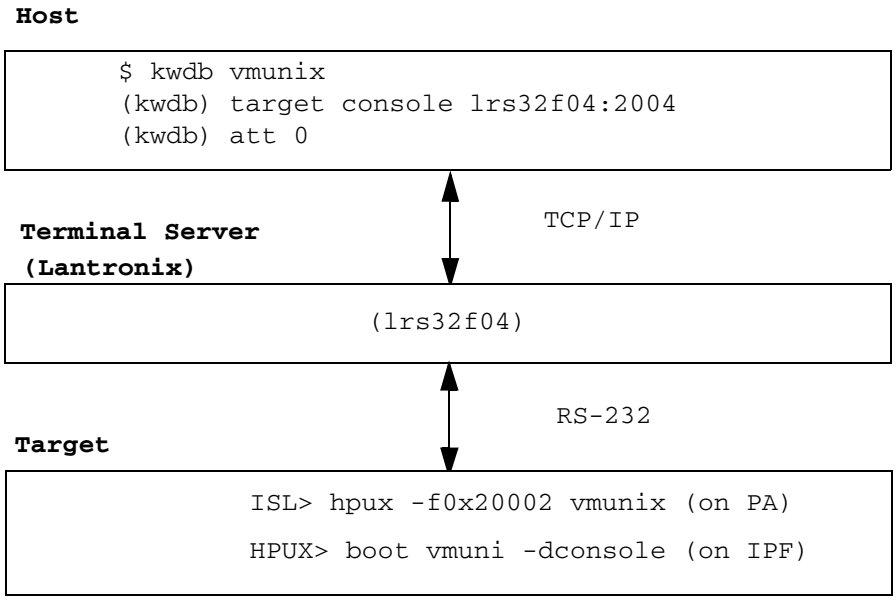
When communication has been established by the `target` command, an xterm will appear on the host system's screen. This will be the new system console window. When the `kwdb[0]` prompt appears on the xterm, enter the following command at "KWDB" prompt from KWDB window.

(kwdb) `attach 0` Begin the debugging session in the LWDB window. If exiting from the debugger, the xterm will disappear. To reconnect, get the `kwdb[0]` prompt back on the system console. To do this, connect to the remote console for the target system and enter **Ctrl-x** on the system console. This will interrupt the running kernel and should see the on-console debugger prompt, `kwdb[0]`. Disconnect from the remote console so that KWDB can access it. Reconnect to the on-console debugger using the same `kwdb` commands that were used to connect when the target was booted.

NOTE Communications between the KWDB on host system and the on-console debugger on target system is currently slower than other remote targets. Improvements have been made in KWDB 3.1.3 release towards improvement of the speed of the console target, however, it still does not work as fast as LAN or UDP based remote debugging. It also depends on the target kernel version whether KWDB client would use the performance improvement enhancements for console target - for example, when KWDB 3.1.3 is used to debug pre 11.31 kernels (which does not support the new protocol improvements for supporting console target performance improvements), KWDB 3.1.3 would automatically use the older method of communication, which would be still slower (as with older versions of KWDB).

This debugging is shown in *Figure 3-10, "Debugging PA/IPF Target Using Remote Console."*

Figure 3-10 Debugging PA/IPF Target Using Remote Console



Using Console Target for Targets with MP or GSP Console

For debugging the console target feature for systems with MP or GSP consoles, users can start the target as mentioned above. On the host system, the user needs to specify the MP or GSP name instead of the lantron name, and use “23” as the port number:

```
$ kwdb kernel_file
(kwdb) target console MP_name[:23]
```

kernel_file Specifies the name of the host’s copy of the kernel executable file booted on the target.

MP_name

Specifies the name of name of the MP representing the remote console of the target. Optionally the user may specify 23 as the port number. If not specify, KWDB would use the port 23 which is the telnet service. Once done, KWDB console would launch an X-terminal representing the remote console, where the user needs to enter the MP/GSP login and password, and bring it upto the console debugger prompt prior to issuing the “attach 0” command in the KWDB client.

MP_name Specifies the name of name of the MP representing the remote console of the target. Optionally the user may specify 23 as the port number. If not specify, KWDB would use the port 23 which is the telnet service. Once done, KWDB console would launch an X-terminal representing the remote console, where the user needs to enter the MP/GSP login and password, and bring it upto the console debugger prompt prior to issuing the “attach 0” command in the KWDB clientMP_name.

Using the kwdb.conf File for Simplifying the Mapping of Lantron Names

To make connecting to the remote target system more user friendly, KWDB provides a mapping file for console and lantron serial targets. The mapping file is located at `/etc/opt/kwdb/kwdb.conf` on the kwdb host system. This file provides a mapping of the terminal server and the port number connected to the target system with a symbolic name. If the `/etc/opt/kwdb/kwdb.conf` file is edited to map the terminal server and the port number with a symbolic name, the user can specify the symbolic name with the attach command instead of the terminal server and the port number to connect to the target. The format of the file is as follows:

```
#
# kwdb.conf (/etc/opt/kwdb/kwdb.conf)
#
# This file contains configuration information for KWDB
# to use with the console and lantron_serial targets.
#
# Lines beginning with '#' are comments which kwdb
# ignores. Blank lines are allowed. Tokens are separated
# by tabs or spaces. All other lines are considered to be
# kwdb directives. (A kwdb directive cannot span multiple
# lines.)
# The general format is "directive arguments ...\n"
#
# The first column cotains the directive name:
#   "console" Maps machine name to lantron name and
#      port number where the remote console of the
#      target is connected. The machine name is specified
#      in the second column. The lantron name and port
#      number is specified in the third column in
#      the format "lantron_name:port".
#
```

```
#   "lantron_serial" Maps machine name to lantron name and
#      port number where the serial port of the target
#      is connected. The machine name is specified in
#      the second column. The lantron name and port number
#      is specified in the third column in the format
#      "lantron_name:port".
#
# Uncomment and edit as appropriate for your system:
#   Directive        Machine name    Ethernet address
#   ---------        ----------      ----------
    console           machine1       lrs02f04:2031
    lantron_serial    machine2       lrs02f04:2032
```

With this support the target command

```
(kwdb) target console machine1
```

can be issued instead of

```
(kwdb) target console lrs02f04:2031
```

Similarly for lantron serial target the command

```
(kwdb) target lantron_serial machine2
```

can be issued instead of

```
(kwdb) target lantron_serial lrs02f04:2032
```

Set the file permission of `kwdb.conf` to world-writable by system administrator, so that users can edit this file to add new entries.

Debugging Targets Using UDP

Every HP-UX kernel 11.22 and later supports source level debugging using KWDB via a UDP connection between host and target systems. In pre 11.31 kernels, debugging via UDP connection is not supported on cell platforms like `Superdome`, `Orca`, `Matterhorn` and `Keystone`. From 11.31 and beyond, UDP connection is suppported for all platforms running HPUX.

For an IPF system, boot the target machine to ISL and enter the following at the boot prompt:

For pre 11.31 kernels,

`HPUX> boot` *`kernel_file`* `-dudp`

For 11.31 and beyond,

`HPUX> boot` *`kernel_file`* `-dudp[.driver]`

or

`HPUX> boot` *`kernel_file`* `kwdb_flags=udp[.driver]`

(Boot-and-wait) The kernel stops and waits for a client connection during the bootup sequence, rather than booting up normally. By default, the **btlan** card with the lowest hardware address will be selected for KWDB communication. It is possible to specify the type of LAN card for KWDB by using the option `-dudp.intl100` for **intl100** card, `-dudp.igelan` for **igelan** card, or `-dudp.iether` for **iether** card.

`HPUX> boot` *`kernel_file`* `-d0x511`

(Boot-without-wait) Attach the debugger client to the target at a later time.

For pre 11.31 kernels,

```
HPUX> boot kernel_file -d0x511
```

For 11.31 and beyond,

```
HPUX> boot kernel_file -dudp[.driver].nowait
```

or

```
HPUX> boot kernel_file kwdb_flags=udp[.driver].nowait
```

For an S700/S800 PA system, boot the target as follows:

(Boot-and-wait) The kernel stops and waits for a client connection during the bootup sequence, rather than booting up normally.

```
ISL> hpux -f0x1c003 kernel_file
```

In 11.31, it is also possible to specify the driver name through the -f option as follows:

```
ISL> hpux -f0x11c003 kernel_file (for specifying btlan driver, same as 0xc003)

ISL> hpux -f0x21c003 kernel_file (for specifying igelan driver)

ISL> hpux -f0x41c003 kernel_file (for specifying intl100 driver)

ISL> hpux -f0x81c003 kernel_file (for specifying iether driver)
```

or

```
ISL> hpux kernel_file kwdb_flags=udp.[driver]
```

(Boot-without-wait) Attach the debugger client to the target at a later time. Where *kernel_file* is usually /stand/vmunix.

For pre 11.31 kernels,

```
ISL> hpux -f0x1c001 kernel_file
```

For 11.31 and beyond,

```
ISL> hpux -f0xc001 kernel_file
```

or

```
ISL> hpux kernel_file kwdb_flags=udp[.driver].nowait
```

If the system is successfully booted with boot flags that enable debugging, an IP address will be displayed on the target system console as shown below:

```
kdebug IP address 15.244.99.173:468
kdebug lancard mac address 0:60:b0:b3:8b:69 (0x0060b0b38b69)

Waiting for kernel debugger to attach (this line is shown only in Boot-and-wait mode)
```

This IP address will be needed later to reattach KWDB using UDP, so make note of it. This is the IP address assigned by the DHCP server and can be used by the host to connect to the target. Without this IP address it is not possible to use UDP connection. This address will also be stored in a kernel variable kdebug_udp_ip_addr on IPF and kgdb_udp_ip_addr on PA systems. To reattach later and if the IP address has been forgotten, get it by examining these variables using ADB or KWDB. The following example shows how to get the IP address using KWDB.

```
# kwdb -q4 -q /stand/vmunix.iademo /dev/mem
q4> kdebug_udp_ip_addr
01775061002    267674114    0xff46202
q4>
```

After booting the target, run KWDB on the host system as follows:

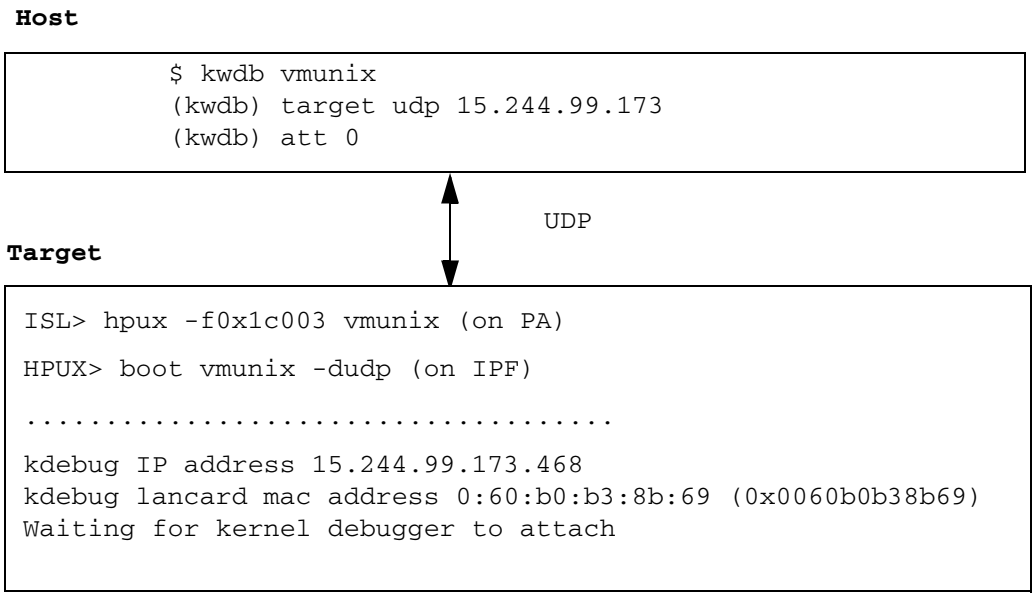
```
$ kwdb kernel_file
(kwdb) target udp IP_address
(kwdb) attach 0
```

kernel_file Specifies the name of the host's copy of the kernel executable file booted on the target.

IP_address The IP address displayed on the target system console.

This is shown in *Figure 3-11, "Debugging PA/IPF Target Using UDP."*

Figure 3-11 Debugging PA/IPF Target Using UDP



Debugging 11.0 and Earlier Kernels with KWDB

Kernels with versions 10.0 through 11.0 were designed to be debugged with a debugger known as NDDB. However, it is possible to debug 11.0 and earlier kernels with some limitations if `kwdb` is used in nddb-compatibility mode. Limitations of `kwdb` in nddb-compatibility mode is discussed in *Chapter 3, "Getting Started with Remote Debugging."*.

For RS-232 serial debugging, boot the target machine to ISL, and enter the following at the ISL> prompt:

```
ISL> hpux -f3 kernel_file
```

After booting the target, run `kwdb` on the host system as follows:

```
$ kwdb kernel_file
(kwdb) target nddb -rs device_file
(kwdb) attach 0
```

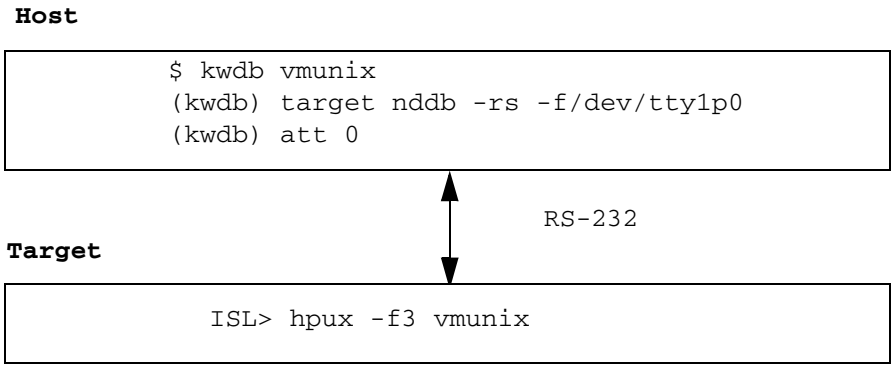
kernel_file Specifies the name of the host's copy of the kernel executable file booted on the target.

`-rs` Specifies RS-232 serial communication.

device_file Specifies the name of the host RS-232 device file, such as `/dev/tty1p0`, used for communicating with the target.

This is shown in *Figure 3-12, "Debugging 11.0 and Earlier Kernel Using Serial Connection."*

Figure 3-12 Debugging 11.0 and Earlier Kernel Using Serial Connection



For LAN debugging, run a different communications server `nddbcs` instead of the normal `kwdbd` communications server. See *Chapter 2, "Setting Up KWDB for Remote Debugging,"* for details. Boot the target machine to ISL, and enter the following at the ISL> prompt:

```
ISL> hpux -f0x4003 kernel_file
```

On the target, *kernel_file* is usually `/stand/vmunix`

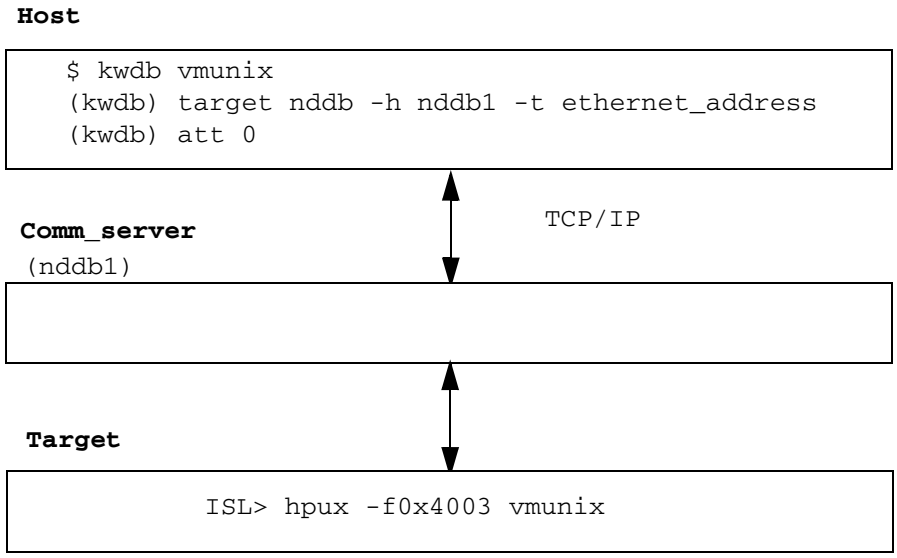
After booting the target, run KWDB on the host system as follows:

```
$ kwdb kernel_file
(kwdb) target nddb -h nddb_comm_server -t ethernet_address
(kwdb) attach 0
```

kernel_file	Specifies the name of the host's copy of the kernel executable file booted on the target.
nddb_comm_server	Specifies the machine where the `nddbcs` communications server is running.
ethernet_address	Specifies the ethernet MAC address of the LAN card on the target system used for debugger communication.

This is shown in *Figure 3-13, "Debugging 11.0 and Earlier Kernel Using LAN."*

Figure 3-13 Debugging 11.0 and Earlier Kernel Using LAN



Debugging the Kernel

Once attached to the target system and connected to the target kernel, begin entering KWDB commands to set breakpoints, execute, single-step, and so forth, to debug the kernel.

Controlling Kernel Execution Using KWDB

- Interrupting Target Kernel Execution
- Detaching from the Target System
- Exit from KWDB
- Re-attaching KWDB to the Target System
- Re-booting the Target System

Interrupting Target Kernel Execution

While the target kernel is running, the execution can be interrupted by entering **Ctrl-c** in the window where the KWDB client is running.

```
(kwdb 0:0) c
Continuing.
^c(interrupt)

Program received signal SIGINT, Interrupt.
0x336078 in idle()
```

If the target kernel is not running, **Ctrl-c** interrupts the execution of the host debugger itself (for example, to abort display of a particularly long data structure).

Detaching from the Target System

To detach from the target kernel but leave KWDB active (to reattach to the kernel at a later time), use the `detach` command.

```
(kwdb 0:0) detach
Detached from remote task.
(kwdb 0:0)
```

Exit from KWDB

To stop debugging and exit KWDB entirely, use the quit command (**q**) or EOF **Ctrl-d**. If KWDB is currently attached to a running kernel, you will be prompted to determine whether you want to detach.

```
(kwdb 0:0) q
The program is running. Quit anyway (and detach it)? (y or n) y
Detached from remote task.
kentucky 53 >
```

Reattaching KWDB to the Target System

Once booted, a target for debugging and detached KWDB, reattach to the running kernel by invoking KWDB on the kernel and issuing the same target and attach commands that were used when attaching at boot time.

Rebooting the Target System

To reboot the target system from KWDB, use the `kill` command **k**.

```
(kwdb 0:0) kill
Kill the program being debugged? (y or n) y
Killing remote task
Killed remote task.
```

Compiling Code for Source Level Debugging

In order to set breakpoints at line numbers, step through the code line by line and display the values of local variables; compile the source code with the `-g` option. In addition, if the target is an IPF system, compile with the *+noobjdebug* option.

Online (Runtime) Initiailization of the Kernel Debugger

Starting with 11.31, the KWDB stub has been enhanced to support online initialization and deletion of the kernel debugger stub.

The following online initializations of the kernel debugger are supported. This can be done using the `kwdbctl` utility (run as superuser) once the kernel has come up to multi-user mode.

Table 3-1 Supported Online Kernel Debugger Initializations

Mode	kwdbctl command line	Platform	Architecture	Remarks
Sub/sync	`kwdbctl -i` *`sub`*	Cell	IPF/PA	• Speed of debugging depends on the speed of the management processor and firmware performance. • System I/O resources not used for remote debugging. • No subnet restrictions between the host and target.
Lan	`kwdbctl -i` *`lan`*	Cell/Non cell	IPF/PA	• No known issues with speed of communication. • Requires at least one LAN card of the system to be in UNCLAIMED state for remote debugging. • Target and host if in different subnets. Requires the comm server to be in the same subnet as target.
Console	`kwdbctl -i` *`console`*	Cell/Non cell	IPF/PA	• Single system assembly level debugging only. • If used in conjunction with console target, then source level debugging is possible.
Crashtime initialization	`kwdbctl -i` *`crash`*	Cell/Non cell	IPF/PA	• Choice of communication mode is deferred to crashtime. • Kernel debugger is NOT activated throughout the lifetime of the system. • Interactive menu presented at system console during a kernel crash. • All types of remote debugging and console debugging possible at crashtime.

Table 3-2 Additional Supported Operations

Operation	Mode	kwdbctl command line	Platform	Architecture	Remarks
Online pre-initialization	Any	`kwdbctl -s pci_ola_card_claim=1` and `kwdbctl -s pci_ola_card_claim=0`	Cell/Non Cell	IPF/PA	• This method is used to pre-initialize the kernel debugger for claiming a LAN card that may be added later via PCI OLA, refer to Table 3-3 for more details (using `pci_ola_card_claim=1`). • The setup can be cancelled by doing `pci_ola_card_claim=0`.
Online deletion	Any	`kwdbctl -d`	Cell/Non cell	IPF/PA	• By this method, kernel debugger initialized by any method, can be destroyed after the system comes up. • All system resources are returned to the kernel, for example, remote LAN card can be reclaimed by kernel's wsio drivers by running `ioscan(1)`. • Online deletion would fail if: • booted or configured in no-deconfig mode • the remote debugger is attached • the remote debugger communication device is not claimed in the I/O tree due to some errors during `ioscan`
Force Online deletion	Any	`kwdbctl -D`	Cell/Non Cell	IPF/PA	• By this method, kernel debugger initialized by any method, can be force destroyed after the system comes up. • It is used to override the failure cases mentioned for normal online deletion. • This functionality should be used at user's risk, and should be applied with extreme caution.
Query	Any	`kwdbctl -q`	Cell/Non cell	IPF/PA	This command allows you to query the state of the kernel debugger on a native system. It displays the MAC address, hardware path, description property of the card, its hardware state and other useful information about the debugger configuration on a native system

Table 3-3 11.31 Support for Kernel PCI OL* Operations

Scenario	Steps	Remarks
Mechanism to start the kernel debugger with LAN without rebooting the system - using an installed LAN card.	1. PCI OLD one of the LAN cards (in 11.31, almost all LAN cards will support PCI OLD) by running: olrad -d slot_id 2. Pre-initialize kernel debugger by running: kwdbctl -s pci_ola_card_claim=1 3. PCI OLA the card by running: olrad -a slot_id	1. These steps will ensure the kernel debugger can start using the card with LAN based communication without rebooting the system. 2. Run "ioscan -fC lan" and ensure that the card is claimed by the "kwdb" driver. Kernel driver would not be able to use the card any longer. 3. Run "kwdbctl -q" to obtain MAC address details.
Mechanism to start the kernel debugger with LAN without rebooting the system - using a newly added LAN card.	1. Pre-initialize the kernel debugger by running: `kwdbctl -s pci_ola_card_claim=1` 2. Physically insert a LAN card. 3. Perform PCI OLA to get the card claimed by kernel debugger, by running: `olrad -a` *`slot_id`*, and `olrad -A` *`slot_id`*	After PCI OLA, perform `kwdbctl -q` to obtain the remote communication LAN MAC address that is required to be used in the host.
Mechanism to replace the debugger LAN card without reboot	1. PCI OLR the debugger LAN card by running: `olrad -r` *`slot_id`*. 2. Replace the card. 3. Resume operation on the card by running: `olrad -R` *`slot_id`*.	If the remote debugger is already connected, the connection would go away after step (1). `kwdbctl -q` shows that the hardware state of the card is Suspended. Once the card is resumed, remote debugger may connect to the target without having the reboot the system.
Mechanism to remove a card being used for remote debugging without rebooting the system	PCI OLD the debugger LAN card by running: `olrad -d` *`slot_id`*	Once this is done, remote debugger, if connected, goes away. The card can be safely taken out after successful completion of the PCI online delete.

Crashtime Kernel Debugging Using KWDB debugger

Starting in 11.31, crashtime debugging capability is provided for HP-UX KWDB remote debugger. This feature eliminates the need for collecting crash dumps from failed HP-UX kernels and improves high availability of HP-UX systems. Standard dump reading utilities like kwdb are able to remotely connect to the crashed kernel through a remote communication device and start analyzing the failed memory and give the user an illusion that it is running on a crashdump. This enables users to remotely analyze a crashed system, do a quick first pass analysis, and apply patches to known problems without having to wait hours and do this after collecting a crash dump. This feature allows the kernel debugger to be started upon a crash (panic, Transfer of Control following a hang, HPMC or MCA) through a stolen LAN card with DLPI (with kwdbd comm server) and/or with UDP as communication protocols. The kernel debugger hardware scan mechanism has been enhanced to scan the system hardware after a system crash and select one of the installed LAN cards with a cable through which the remote debugger client would be able to communicate to the crashed target. All q4 perl scripts and relevant kwdb commands have been extended to work with a crashtime target (refer to detailed list below).

Some of the salient features of crashtime debugging are described in the following list:

- kwdb client can connect to the crashtime target with the same set of "target/attach" command pair as used for normal remote attachment.
- All q4 dump-reading commands work on a crashtime target through inspection of crash events ("trace event N", "trace processor N", "trace process at addr", etc), examination of target memory, reading of module information, etc.
- All perl scripts for the appropriate (11.31) kernel version also work for a crashtime debugging session.
- Execution control commands (such as stepping, jumping to an address, and return to callee functions) are not supported in a crashtime debugging session.
- If used appropriately, almost all dump reading commands are supported in a crashtime debugging session; thereby, avoiding the need to collect crash dumps.

Setting up a system for Crashtime Debugging

The following are various means by which the crashtime debugging session can be enabled.

1. The kernel can be booted with a new `-dcrash` option from the boot loader prompt. When booted with this option, the kernel would not directly attach to a kernel debugger during its normal operation, but, would enable attachment to a remote system upon a crash.

   Example:

   On IPF:
   HP-UX> boot /stand/vmunix -dcrash
   On PA-RISC:
   ISL> hpux -f0x80000 /stand/vmunix
   [..]
   Kernel debugger configured for crashtime attachment.
   Kernel debugger would be initialized for reading the memory of the failed
   system through remote or on-console kwdb after the kernel crashes
   [..]

   As can be seen from this example, the printed messages indicate that the kernel debugger has been configured for crashtime attachment.

If, after the system reboots, a panic occurs, then the following menu displays. This menu allows the user to attach from the remote system after printing the message buffer.

```
[...]
*** You can connect to "HP-UX KWDB kernel debugger" prior to collecting dump.

*** Kernel debugger crashtime session can be established in following ways

*** Options (enter your selection within next 20 seconds):

*** L) Connect to "HP-UX KWDB remote kernel debugger" through stolen lan card
       with intermediate communication server. (default)

*** U) Connect to "HP-UX KWDB remote kernel debugger" through stolen lan card
       with UDP/IP communication.

*** C) Connect to "HP-UX KWDB console debugger".

*** N) Donot connect to kernel debugger.
```

If the user selects L, then a lan card will be scanned for communication with the kwdb client on the host system. The scan code of the kernel debugger has been enhanced to perform this scanning and select a LAN card at the time of system crash.

Once a LAN card has been stolen, the MAC address of the lan card is printed which can then be used for connecting to the crashed system from the remote system. The following are the emnu selections provided to the user after option `L` is selected.

```
*** This selection requires a LAN card to be scanned for remote communication.
*** The default preference order for LAN cards while scanning hardware is:
btlan, igelan, intl100, iether

*** Press any key within the next 20 seconds to change this setting.

*** Setting hardware scan preference for LAN based remote communication
(enter your selection within the next 20 seconds)
*** 1) btlan, igelan, intl100, iether (default)
*** 2) igelan, btlan, intl100, iether
*** 3) intl100, btlan, igelan, iether
*** 4) iether, btlan, igelan, intl100
*** M) return to main menu for reselecting remote debugger communication

*** User input: 1 (preference order: btlan, igelan, intl100, iether).
```

Notice that options are given for the user to scan the LAN cards in the order preferred by the user. Depending on the selected order, the LAN cards will be scanned for. If the user input is `1`, then the scan order will be that indicated by menu item 1.

```
Starting "HP-UX KWDB kernel debugger" prior to dump.
Type 'help' for complete command list upon attachment to the kernel debugger.
Attempting to connect to remote HP-UX KWDB.

Initiating hardware scan for detecting lan card for kernel debugger
Driver selection preference order: btlan igelan intl100 iether

        Hardware scan results:
Detected igelan card (0x14e4:0x1645:0x103c:0x1300)
Detected igelan card (0x14e4:0x1645:0x103c:0x128a)
```

```
No btlan card was found or could be used for kernel debugging.

Kernel debugger would select another network card from the ones
installed in the system. Press Control-C within next 15 seconds to
prevent this behavior and continue with crashdump.

Attempting to select another network card for kernel debugger

        Card selection preference order: igelan intl100 iether
Configuring igelan card (0x14e4:0x1645:0x103c:0x1300)

Kernel debugger communication device setup

        Device: HP A6794-60001 Procurium (igelan) PCI 1000Base-T adapter
MAC address of the LAN card: 0:30:6e:a7:2c:73 (0x00306ea72c73)
Hardware Path of the communication device: 0/1/1/0/4/0

Kernel debugger is initialized

Options for remote attachment (enter your selection within the next 10 seconds)

*** T) Timeout after 5 mins if remote debugger does not connect (default).
*** D) Disable remote attachment timeout.

Timer expired: (attachment to timeout after 5 minutes).
```

As can be seen in the scan code selected, an igelan card and the MAC address are printed. From the remote system a kwdb client can be started and attached to this crashed system using the target and attach commands as for the remote debugger. On the remote host system, start `kwdb` on vmunix.

```
#kwdb <vmunix>
[..]
(kwdb) target ia64_kern <comm-server>

[..]

(kwdb) att 0 <mac-address>

Attaching program:

  /user/kwdbtest/current_vmunix/em_64-debug/vmunix task: 0, address:
0x00306ea72c73


Target is in crash/reboot path prior to dump

crashpath information:

  hostname  hpkdbia7

  model     ia64 hp server rx5670

  panic     kwdb_inline_test_0_2: deliberate

  release   @(#) $Revision: vmunix:    jazz @ 20060927.07:44:31IST; jmkvw -proj
commands -RW -share i80_bl2006_09

25 i80(I80_BL2006_0925) ; FLAVOR=debug

  dumptime  N/A

  savetime  N/A

  dumptype  N/A
```

```
Event selected is 0. It was a panic

0xe000000001e6ced0:0 in panic_save_regs_switchstack+0x110

    (0x611, 0xe000000001e7caf0, 0x1a8f, 0x0, 0xe00000010367bb00,
0xe00000010150df00,

       0xe00000000053fe40, 0xe00000010367bb60)

q4> trace event 0

#0  0xe000000001e6ced0:0 in panic_save_regs_switchstack+0x110

    (0x611, 0xe000000001e7caf0, 0x1a8f, 0x0, 0xe00000010367bb00,
0xe00000010150df00,

       0xe00000000053fe40, 0xe00000010367bb60)

#1  0xe000000001e7cb30:0 in panic

    (0xe0000001410f1ff0, 0x1, 0x388, 0xe0000001410f76b0, 0x1a4f,
0xe000000103af9f20,

       0x0, 0xe000000200044000) at /ux/core/kern/em/svc/shutdown/panic.c:311

.....

q4>

q4> detach
```

As can be seen, upon attaching to the crashed target, the panic string is printed and a q4 interface is available for the user. From this interface the user can execute q4 commands, run perl scripts and analyze the cause of the crash. Once detached the target kernel continues collecting the crash dump.

If you do not attach to the target within the timeout period, then the following message appears on the console:

```
Connection timed out with KWDB remote debugger client.
Remote debugger initialization aborted. Kernel would continue with crash dump.
Press the 'c' key within the next 10 seconds to start the console debugger.
```

Upon pressing the **c** key, the control will pass to the on-console debugger. The on-console debugger supports a new panictrace command that prints the stack trace and other useful debug information during a crash time debugging session.

The usage of this command is shown below:

a. `panictrace event <eventno>` - This command prints the stack trace of the specified event identified by *eventno*. *eventno* can be a C-style expression that evaluates to an index of the crash event table[].

b. `panictrace processor <procindex>` - This command prints the processor mpinfo t, pdk mpinfo t, pid of the running process, the associated kernel tid (thread ID), the address of the process entry in the kernel's proc structure, the address of the kernel thread entry in the kernel kthread t structure, and the stack trace of the process. *procindex* can be a C-style expression that evaluates to a valid index of the kernel spu info[] data structure.

   In the case of cell platforms, an additional option `sub-sync` is available. This option enables the kwdb client on the remote system to attach and debug the cause of the crash using the following commands.

   On the host, start kwdb as:

```
#kwdb <vmunix>
[..]
(kwdb)target sub <sub-name>:47001
[..]
(kwdb)att 0 "Partition 0"
[..]
q4>
```

The timeout mechanism for remote attachment at crashtime can be disabled and the target can be made to wait indefinitely using the boot flags `-dcrash.wait` or `kwdb_flags=crash.wait` for IPF and `-f0x80002` or `kwdb_flags=crash.wait` for PA systems. If booted with these options, then upon a system crash the target will wait for an indefinite period of time for an attachment request from the remote system.

2. Even if the system has not been booted with the `-dcrash` flags, kwdbctl utility can be used to configure the kernel debugger for crashtime attachment. This can be done once the system comes to multi-user mode using the following command.

   ```
   # kwdbctl -i crash
   ```

   The timeout mechanism can also be disabled using the kwdbctl utility once the target system boots to multi user mode

   ```
   # kwdbctl -s crash_wait_timeout=0
   ```

   On the client side, data caching has been implemented which allows the data to be cached instead of data being requested from the crashed system.

4 Command Reference

This chapter is divided into two sections, “KWDB Commands”, and “Q4 Commands”. The KWDB commands section discusses various commands available in KWDB for source level debugging of HP-UX kernel and DLKM modules. The Q4 Commands section deals with all the Q4 commands which are now available in KWDB.

KWDB Commands

This section describes various activities performed with KWDB:

- “Beginning a Debugging Session”
- “Ending a Debugging Session”
- “Getting Help”
- “Command Completion”
- “Executing KWDB Commands Automatically at Startup”
- “Reading KWDB Commands From a File”
- “Logging KWDB Output to a File”
- “Turning Off Output to the User’s Terminal”
- “Defining an Alias for Commands”
- “Source Information”
- “Controlling KWDB Using set Command”
- “Calling a Kernel Function From the Command Line”
- “Invoking Commands or Shell Scripts”
- “Using Breakpoints”
- “Setting Watchpoints”
- “Stepping and Continuing”
- “Examining Source Code”
- “Examining Assembly Code”
- “Examining Variables”
- “Examining Memory”
- “Examining Registers”
- “Navigating the Stack”
- “Displaying Symbol Table Information”
- “Trapping Panics”
- “Debugging Multiple Processor Systems”
- “Debugging DLKMs”
- “Assembly Level Debugging Using On-Console Debugger”
- “Debugging PA-RISC 11.0 and Earlier Kernels with KWDB”
- “Debugging Code with KWDB”

Beginning a Debugging Session

Begin to debug the kernel by entering KWDB commands to set breakpoints, execute, single step, and so forth.

Ending a Debugging Session

To interrupt or end the debugging session, take one of several actions:

- "Interrupting Target Kernel Execution"
- "Detaching from the Target System"
- "Rebooting the Target System"
- "Ending the KWDB Session"

Interrupting Target Kernel Execution

While the target kernel is running, it can be interrupted, by entering `INT` **Ctrl-c** in the window where the KWDB client is running.

```
(kwdb 0:0) c
Continuing.
^c(interrupt)

Program received signal SIGINT, Interrupt.
0x336078 in idle ()
```

If the target kernel is not running, **Ctrl-c** interrupts the execution of the host debugger itself (for example, to abort display of a particularly long data structure).

Detaching from the Target System

To detach from the target kernel, but leave KWDB active (to reattach to the kernel at a later time), use the detach command. Detach clears any break points and watch points set by KWDB, and the target continues to run.

```
(kwdb 0:0) detach
Detached from remote task.
(kwdb 0:0)
```

Rebooting the Target System

To reboot the target system from KWDB, use the kill command **k**.

```
(kwdb 0:0) kill
Kill the program being debugged? (y or n) y

Killing remote task
Killed remote task.
(kwdb 0:0)
```

Getting Information About the Target

Recent versions of kwdb support the `info target` command. This command gives detailed information about the target which is being debugged from kwdb.

While remote debugging with LAN, the MAC address of the remote target and the name of the communication server are printed.

While remote debugging with UDP, the UDP IP address is printed.

While debugging with sub/sync, the remote MP name and the partition connected to are printed.

While debugging with console target, the remote MP and/or lantron console name and the console port number are printed.

Ending the KWDB Session

To stop debugging and exit the KWDB client session, use the quit command **q** or EOF **Ctrl-d**. If KWDB is currently attached to a running kernel, with a prompt for confirmation. If confirmed by pressing **y**, KWDB will be detached from the target kernel before terminating the KWDB session. There may be a degradation in performance because KWDB related code is running in the kernel. If finished with the debugging session and do not want to attach KWDB again, reboot the kernel without the KWDB flags to ensure optimum performance.

```
(kwdb 0:0) q
The program is running.  Quit anyway (and detach it)?
(y or n) y
Detached from remote task.
kentucky 53 >
```

Getting Help

For information about any debugging command, use the help command **h**. Using help with no arguments gives a list of topics for which help is available.

```
(kwdb 0:0) help
List of classes of commands:
running -- Running the program
stack -- Examining the stack
data -- Examining data
breakpoints -- Making program stop at certain points
files -- Specifying and examining files
status -- Status inquiries
support -- Support facilities
user-defined -- User-defined commands
aliases -- Aliases of other commands
obscure -- Obscure features
internals -- Maintenance 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.

(kwdb 0:0) help breakpoints
Making program stop at certain points.
List of commands:
awatch -- Set a watchpoint for an expression
rwatch -- Set a read watchpoint for an expression
watch -- Set a watchpoint for an expression
tcatch -- Set temporary catchpoints to catch events
catch -- Set catchpoints to catch events
xbreak -- Set breakpoint at procedure exit
break -- Set breakpoint at specified line or function
clear -- Clear breakpoint at specified line or function
delete -- Delete some breakpoints or auto-display expressions disable -- Disable some
breakpoints
enable -- Enable some breakpoints
thbreak -- Set a temporary hardware assisted breakpoint
hbreak -- Set a hardware assisted breakpoint
```

```
txbreak -- Set temporary breakpoint at procedure exit
tbreak -- Set a temporary breakpoint
condition -- Specify breakpoint number N to break only if COND is true
commands -- Set commands to be executed when a breakpoint is hit
ignore -- Set ignore-count of breakpoint number N to COUNT

---Type <return> to continue, or q <return> to quit---
Type "help" followed by command name for full documentation. Command name abbreviations are
allowed if unambiguous.
(kwdb 0:0) help enable
Enable some breakpoints.
Give breakpoint numbers (separated by spaces) as arguments. With no subcommand, breakpoints
are enabled until commanded otherwise. This is used to cancel the effect of the "disable"
command. With a subcommand can enabled temporarily.

List of enable subcommands:

enable display -- Enable some expressions to be displayed when program stops enable once --
Enable breakpoints for one hit enable delete -- Enable breakpoints and delete when hit

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

Specifying Multiple Commands in the Same Command Line

It is possible to specify multiple commands in the same command line in KWDB. This can be done by separating each KWDB command by a semicolon character, as shown below:

```
(kwdb 0:0) break kwdb_test; info break; continue
```

The above three commands will be accepted one after the other, and kwdb client will first set a breakpoint in `kwdb_test`, print the output of "info break" and finally continue kernel execution.

Command Completion

Type a letter or several letters of a command then type the **Tab** key twice, KWDB will list all commands whose first letter(s) match the ones typed. This can be used to determine the minimum number of characters of the command that are necessary to remove ambiguity. If there is no ambiguity, pressing the **Tab** key once will complete the command. For example:

```
(kwdb 0:0) de<Tab><Tab>
define  delete  detach
(kwdb 0:0) def<Tab>
(kedb 0:0) define
```

Pressing the **Enter** key will repeat the previous command. By default, this feature is turned off in q4 mode. To turn it on, use the command:

```
q4>  set auto-repeat on
```

Executing KWDB Commands Automatically at Startup

Commands in files `$HOME/.kwdbinit` and `./.kwdbinit` (current directory where KWDB is run) will be automatically executed each time KWDB is started. The commands in `$HOME/.kwdbinit` will be executed first followed by those in `./.kwdbinit`.

Reading KWDB Commands From a File

Commands can be placed in a file and KWDB will execute them when the source command is used. The syntax is:

```
source <filename>
```

Logging KWDB Output to a File

T start logging a KWDB session to a file, use the command:

```
(kwdb 0:0) set kwdb log on
```

The default is to set kwdb log on so the previous command could be abbreviated to:

```
(kwdb 0:0) set kwdb log
```

To turn logging off, use the command:

```
(kwdb 0:0) set kwdb log off
```

By setting kwdb log on and kwdb log off selectively, it is possible to send any part of the KWDB session to the file. The default file to which KWDB session is written is kwdb-log. To change the name of the file, use the command:

```
(kwdb 0:0) set kwdb logfile <filename>
```

If you change the name of the logfile using the "`set kwdb logfile`" command, you must issue this command before issuing the "`set kwdb log on`" command. If the logfile from a previous KWDB session already exists when logging is turned on, it will be renamed with the "~" character appended to it. Thus, each KWDB session will start with the new log file.

Turning Off Output to the User's Terminal

To turn off display of KWDB's output on your terminal, use the command:

```
(kwdb 0:0) set ttyoutput off
```

If logging of the KWDB session to a file is on, the output will still go to the log file. This could be useful when logging is on and a command is issued, giving many screenfuls of output.

If KWDB has been started in "`perl mode`" (i.e., with "`-p`") `ttyoutput` cannot be set to "`off`". In this case, use the redirect character ">" to send output to a file instead of the terminal.

To display KWDB's output on your terminal after is has been turned off, use the command

```
(kwdb 0:0) set kwdb ttyoutput on
```

Enable/Disable Writing to the Target

The set write feature of GDB can be used to turn on/off writing to the target when KWDB is not started with the --write option.

`set write [on | off]` - Can be used to enable (or disable) writing to the target. This is a GDB feature, it can be used to allow for writing to the target if KWDB was not started with the --write option.

Defining an Alias for Commands

The `define` command allows definition of an alias for any command or sequence of commands typed. This can be useful when typing a long command frequently. For example, to type the q4 command `load struct proc from proc_list max nproc next p_factp skip 10`, alias it to the user-defined command `myload` as follows:

```
(kwdb 0:0) define myload
Type commands for definition of "myload".
End with a line saying just "end".
>load struct proc from proc_list max nproc next
p_factp skip 10
>end
```

To display useful information about user-defined commands use the `document` command. Then use the `help` command on the commands defined. For example:

```
(kwdb 0:0) document myload
Type documentation for "myload".
End with a line saying just "end".
>load struct proc from proc_list
>end
(kwdb 0:0) help myload
load struct proc from proc_list
```

To list user-defined commands use "`help user-defined`" command.

Source Information

KWDB can display source file and line number information from source files compiled with debug options. Refer to *Chapter 3, "Getting Started with Remote Debugging."*

For HP-UX version 11.23 and later KWDB can display source file and line number information even for files not compiled with `-g`. This feature exists only for IPF targets.

This feature is controlled by the KWDB command line option "`-src_no_g`". By default, KWDB displays source information. To turn it off, specify the command line option "`-src_no_g none`". To exclude source information for system libraries such as `libc`, but display it for other files, specify "`-src_no_g no_sys_libs`".

Controlling KWDB Using set Command

The `set kwdb` subcommands control things that are specific to kernel debugging with KWDB. To see the current setting for any of these subcommands, use `show kwdb` <subcommand>. The boolean commands take the optional arguments *on* or *off*.

List of set KWDB subcommands:

`set kwdb cache[on|off]` — Sets the cache remote memory.

`set kwdb memory_cache <integer>` — Sets number of pages for caching memory read from crash dump. This has to be set before target command is issued. The default value is 10,000 pages, i.e., 40MB memory will be allocated for cache while analyzing crash dumps.

`setkwdbdebug[on|off]` — Sets debugging of remote target.

`set kwdb log [on|off]` — Set logging of KWDB output.

`set kwdb ttyoutput [on|off]` — Set display of KWDB output on terminal.

`set kwdb logfile <filename>` — Sets the filename to record KWDB output. Default is `kwdb-log`.

`set kwdb remotelog [on|off]` — Sets logging of remote I/O.

`set kwdb remotelogfile <filename>` — Sets the filename to record the `kwdb/stub` log. Default is `kwdb-remote-log`.

`set kwdb remotelogflush [on|off]` — Sets strict flushing of `kwdb-remote-log` I/O.

`set kwdb ntimeout <integer>` — Sets number of retries for remote network I/O.

`set kwdb spaceid <integer>` — Sets the space id used for memory transfers.

`set kwdb timeout <integer>` — Sets time-out for remote network I/O (tenths of seconds).

`set kwdb q4 [on|off]` — Sets KWDB to q4 mode or turn q4 mode off.

`set kwdb tty output [on|off]` — Sets terminal output on/off.

`set kwdb performanceregs [on|off]` — Enable/Disable display of IPF performance registers.

`set kwdb controlregs [on|off]` — Enable/Disable display of IPF control registers.

`set kwdb floatregs [on|off]` — Enable/Disable display of IPF floating point registers.

`set kwdb field address first [1|0]` — When *`&name`* is used in any command and *`name`* is a filed name in current pile and *`name`* is also a kernel symbol, it can be treated as either (1) address of field from the current pile or it can be treated as (2) address of kernel symbol. By default, option 2 is used by KWDB; that is, *`&name`* will be treated as address of the kernel symbol *`name`*. To override the default and treat it as address of the field from current pile `set kwdb field address first` 1.

`set kwdb module-debug [on|off] -` Can be used to enable (or disable) processing of modules in kwdb. Useful when kwdb is not started with the -m option from the command line.

`set kwdb vmm-translation [on|off] -` Can be used to enable (or disable) translations for symbols from vmm module during debugging of HPVM. For this to work properly with the vmm symbols, vmm object module symbols need to be pre-sourced in by using the add-symbol-file command or by starting kwdb with the `-s` option.

Type `help set kwdb` followed by `set kwdb` subcommand name for full documentation.

```
(kwdb 0:0) help set kwdb
```

Command name abbreviations are allowed if unambiguous. To set default input and output radices use `set input-radix` or `set output-radix`, respectively.

Calling a Kernel Function From the Command Line

The kernel functions can be called from the KWDB command line. Pass up to eight 64 bit arguments and one 64 bit value is returned. The syntax has two forms; use either the `call` or `print` command. The following examples call a function `function_name` and pass two parameters, *`arg1`* and *`arg2`*:

```
call function_name(arg1, arg2)
print function_name(arg1, arg2)
```

If the following message is received; `Unsupported feature number from remote stub: 16` — it means that the kernel supports the command line call feature but the KWDB client does not. To remedy this, install the latest version of KWDB on the host.

Invoking Commands or Shell Scripts

Execute a command, an executable program or shell script from the KWDB command line using `shell` or `system` commands. Create a new session using the `shell` command from the KWDB command line, and when exiting the session be back in KWDB command line. Here are some examples:

```
(kwdb) system date
Thu Sep 26 13:08:45 PDT 2002
(kwdb) shell date
Thu Sep 26 13:08:50 PDT 2002
(kwdb) shell
$ date
Thu Sep 26 13:08:56 PDT 2002
$ pwd
/test/hpad1879/dumps/dlkm/gl
$ exit
(kwdb)
```

Using Breakpoints

Use breakpoints to stop execution at a particular location in the program.

Topics in this section are:

- “Setting Breakpoints”
- “Setting Temporary Breakpoints”
- “Listing Breakpoints”
- “Deleting Breakpoints”
- “Attaching Command Sequences to Breakpoints”
- “Setting Thread Level Breakpoints”

Setting Breakpoints

Use the `break` command **b** to set a breakpoint. The command takes several kinds of arguments:

- Procedure names.
- Line numbers. To set a breakpoint at the current line, use break with no arguments.
- Offsets from the current line.
- Line numbers in a given file.
- Memory addresses. Use an asterisk * to indicate an address:

```
(kwdb 0:0) b enet_install
Breakpoint 1 at 0x58e60c: file enet.c, line 519.
(kwdb 0:0) b enet_attach
Breakpoint 2 at 0x58e6c8: file enet.c, line 566.
```

Setting Temporary Breakpoints

Use the `tbreak` command **tb** to set a temporary breakpoint. This breakpoint stops execution only once, and is then deleted.

```
(kwdb 0:0) tbreak enet_install
Breakpoint 1 at 0x146fd8: file enet.c, line 529.
(kwdb 0:0) jump enet_install
Continuing at 0x146fd8.
enet_install () at enet.c:529
Source file is more recent than executable.
529             enet_saved_pci_attach = pci_attach;
(kwdb 0:0) tbreak *0x146fd8
Breakpoint 2 at 0x146fd8: file enet.c, line 529.
(kwdb 0:0) info break
Num Type           Disp Enb Address    What
2   breakpoint     del  y   0x00146fd8 in enet_install at
                                       enet.c:529
(kwdb 0:0) jump *0x146fd8
Continuing at 0x146fd8.
enet_install () at enet.c:529
529             enet_saved_pci_attach = pci_attach;
(kwdb 0:0)
```

Setting Hardware Breakpoints

Use the `hbreak` command **hb** to set a hardware breakpoint. This breakpoint stops execution only once, and is then deleted.

```
(kwdb 0:0) hbreak enet_install
Breakpoint 1 at 0x146fd8: file enet.c, line 529.
(kwdb 0:0) jump enet_install
Continuing at 0x146fd8.
enet_install () at enet.c:529
Source file is more recent than executable.
529             enet_saved_pci_attach = pci_attach;
(kwdb 0:0) hbreak *0x146fd8
Breakpoint 2 at 0x146fd8: file enet.c, line 529.
(kwdb 0:0) info break
Num Type           Disp Enb Address    What
```

```
2   hw breakpoint del  y   0x00146fd8 in enet_install at
                                      enet.c:529
(kwdb 0:0) jump *0x146fd8
Continuing at 0x146fd8.
enet_install () at enet.c:529
529             enet_saved_pci_attach = pci_attach;
(kwdb 0:0)
```

Listing Breakpoints

Use the `info break` command **i b** to get a list of all current breakpoints:

```
(kwdb 0:0) info break
Num Type       Disp  Enb Address    What
1   breakpoint keep  y   0x0058e60c in enet_install at
                                    enet.c:519
         breakpoint already hit 1 time
2   breakpoint keep  y   0x0058e6c8 in enet_attach at
                                    enet.c:566
         breakpoint already hit 1 time
```

Deleting Breakpoints

Use the `delete` command **d** with a breakpoint to delete the specified breakpoint. For example, the following example deletes Breakpoint 2, then uses the "i b" command to display the results of the operation:

```
(kwdb 0:0) b enet_install
Breakpoint 1 at 0x146fd8: file enet.c, line 529.
(kwdb 0:0) b enet_attach
Breakpoint 2 at 0x147094: file enet.c, line 576.
(kwdb 0:0) i b
Num Type           Disp Enb Address    What
1   breakpoint     keep y   0x00146fd8 in enet_install at
                                       enet.c:529
2   breakpoint     keep y   0x00147094 in enet_attach at
                                       enet.c:576
(kwdb 0:0) d 2

(kwdb 0:0) i b
Num Type           Disp Enb Address    What
1   breakpoint     keep y   0x00146fd8 in enet_install at
                                       enet.c:529
(kwdb 0:0) c
Continuing.

To delete a breakpoint on the current line, use the clear (cl) command.

Breakpoint 1, enet_install () at enet.c:529
Source file is more recent than executable.
529             enet_saved_pci_attach = pci_attach;
(kwdb 0:0) i b
Num Type           Disp Enb Address    What
1   breakpoint     keep y   0x00146fd8 in enet_install at
                                       enet.c:529
        breakpoint already hit 1 time
```

```
(kwdb 0:0) cl
(kwdb 0:0) i b
No breakpoints or watchpoints.
```

Attaching Command Sequences to Breakpoints

To execute a given sequence of commands each time the debugger encounters a breakpoint, use the `commands` command (comm), with instructions on how to enter commands.

```
(kwdb 0:0) list enet_attach
564    #ifdef __LP64__
565    enet_attach( uint32_t id, struct isc_table_type *isc)
566    #else
567    enet_attach( PCI_ID id, struct isc_table_type *isc)
568    #endif
569    {
570             ubit16 reghwid, options, sub_id;
571             ubit32 ssid;
572         /*
573          * OLA/R Variables to set timeouts and events

(kwdb 0:0) b enet_attach
Breakpoint 1 at 0x147094: file enet.c, line 576.
(kwdb 0:0) i b
Num Type           Disp Enb Address    What
1   breakpoint     keep y   0x00147094 in enet_attach at
                                       enet.c:576

(kwdb 0:0) commands 1
Type commands for when breakpoint 1 is hit, one per line.
End with a line saying just "end".
>print id
>end
(kwdb 0:0) i b
Num Type           Disp Enb Address    What
1   breakpoint     keep y   0x00147094 in enet_attach at
                                       enet.c:576
        print id
(kwdb 0:0) c
Continuing.

Breakpoint 1, enet_attach
(id={vendor_id = 4113, device_id = 25}, isc=0xf66200)
    at enet.c:576
576    wsio_event_mask_t event_mask = 0;
$1 = {vendor_id = 4113, device_id = 25}
(kwdb 0:0)
```

To remove the command sequence from the breakpoint, enter an empty command sequence.

```
(kwdb 0:0 commands 1
Type commands for when breakpoint 1 is hit, one per line.
End with a line saying just "end".
>end
(kwdb) 0:0
```

Setting Conditional Breakpoints

Set a breakpoint that triggers only if a given expression is true. To create a conditional breakpoint, attach an `if` expression to a `break` command.

To attach a condition to a previously created breakpoint, use the `cond` command.

```
(kwdb 0:0) b enet_install
Breakpoint 1 at 0x58e60c: file enet.c, line 519.
(kwdb 0:0) b enet_attach
Breakpoint 2 at 0x58e6c8: file enet.c, line 566.
(kwdb 0:0) b enet_init
Breakpoint 3 at 0x58e8a8: file enet.c, line 657.
(kwdb 0:0) info break
Num Type       Disp Enb Address    What
1   breakpoint keep y   0x0058e60c in enet_install
                                   at enet.c:519
2   breakpoint keep y   0x0058e6c8 in enet_attach
                                   at enet.c:566
3   breakpoint keep y   0x0058e8a8 in enet_init
                                   at enet.c:657
(kwdb 0:0) cond 3 (isc != '\0')
(kwdb 0:0) info break
Num Type       Disp Enb Address    What
1   breakpoint keep y   0x0058e60c in enet_install
                                   at enet.c:519
2   breakpoint keep y   0x0058e6c8 in enet_attach
                                   at enet.c:566
3   breakpoint keep y   0x0058e8a8 in enet_init
                                   at enet.c:657
        stop only if isc != 0 '\000'
```

To remove a condition from a breakpoint, use the `cond` command with no arguments.

Setting Processor Level Breakpoints

It is possible to associate a breakpoint with a CPU so that kwdb will only stop if the CPU you specify is executing the code that hit the breakpoint. If any other CPU executes the code that hits the breakpoint, kwdb will not stop. To set a breakpoint at a CPU, append the CPU number at the end of the breakpoint command. For example, to set a breakpoint at function "`foo`" to stop only when CPU #1 is executing code which hits the breakpoint:

```
(kwdb 0:0) break foo cpu 1
```

If you specify a CPU number that is greater than the highest CPU number on the target system, kwdb will issue a warning, but will allow you to associate the CPU number with the breakpoint. This means that the breakpoint will never be hit.

Setting Thread Level Breakpoints

Associate a breakpoint with a thread so that KWDB will only stop if the thread specified has hit the breakpoint. If any other thread hits the breakpoint, KWDB will not stop. To set a breakpoint at a thread, append the keyword "thread" followed by the thread number at the end of the breakpoint command. For example, to set a breakpoint at function "`foo`" to stop only when thread #2863 hits the breakpoint:

```
(kwdb 0:0) break foo thread 2863
```

To find out what threads are running on the target system being debugged, use the `info threads` command.

Until now, kernel hangs often required a kernel reboot if the remote debugger client was accidentally killed and the kernel stopped at a breakpoint or hit a breakpoint that was set by the client that died. Though it is possible to force attach to the target kernel in such cases, the kernel will not proceed because the client does not know that this breakpoint is set; therefore, the original instruction will not be replaced. In most cases, this would require a reboot of the kernel. Starting with 11.31 kernels and the kwdb-3.1.5 client, the kernel will not hang if the client is killed accidentally during debugging.

There are two ways to recover from this situation:

- Force attach to the target. Upon force attaching, the kernel will delete all the stale breakpoitns from kernel memory.
- The kwdbctl utility can be used to destroy the debuger stub. As part of this destruction, all the breakpoints that were installed will be deleted from the kernel memory.

  To use this option use `kwdbctl -D`.

Setting Watchpoints

In addition to setting breakpoints which cause KWDB to get control when the flow of control reaches the specified address, set watchpoints at data addresses which causes KWDB to get control when that address is modified.

To set a watchpoint at a particular address (by default, 4 bytes will be watched):

watch *addr

To set a watchpoint at a global symbol specified by <*symbol-name*>

watch <*symbol-name*>

To set a watchpoint over a range of addresses we use:

watch <*symbol-name*> length <*length-name*>

symbol-name is the symbol on which the watchpoint must be set. *length-name* is the range for which the watchpoint must be set. The watchpoint will be set from the address corresponding to the *symbol-name* to the address of the symbol + *length-name*

watch_target *address*

This command takes *address* as a pointer and puts a watchpoint at the target of that address. This is useful for setting watchpoint on a structure or union pointer.

For example :

```
(kwdb 0:0) watch_target proc_list
is equivalent to executing:
(kwdb 0:0) print proc_list
$1 = (struct proc_list *) 0x7fdf78
(kwdb 0:0) watch *(struct proc *) 0x7fdf78
```

KWDB also supports deferring of hardware watchpoints, if watchpoint symbol does not correspond to any address in the loaded modules or in the vmunix being debugged. The watchpoint is put in the deferred list of breakpoints (and watchpoints), and is activated as soon as a module containing the symbol gets loaded, and the corresponding address is watched. When the module gets unloaded in the target, the watchpoint again gets back to the deferred list.

NOTE On IPF, set a maximum of four hardware watchpoints. If more than four are set, the additional watchpoints will be implemented in software and be *very* slow as it is on PA-RISC.

Stepping and Continuing

Topics in this section are:

- "Basic Stepping"
- "Continuing to the End of a Function"
- "Stepping Over Called Functions"
- "Jumping to a New Location"
- "Lock Stepping Into a Function"
- "Lock Stepping Over a Function"
- "Continuing Execution"

Basic Stepping

To step through the kernel code, use the `step` command **s**:

```
(kwdb 0:0) s
```

For example:

```
(kwdb 0:0) list
514    enet_install(void)
515    {
516        int rv_wsio;
517
518        /* add our attach function to the list */
519        enet_saved_pci_attach = pci_attach;
520        pci_attach = (int (*)()) enet_attach;
521
522        /*
523         Initialize our drv_ops. Zero the function pointers
            since we = don't support LLA
            */
(kwdb 0:0) s
520    pci_attach = (int (*)()) enet_attach;
(kwdb 0:0) s
526    bzero((caddr_t)&enet_drv_ops,sizeof(drv_ops_t));
(kwdb 0:0) list
521
522    /*
523    Initialize our drv_ops. Zero the function pointers
524     since  we don't support LLA.
525    */
526        bzero((caddr_t)&enet_drv_ops,sizeof(drv_ops_t));
527
528    /* tell wsio about ourselves */
529    if ((rv_wsio=
530        wsio_install_driver(&enet_wsio_drv_info))) {
531    if(rv_wsio = str_install(&enet_str_info)) {
```

The `step` command steps "into" any called functions.

Continuing to the End of a Function

Ending function without stepping through the remaining lines of source code, use the `finish` command (`fin`):

```
(kwdb 0:0) list
524    support LLA.
525    */
526    bzero((caddr_t)&enet_drv_ops,sizeof(drv_ops_t));
527
528    /* tell wsio about ourselves */
529    if ((rv_wsio =
530        wsio_install_driver(&enet_wsio_drv_info))) {
531            if(rv_wsio = str_install(&enet_str_info)) {
532                  wsio_uninstall_driver(&enet_wsio_drv_info);
533            }
534        }
(kwdb 0:0) fin
Run till exit from #0 enet_install () at enet.c:529
0x228bc8 in gio_install_drivers ()
Value returned is $1 = 0
```

Use the **Enter** key to repeat the previous command.

Use the `stepi` command `si` to step through the code by the machine instruction rather than by the source line.

Stepping Over Called Functions

To step over a called function, use the `next` command **n**:

```
(kwdb 0:0) b enet_init
Breakpoint 3 at 0x58e8a8: file enet.c, line 657.
(kwdb 0:0) n
569             pci_read_cfg_uint32_isc(isc,SSID,&ssid);
(kwdb 0:0) n
570             sub_id = (ubit16)(ssid >> 16) ;
(kwdb 0:0) n
574              if (!(id.vendor_id==DEC21143_VENDERID && = id.device_id==DEC21143_DEVICEID))
{ (kwdb 0:0) n
588 isc-gfsw = &enet_gfsw;
```

Use the `nexti` command **ni** to step through the code by machine instruction rather than source line.

Jumping to a New Location

To resume execution of the target kernel, at a location specified by line number or address, use the `jump` command **j**.

```
(kwdb 0:0) tbreak enet_install
Breakpoint 1 at 0x146fd8: file enet.c, line 529.

(kwdb 0:0) jump enet_install
Continuing at 0x146fd8.
enet_install () at enet.c:529
Source file is more recent than executable.
529             enet_saved_pci_attach = pci_attach;

(kwdb 0:0) tbreak *0x146fd8
Breakpoint 2 at 0x146fd8: file enet.c, line 529.

(kwdb 0:0) info break
Num Type           Disp Enb Address    What
2   breakpoint     del  y   0x00146fd8 in enet_install at
                                       enet.c:529
```

```
(kwdb 0:0) jump *0x146fd8
Continuing at 0x146fd8.
enet_install () at enet.c:529
529             enet_saved_pci_attach = pci_attach;
(kwdb 0:0)
```

Lock Stepping Into a Function

This feature is similar to step except that only the foreground processor will be allowed to continue execution. All the other processors will be stopped at whatever they were doing at the time kernel was previously stopped. To lockstep into a function, use the `next` command use the `ls or lockstep` command

```
(kwdb 0:0) b enet_init
Breakpoint 3 at 0x58e8a8: file enet.c, line 657.
(kwdb 0:0) set cpu 1
0x775880 in idle+0x8f0 ()
(kwdb 0:1) set cpu 2
0x775880 in idle+0x8f0 ()
(kwdb 0:2) set cpu 0
0x58e8a8: file enet.c, line 657
(kwdb 0:0) lockstep
0x58e8b0 pci_read_cfg_uint32_isc(isc,SSID,&ssid);
(kwdb 0:0) set cpu 1
0x775880 in idle+0x8f0 ()
(kwdb 0:1) set cpu 2
0x775880 in idle+0x8f0 ()
(kwdb 0:2) set cpu 0
```

Lock Stepping Over a Function

This feature is similar to `next` except that only the foreground processor will be allowed to continue execution. All the other processors will be stopped at whatever they were doing at the time kernel was previously stopped. To lockstep over a function, use the `locknext` or `ln` command.

```
(kwdb 0:0) b enet_init
Breakpoint 1, 0x4a3150 in kwdb_test () at
/ux/core/kern/common/util/kwdb/kwdb_test.c:12
12 kwdb_test_1();
(kwdb 0:0)set cpu 1
0x775880 in idle+0x8f0 ()
(kwdb 0:1)set cpu 0
0x4a3150 in kwdb_test () at /ux/core/kern/common/util/kwdb/kwdb_test.c:12
12 kwdb_test_1();
(kwdb 0:0)locknext
0x4a315c in kwdb_test () at /ux/core/kern/common/util/kwdb/kwdb_test.c:13
12 kwdb_test_4();
(kwdb 0:0)set cpu 1
$0x775880 in idle+0x8f0 ()
```

It is possible to configure the behaviour of the next and step commands. This can be done using the command:

```
(kwdb 0:0) set scheduler-locking <mode>
```

Here *mode* can be:

on	When the mode is set to on, then the next, step, nexti and stepi commands will behave like lockstep and locknext commands.

step	When the mode is set to step, then step and stepi commands will behave like lockstep and lockstepi; whereas, the next and nexti commands behave like normal commands.
off	When the mode is set to off then the step, next, stepi and nexti behave like normal commands.

Continuing Execution

To continue running the target kernel, use the continue command **c**.

```
(kwdb 0:0) c
Continuing.
```

Examining Source Code

To examine source code not located in the current directory; first find the source files, then examine lines within them:

- Finding Source Files
- Displaying Source Code

Finding Source Files

To view source code (not located in the current directory), set the directory path to point to the location of the source files. Use the `dir` command with the associated path name to specify the location of the source files.

```
(kwdb 0:0) dir path_name_to_source
```

Issue the command for additional directories to be included in the search path.

```
(kwdb 0:0) dir /home/tester/enet
Source directories searched:
/home/tester/enet:$cdir:$cwd
```

If invoke `kwdb` from the build directory, the source files are available to KWDB without issuing the `dir` command.

The `show dir` command displays the value of search path.

The `dir` command with no argument clears the search path.

Displaying Source Code

Use the `list` command **l** to look at the source code in the immediate vicinity of the current line:

```
(kwdb 0:0) list
14     enet_install(void)
515     {
516          int rv_wsio;
517
518          /* add our attach function to the list */
519          enet_saved_pci_attach = pci_attach;
520          pci_attach = (int (*)()) enet_attach;
521
```

Subsequent **l** commands display the next few lines of source.

A minus sign (**-**) after the command shows previous sections of code.

Use **l** `linenumber` around a specified line number, and **l** `function` to display source around a given function.

Examining Assembly Code

To obtain a disassembly of the current function, use the `disassemble` command `disas`:

```
(kwdb 0:0) disas
```

As an argument to the `disas` command, give an address, a function name or a range of addresses, or view the current function. If a single address or a function name is given, we get a dump of the entire function. If a range of addresses is given, we get the disassembled code for only those addresses. Starting with kwdb-3.1.7, the disas command can also accept a <*filename:function_name*> as argument. This gives the disassembled output of the function <*function_name*> belonging to the file <*filename*> (If the file does not contain the function being asked then the function will be looked for in the entire vmunix).

KWDB displays the assembly code interspersed with the source code if the source file was compiled with `-g`

```
(kwdb 0:0) disas
Dump of assembler code for function enet_attach:
;;; File: enet.c
;;; {
0x58e6b8 : stw %rp,-0x14(%sr0,%sp)
0x58e6bc :       stw,ma %r3,0x78(%sr0,%sp)
0x58e6c0 :       stw %r26,-0x9c(%sr0,%sp)
0x58e6c4 :       stw %r25,-0xa0(%sr0,%sp)
;;; wsio_event_mask_t event_mask = 0;
0x58e6c8 :       ldi 0,%r20
0x58e6cc :       ldi 0,%r21
0x58e6d0 :       stw %r20,-0x60(%sr0,%sp)
0x58e6d4 :       stw %r21,-0x5c(%sr0,%sp)
;;; pci_read_cfg_uint32_isc(isc,SSID,&ssid);
0x58e6d8 :       ldw -0xa0(%sr0,%sp),%r22
0x58e6dc :       ldw 0xbc(%sr0,%r22),%r1
0x58e6e0 :       ldw 8(%sr0,%r1),%r31
0x58e6e4 :       ldw 8(%sr0,%r31),%r19
0x58e6e8 :       ldw -0xa0(%sr0,%sp),%r20
0x58e6ec :       ldw 0xbc(%sr0,%r20),%r21
0x58e6f0 :       ldw 0(%sr0,%r21),%r26
0x58e6f4 :       ldw -0xa0(%sr0,%sp),%r22
0x58e6f8 :       ldw 0xbc(%sr0,%r22),%r1
0x58e6fc :       ldw 4(%sr0,%r1),%r25
---Type <return> to continue, or q <return> to quit---q
Quit

(kwdb 0:0) disass kwdb_test.c:kwdb_test
0x58e6b8 : stw %rp,-0x14(%sr0,%sp)
0x58e6bc :       stw,ma %r3,0x78(%sr0,%sp)
0x58e6c0 :       stw %r26,-0x9c(%sr0,%sp)
0x58e6c4 :       stw %r25,-0xa0(%sr0,%sp)
;;; kwdb_test_1();
0x58e6c8 :       ldi 0,%r20
0x58e6cc :       ldi 0,%r21
0x58e6d0 :       stw %r20,-0x60(%sr0,%sp)
0x58e6d4 :       stw %r21,-0x5c(%sr0,%sp)
;;; kwdb_test_2();
```

Use the `x/i` command to examine instructions, described in Examining Instructions.

For information on the PA-RISC architecture and instruction set, refer to *PA-RISC 1.1 Architecture and Instruction Set Reference Manual* and PA-RISC 2.0 Architecture Manual Title: *HP Assembler Reference Manual*. For information on the IPF architecture and instruction set, refer to *Intel IA-64 Architecture Software Developer's Manual*.

Examining Variables

To inspect the values of variables, see:

- "Printing the Value of a Variable"
- "Printing the Value of String Variables"
- "Displaying the Values at Every Stop"
- "Creating Debugger Variables"
- "Changing the Value of a Variable"

The variable or expression used as an argument to these commands must be in scope at the time issuing the inspection command. KWDB has no syntax for specifying variables that are not currently in scope, but can create variables or change a variable value as explained later in the Creating Debugger Variables and Changing the Value of a Variable sections.

Printing the Value of a Variable

To print the value of a variable or expression, use the `print` command **p**. By default, the **p** command prints the value in a format appropriate to the declared type of the variable.

```
588 isc->gfsw = &enet_gfsw;
(kwdb 0:0) info source
Current source file is enet.c
Located in /home/tester/enet/enet.c
Contains 12705 lines.
Source language is c. (
kwdb 0:0) p reghwid
$3 = 0
(kwdb 0:0) p options
$4 = 8
(kwdb 0:0) p sub_id
$5 = 4198
```

To set default output number radix, use the `set output-radix` command. Every printed expression is assigned a number, prefixed by a dollar sign ($), by which it can referenced in subsequent commands. The current value of `reghwid` has the number $3. KWDB supports all the special characters supported by `gdb` to refer to the value history. Use a slash (/) and a format specifier to request another format. For example, use `x` for hexadecimal, `c` for character, `d` for decimal, and `t` for binary.

```
(kwdb 0:0) list 559
554    #ifdef __LP64__
555    enet_attach( uint32_t id, struct isc_table_type *isc)
556    #else
557    enet_attach( PCI_ID id, struct isc_table_type *isc)
558    #endif
559    {
560             ubit16 reghwid, options, sub_id;
561             ubit32 ssid;
562        /*
563         * OLA/R Variables to set timeouts and events
```

```
(kwdb 0:0) p/x ssid
$6 = 0x1066103c
(kwdb 0:0) p/d ssid
$7 = 275124284
(kwdb 0:0) p/t ssid
$8 = 10000011001100001000000111100
(kwdb 0:0) p/x $$
$9 = 0x1066103c
(kwdb 0:0) p id
$10 = {vendor_id = 4113, device_id = 25}
(kwdb 0:0) c
Continuing
```

Print expressions, an array or array element. To find the type of a variable, use the `ptype` command **pt**:

```
(kwdb 0:0) ptype rv_s wsio
type = int
(kwdb 0:0) ptype enet_drv_opts
type = struct drv_ops {
    int (*d_open)();
    int (*d_close)();
    int (*d_strategy)();
    int (*d_dump)();
    int (*d_psize)();
    int (*reserved0)();
    int (*d_read)();
    int (*d_write)();
    int (*d_ioctl)();
    int (*d_select)();
    int (*d_option1)();
    struct pfilter *pfilter;
    int (*reserved1)();
    int (*reserved2)();
    struct aio_ops *d_aio_ops;
    int d_flags;
}
(kwdb 0:0) ptype enet_wsio_drv_info
type = struct wsio_drv_info {
    struct drv_info *drv_info;
    struct drv_ops *drv_ops;
    struct wsio_drv_data *drv_data;
    unsigned int driver_version;
}
```

Using the `print` command, access variable that are declared in files that have not been compiled with `-g`. KWDB assumes these variables are integers. If the variables have been declared as anything other than interger and the file was not compiled with `-g`, specify what the type is, when using the `print` command, as follows:

```
(kwdb 0:0 print (type-cast) variable
```

where `type-cast` is the type of variable as declared in the source file.

The debugger also provides a `printf` command that allows formatted data to be displayed. This command is useful when attaching commands to breakpoints or creating user-defined commands. Refer to the *Attaching Command Sequences to Breakpoints* section.

Printing the Value of String Variables

KWDB does not attempt to automatically de-reference variables of type **char*** and display a null terminated string that the variable points to. KWDB does not automatically de-reference pointers in kernels because:

- Some pointers are not set to valid values.
- The **char*** variables are often used to point to data that is not a null terminated string.
- Pointers may point to I/O memory, which can cause an HPMC if accessed as a string.

In order to print the string pointed to by a **char*** variable, use the command:

x/s *pointer_name*

For KWDB to print strings pointed to by **char*** variables by default, use the set command as follows:

set print strings on

To turn printing strings off, use the following:

set print strings off

```
(kwdb 0:0) ptype enet_wsio_drv_info.drv_info
type = struct drv_info {
    char *name;
    char *class;
    unsigned int flags;
    int b_major;
    int c_major;
    struct cdio *cdio;
    signed char *gio_private;
    signed char *cdio_private;
} *
(kwdb 0:0) p set print strings on
(kwdb 0:0) print (char *)(enet_wsio_drv_info.drv_info.name)
$1 = 0x7a2df0 "enet"
```

Displaying the Values at Every Stop

Instead of using a print command each time to view a variable, set the debugger to show one or more values automatically every time the debugger stops — for example, step or reach a breakpoint. To do this, use the `display` command (`disp`).

```
(kwdb 0:0) display rv_wsio
1: rv_wsio = 7752912
(kwdb 0:0) n
520             pci_attach = (int (*)()) enet_attach;
1: rv_wsio = 7752912
(kwdb 0:0) n
526             bzero((caddr_t)&enet_drv_ops,
                       sizeof(drv_ops_t));
1: rv_wsio = 7752912
```

Each displayed variable is assigned a number. To stop displaying a variable expression, use the expression number as an argument to the `undisplay` command (`und`). To stop displaying all expressions, use `undisplay` with no arguments:

(kwdb 0:0) **undisplay**

Creating Debugger Variables

Create variables to use within the debugger, the term for these variables is “convenience variables”. These variables are not part of the user’s program/drivers or the kernel.

To create a convenience variable, use the `set var` command, and put a dollar sign ($) before the name of the variable. Use the assignment operator (=) to assign an expression to the variable:

```
(kwdb 0:0) set $myVariable = 200
(kwdb 0:0) print $myVariable
$2 = 200
```

Use the print command interchangeably with `set var` to create convenience variables and assign values to them. The only difference is that `set var` performs the assignment silently, while `print` displays the value after performing the assignment.

The show convenience commands (`sho conv`) list all convenience variables currently in use. The variable *`$_`* is automatically set to the last memory address examined.

```
(kwdb 0:0) sho conv
```

Changing the Value of a Variable

Use `print` or `set var` to change the value of a variable, either a convenience variable or a program variable:

```
(kwdb 0:0) print gio_config_state = 1
$3 = 1
(kwdb 0:0) print gio_config_state
$4 = 1
(kwdb 0:0) print gio_config_stat = 2
$5 = 2
(kwdb 0:0) print gio_config_state
$6 = 2
(kwdb 0:0) print $myVariable = 123
$7 = 123
(kwdb 0:0) print $myVariable
$8 = 123
```

Starting with kwdb-3.1.7, the print command can accept variables in the form of:

<*`filename`*>:<*`variable_name`*>.

It prints the value of the variable *`variable_name`* present in the file corresponding to *`filename`*. If the variable is not present in the filename, then an error is reported that the variable is not present in the file.

```
(kwdb 0:0)print kwdb_test.c:kwdb_test_trap_into_tests
$1 = 0
(kwdb 0:0)
```

Examining Memory

KWDB commands for reading and writing data structures or ranges of memory include such commands as the `print` command **p** and **x** (examine memory range) commands. Display and modify C language data structures in C expression syntax using the `print` command.

Debug at the assembly level, to look at data or instructions in memory. Topics in this section are:

- “Examining Memory Addresses”
- “Examining Instructions”

- "Specifying Virtual Space IDs"

Examining Memory Addresses

To see how the array `my_list` is arranged in memory, first find the address of the array. Use either the print command or the `info address` command:

```
(kwdb 0:0) info address my_list
```

Symbol "my_list" is at 0xe00000010016b6c0 in a file compiled without debugging.

```
(kwdb 0:0) &my_list
```

$1 = 0xe00000010016b6c0

Use the address as an argument to the "x" (examine memory range) command. In the example, the 10 tells the debugger to display 10 units of data:

```
(kwdb 0:0) x/10x 0xe00000010016b6c0

0xe00000010016b6c0 <my_list>:   0xffffffff   0xffffffff
0xffffffff   0xffffffff

0xe00000010016b6d0 <my_list+0x10>:   0xffffffff
0xffffffff  0x00000000   0x0000001b

0xe00000010016b6e0 <my_list+0x20>:   0x00000031
0x00000032
```

By default, the debugger displays the data using the last format specifier used in either the `x` or `print` command.

Display the values in any of the formats allowed by the `print` command, and the additional formats `s` (null terminated string) and `i` (machine instruction).

If a print format specifier has not been previously used, the default for the `x` command is hexadecimal.

Examining Instructions

To display a more manageable number of instructions than the `disassemble` (`disas`) command shows, use the `x` command with the *`i`* (for instruction) format specifier. The following `x/i` command displays the instruction at a specified address.

```
kwdb (0:0) x/i 0x22d4
```

The following command displays ten instructions, starting with the program counter register ($`pc`):

```
kwdb (0:0) x/10i $pc
```

Specifying Virtual Space IDs

When specifying a virtual address in a KWDB command without a corresponding space ID, KWDB determines the correct space ID from the current state of the kernel executing on the target.

To explicitly specify space IDs in memory `read` and `write` commands, use the `set` command as follows:

```
set kwdb spaceid space_id
```

To find out the current `spaceid` use the show command as follows:

```
show kwdb spaceid
```

Some `spaceid` commands:

```
(kwdb 0:0) show kwdb spaceid
The space id used for memory transfers is 0.
(kwdb 0:0) set kwdb spaceid 2
(kwdb 0:0) show kwdb spaceid
The space id used for memory transfers is 2.
(kwdb 0:0) set kwdb spaceid 0
(kwdb 0:0) show kwdb spaceid
The space id used for memory transfers is 0.
(kwdb 0:0)
```

Examining Registers

KWDB provides the ability to examine the contents of registers and additional register support.

To see the contents of the registers, use the “info registers”. PA-RISC and IPF have different register sets. The following is a PA-RISC example:

```
(kwdb 0:1) info reg
General Registers
 flags:          0x9000044   r11:            0xb18e00    r22:0x400003ffffff0530
    r1:           0xae1800   r12: 0xffffffff0ffffffff    r23:          0x1c35340
    rp:           0x3c530c   r13:            0xb22e00    r24:         0x40ffac00
    r3:0x400003ffffff0e08   r14:                0x8b    r25:                0x1
    r4:              0x1bf   r15:           0x10e52c8    r26:0x400003ffffff03a0
    r5:0x400003ffffff0000   r16:            0xb257e8     dp:           0xc36000
    r6:          0x1c35340   r17:              0x8bb0   ret0:                  0
    r7:          0x1c7c180   r18:                   0   ret1:0x400003ffffff0dd8
    r8:           0xae1800   r19:            0x88a40c     sp:0x400003ffffff12d8
    r9:                  0   r20:                0x10    r31:           0x349000
   r10:                0x3   r21:          0x10 e52c8
Control Registers
 pcoqh:           0x3495f8   isr:           0x18340022   cr0:                0x1
 pcsqh:                  0   ior:  0x400000008800ce18  cr24:          0x10e52c8
 pcoqt:           0x3495fc  ipsw:            0x806000f  cr25:            0x357fc
 pcsqt:                  0   cr8:                0xfd  cr26:             0x3200
   sar:               0x1f   cr9:                0xf3
   cr0:                0x1  cr12:                0x2
   iir:              0xa00c  cr13:           0xf0000114
Miscellaneous
   sr0:           0x4fbc00   sr4:                   0
   sr1:          0xb101800   sr5:            0xf941c00
   sr2:          0xf941c00   sr6:            0x2dc7c00
   sr3:                  0   sr7:                   0
```

To display the contents of a given register, use the register name as an argument to the `info reg` command:

```
(gdb) i r rp
rp 0x3c530c
```

Use a register name in a `print` command `p`, prefixed by a dollar sign ($):

```
(gdb) p/x $rp
$10 = 0x3c530c
(kwdb 0:0) print/x $pc
$2 = 0x28c658
(kwdb 0:0) print/x $pcoqt
$3 = 0x28c65c
```

Additional Register Support

On IPF, KWDB can access the following additional registers.

Floating point registers:

- f0 through f127 will be displayed (not all of these contain valid values)

  To display the floating point registers use the command info all-reg or: issue the command: `set kwdb floatregs on`.

Performance registers:

- Data breakpoint registers dbp0 through dbp5 will be displayed
- Instruction breakpoint registers ibp0 through ibp5 will be displayed
- Performance monitor config registers pmc0 through pmc12 will be displayed
- Performance monitor data registers pmd0 through pmd16 will be displayed

  To display the performance registers issue the command:

  `set kwdb performanceregs on`

Control registers:

- `dcr`, `iva`, `pta`, `ipsr`, `isr`, `iip`, `ifa`, `iim`, `pmv` will be displayed

  To display the control registers, issue the command:

  `set kwdb controlregs on`

Navigating the Stack

The debugger provides several commands that allow where in the program's call stack and helps to traverse the stack. Topics in this section are:

- "Obtaining a Stack Trace"
- "Moving Up and Down the Stack"
- "Moving to a Specific Stack Frame"
- "Finding Information About a Frame"

Obtaining a Stack Trace

To find out where in the call stack the program has stopped, use the `backtrace` command **bt**:

```
(kwdb 0:0) bt
#0 enet_install () at enet.c:526
#1 0x228bc8 in gio_install_drivers ()
#2 0x228a94 in io_virt_mode_config ()
#3 0x30f718 in DoCalllist ()
#4 0x20ca3c in main ()
#5 0xa9c0c in $vstart ()
#6 0x146f90 in istackatbase ()
```

The command output begins with the number the debugger gives to each stack frame. The stack frame for the current program always has the number zero. The stack frame of the outermost or "main" function has the highest number.

The `bt` command output also includes the function name, its arguments, and the source file and line number, for files compiled with `-g`.

Use `where` as a synonym for `bt`.

Moving Up and Down the Stack

To move to a higher level of the stack (closer to main), use the `up` command. To move to a lower level, use `down`. Specify a numerical argument to either command to move more than one level at a time:

```
(kwdb 0:0) up

(kwdb 0:0) bt
#0 enet_install () at enet.c:526
#1 0x228bc8 in gio_install_drivers ()
#2 0x228a94 in io_virt_mode_config ()
#3 0x30f718 in DoCalllist ()
#4 0x20ca3c in main ()
#5 0xa9c0c in $vstart ()
#6 0x146f90 in istackatbase ()
(kwdb 0:0) up
#1 0x228bc8 in gio_install_drivers ()
(kwdb 0:0) up
#2 0x228a94 in io_virt_mode_config ()
(kwdb 0:0) bt
#0 enet_install () at enet.c:526
#1 0x228bc8 in gio_install_drivers ()
#2 0x228a94 in io_virt_mode_config ()
#3 0x30f718 in DoCalllist ()
#4 0x20ca3c in main ()
#5 0xa9c0c in $vstart ()
#6 0x146f90 in istackatbase ()
(kwdb 0:0) info frame
Stack level 2, frame at 0x7fff05b8:
 pcoqh = 0x228a94 in io_virt_mode_config; saved pcoqh
 0x30f718 called by frame at 0x7fff0580, caller of frame at
 0x7fff05f0
 Arglist at 0x7fff05b8, args:
 Locals at 0x7fff05b8, Previous frame's sp is 0x7fff05b8
 Saved registers:
  rp at 0x7fff05a4, r3 at 0x7fff05b8
(kwdb 0:0) down
#1 0x228bc8 in gio_install_drivers ()
```

Moving to a Specific Stack Frame

To move to a particular stack level, use the `frame` command **f** with the desired frame number as argument:

```
(kwdb 0:0) frame 3
#3 0xac80c in $vstart ()
(kwdb 0:0) frame 1
#1 0x489764 in DoCalllist ()
(kwdb 0:0)
```

Finding Information About a Frame

To see a brief description of the current stack frame, use the `frame` command **f** with no arguments:

```
(kwdb 0:0) f
```

or the `info frame` command.

```
(kwdb 0:0) down
#0 enet_install () at enet.c:526
526 bzero((caddr_t)&enet_drv_ops, sizeof(drv_ops_t));
(kwdb 0:0) info frame
Stack level 0, frame at 0x7fff0628:
 pcoqh = 0x58e62c in enet_install (enet.c:526); saved pcoqh = 0x228bc8
 called by frame at 0x7fff05f0
 source language c
 Arglist at 0x7fff0628, args:
 Locals at 0x7fff0628, Previous frame's sp is 0x7fff0628
 Saved registers:
  rp at 0x7fff0614
(kwdb 0:0) frame 1
#1 0x228bc8 in gio_install_drivers ()
(kwdb 0:0) info frame
Stack level 1, frame at 0x7fff05f0:
 pcoqh = 0x228bc8 in gio_install_drivers; saved pcoqh
 0x228a94 called by frame at 0x7fff05b8, caller of frame at
 0x7fff0628 Arglist at 0x7fff05f0, args:
 Locals at 0x7fff05f0, Previous frame's sp is 0x7fff05f0
 Saved registers:
  rp at 0x7fff05dc
```

Displaying Symbol Table Information

KWDB provides commands to display information about the contents of symbol tables:

- "Displaying the Location of a Symbol"
- "Displaying Information About Defined Functions"
- "Displaying Information About Global Variables"
- "Displaying Information About the Data Type of an Expression"

Displaying the Location of a Symbol

To find the location in storage where a symbol is stored, use the `info address symbol` command:

```
(kwdb 0:0) list
521
522    /*
523     Initialize our drv_ops. Zero the function pointers
524     since we = don't support LLA.
525     */
526        bzero((caddr_t)&enet_drv_ops,sizeof(drv_ops_t));
527
528        /* tell wsio about ourselves */
529         if ((rv_wsio =
531            wsio_install_driver(&enet_wsio_drv_info))) {
532             if(rv_wsio = str_install(&enet_str_info)) {
(kwdb 0:0) info address enet_drv_ops
Symbol "enet_drv_ops" is static storage at address 0x7e7518.
(kwdb 0:0) info address rv_wsio
Symbol "rv_wsio" is a local variable at frame offset 0.
```

Displaying Information About Defined Functions

To show the name and type of defined function, for all functions, or those matching a optional regular expression, use the `info func [regex]` command.

```
(kwdb 0:0) info func enet*
All functions matching regular expression "enet*":

File enet.c:
int enet_802_2_ics(struct lan_ift_s *, char *, int, int);
long enet_802_2_test_ctl(char *, struct lan_ift_s *);
unsigned int enet_abnormal_isr(struct enet_ift *,
                               unsigned int);
int enet_attach(struct _PCI_ID, struct isc_table_type *);
 ....
```

It will show a whole list of symbols from files not compiled with the debug option. An example is the following:

```
Non-debugging symbols:
    00034e8c restore_general_regs
    000404ac pa_generic_psm_pdc_rtc
    00047b3c tcp_hash_insert_listener
```

Displaying Information About Global Variables

To show names and types of global variable (all, or those matching an optional regular expression), use the `info var [regex]` command.

```
(kwdb 0:0) info var enet*
All variables matching regular expression "enet*":

File globals:
char enet_brdcst_addr[6]:
unsigned int enet_cfit;
unsigned int enet_debug;

Non-debugging symbols:
    0070ede0 general_log_lock
    0070ee00 general_log_ptr
```

Displaying Information About the Data Type of an Expression

To show the data type of an expression (or $) without evaluating it, use the `whatis expr` command to determine its type. Use the `ptype expr` command to display its type.

```
(kwdb 0:0) whatis enet_wsio_drv_info
type = struct wsio_drv_info
(kwdb 0:0) ptype struct wsio_drv_info
type = struct wsio_drv_info {
    struct drv_info *drv_info;
    struct drv_ops *drv_ops;
    struct wsio_drv_data *drv_data;
    unsigned int driver_version;
}
(kwdb 0:0) ptype wsio_drv_info_t
type = struct wsio_drv_info {
    struct drv_info *drv_info;
```

```
struct drv_ops *drv_ops;
struct wsio_drv_data *drv_data;
unsigned int driver_version; }
```

Trapping Panics

To trap kernel panics, set a breakpoint at function `panic()`.

Trapping Panics After File System Flush on PA-RISC

The default PA kernel has a breakpoint set at routine `KWDB_stop_before_dump()` to stop a kernel panic after the file system flush, but before the crash dump. Once the crash dump is started, communication with KWDB is no longer possible.

Trapping Panics: Crashtime Kernel Debugging

KWDB supports multiple ways to debug a crashed system:

1. Start the target operating system with any kernel debugger option and attach to the target system from the kernel debugger client. When the kernel panics, the target kernel would automatically enter KWDB prior to collecting crash dumps.
2. Start the target Operating System with the `-dcrash` option on IPF, and with `-f0x80000` flag on PA-RISC. This initializes the kernel debugger for crashtime attachment only. For 11.31 kernels and beyond, crashtime kernel debugger can be enabled by booting the kernel with the `kwdb_flags=crash` option from the boot loader prompt. Currently, kernel debugger can be initialized at crashtime with console debugger on all platforms, and remote debugger through sub/sync only on cell platforms. For source level debugging with console debugger, the console target method can be used (as described in chapter 3).

NOTE During the crashtime debugger session, none of the execution control commands of KWDB are available. Only commands pertaining to examinging the state of the system are available. Also, all q4 commands that are applicable on a crash dump are available.

Debugging Multiple Processor Systems

When one processor of a multiprocessor system stops because of a debug event such as a single step, breakpoint being hit, or the user typing **Ctrl-c** in KWDB on the host system, it will stop the other processors. When all processors have stopped, KWDB will display the user prompt, enter KWDB commands. A request to display registers or other processor specific items will cause KWDB to display the environment of the processor (known as the foreground CPU) that originally stopped because of the debug event. Change the foreground CPU using the `cpu select` command. For example, `cpu select 1` selects processor #1 as the foreground CPU. If the foreground CPU is allowed to run by a `continue` or single step command, all other CPUs will also run until one of them stops because of a debug event.

Unusual results can occur if a single step on the foreground CPU and another CPU stops for a debug event (for example, hitting a breakpoint) before the foreground CPU has finished the single step. The processor that stopped because of hitting a breakpoint becomes the new foreground CPU. If the user continues at this point, the `continue` command will first cause a single step to occur, as part of continuing past a breakpoint and on PA a warning will be issued on the console that it can not have two single steps at the same time. On IPF no warning will be issued, but results will be unpredictable. To avoid this problem, the user must determine the reason that the target system has stopped after doing a single step on a multiprocessor system by carefully

examining the information displayed by KWDB. If the user does a single step and the next KWDB message indicates that it stopped in a different CPU because of hitting a breakpoint, the user should delete the breakpoint before continuing to avoid the problem of having two single steps at the same time.

Debugging DLKMs

This section describes how to debug dynamically loadable kernel modules with KWDB:

- "Preparing to Debug DLKMs"
- "Executing KWDB on DLKMs"

A **Dynamically Loadable Kernel Module** (DLKM) is written in the DLKM format, which allows the module to be dynamically linked to the kernel without having to re-link the entire kernel or re-boot the system.

Kernel modules written in the DLKM format can either be configured as dynamically loadable modules or as statically linked modules. Kernel modules written prior to HP-UX 11.0 (static modules) — can only be configured as statically linked modules.

Preparing to Debug DLKMs

This section describes the conditions needed to debug dynamically loadable kernel modules. Complete these conditions before starting the KWDB session.

To debug a dynamically loadable module at source level, place a copy of the module object file with debugging information (generated via the compiler `-g` option) on the debugger host system. Do not specify optimization when compiling.

If source level debugging is not required, do not generate debugging information in the module object file, but a copy of the module object file must be present on the host. Even if not planning to debug a particular module, it's good practice to place a copy of the module file on the host and indicate the location of the module object file using the `path` command. This allows KWDB to debug the module in case kernel execution stops during the session while the module is executing or is active on the execution stack.

The module object file that is copied to the host is the DLKM loadable module file generated by *config* (1M). The `config` command stores the module file in the default location for such files on the target, in directory `/stand/dlkm/mod.d`. If the kernel is not named `vmunix`, the directory is `/stand/dlkm.kernel/mod.d`. For example, to debug module `mod1` using kernel `mykern`, copy the module object file from target path `/stand/dlkm.mykern/mod.d/mod1` to a directory on the host.

Place the copies of module object files in any filesystem path on the host. The module object files do not need to be located in the same paths as they reside on the target. Use the KWDB `path` command to specify the location of the DLKM module on the host.

If a dynamically loadable module being debugged accesses an external variable defined in another dynamically loadable module, copy the module object file for the defining module to the host. Place the module object file which defines the variable in a path on the host specified in a `path` command, so KWDB can locate the host's copy of the file. It is not necessary to generate debug information for the module object file that defines the variable. If a copy of the module object file containing the definition is not available, KWDB can not correctly access the value of the external variable.

Keep the host copy of the module object file current with the module object file loaded on the target. If a module being debugged is unloaded, modified, and re-loaded on the target during a debugging session, recopy the new module object file to the host.

Executing KWDB on DLKMs

This section describes how to run KWDB to debug DLKM modules. Complete the preparation from the Preparing to Debug DLKMs section before executing KWDB.

First, execute KWDB on the static kernel and attach to the target system, as usual. Before the modules of interest are loaded, enter the following KWDB commands:

```
path directory_name
```

Required: Enter this command to specify to KWDB where the host copies of the module object files are located. Enter the name of one or more directories where copies have been placed, of the module object files on the host. Place all module object files in the same host directory and enter that directory name here. Enter this command, so that KWDB can read the debugging information about the modules.

```
catch load [module-name]
```

Optional: Enter this command if KWDB is to stop and prompt for commands whenever the named modules are loaded. If *module-name* is omitted, KWDB will stop for all module loads. Set breakpoints in the new module or perform other debugging operations before the newly-loaded module begins execution. If debugging commands are not wanted when a module is loaded, do not issue a `catch load` command for the module.

For example, assume a copy of each module object file is placed to debug on the host in directory `/home/me/mykern`.

The following KWDB command allows KWDB to locate the host's copy of all modules:

```
kwdb (0:0)> path /home/me/mykern
```

To debug all modules, enter the KWDB command:

```
kwdb (0:0)> catch load
```

To debug modules 1 and 2, enter the KWDB commands:

```
kwdb (0:0)> catch load mod1
kwdb (0:0)> catch load mod2
```

so that KWDB stops each time these modules are loaded, allowing to set breakpoints in the modules.

Other operations, such as intercepting unload events and listing the currently loaded modules, include the following:

```
catch unload [module-name]
```

Enter this command if KWDB is to stop and prompt for commands whenever the named modules are unloaded. If omitting *module-name* KWDB will stop for all module unloads.

```
info shared
```

This displays information about loaded modules.

KWDB intercepts a module load as soon as the kernel has loaded the module into memory and relocated the module. The intercept occurs before the module's `_install()` or `_load()` entry points are called. The intercept also occurs before the module is "logically connected" with the kernel by installing the module into type-specific switch tables. A module unload is intercepted after the module's `_unload()` entry point has been called, and after memory for the module has been de-allocated.

If a module of interest depends on other dynamically loadable modules that are not loaded, KWDB first processes the loading of the dependent modules before processing the load of the module of interest.

```
tcatch load [module-name]
```

Like `catch load` but temporary — deleted when the load is caught by KWDB.

`tcatch unload [module-name]`

Like `catch unload` but temporary — deleted when the unload is caught by KWDB.

`uncatch load [module-name]`

No longer `catch load` for [*module-name*]. If [*module-name*] is omitted, then no longer catch any DLKM loads

`uncatch unload [module-name]`

No longer `catch unload` for [*module-name*]. If [*module-name*] is omitted, then no longer catch any DLKM unloads

KWDB can not perform operations on an unloaded module. For example, display the values of statically-initialized variables or code instructions in a module that is not currently loaded, nor can the breakpoints in that module be set, or view the source code that corresponds to a function in that module. Debugging information about a dynamically loadable module only becomes available at the time the module is loaded, and becomes unavailable at the time the module is unloaded.

On PA-RISC systems, the local copy of the DLKM module is processed by the `pxdb` utility every time the module is loaded. Symbolic debugging of DLKM modules will not work if the module is not processed by `pxdb` so, make sure that a version of `pxdb` that processes 64 bit PA-RISC files is present on the system. By default, KWDB looks for `pxdb` in `/opt/langtools/bin/pxdb`. If the version of `pxdb` that is needed is not in that directory, tell KWDB to look for `pxdb` in another directory by setting the environment variable *`PXDB`* to the absolute pathname of the version of `pxdb` that is to be used.

If kwdb client gets attached to a running kernel with one or more dlkms already loaded then kwdb will not process those modules for debugging. To process already loaded dlkms for debugging invoke kwdb with the `-m` option. In addition to processing all loaded dlkms, `-m` option enables processing of modules as and when they get loaded.

Starting with kwdb-3.1.4, there is support for debugging IPF DLKM's built with +nosectionmerge. If a DLKM is built with +nosectionmerge option, then the corresponding object file will have multiple .text, .data, .debug sections.

Starting with kwdb-3.1.5, there is support for debugging PA DLKM's built with +nosectionmerge.

Assembly Level Debugging Using On-Console Debugger

Every HP-UX kernel 11.11 and later has a built-in debugger that can be accessed from the system console. This is commonly referred to as the "on-console" debugger. This is also called "single system debugger" as debugging can be done on the target system itself.

This debugger has the advantage of requiring no communications setup since it runs on the target system itself, but it has a limited set of commands. The on-console debugger only allows assembly level debugging. If source-level debugging is needed, the remote debugger's *console target* method can be used as discussed in Chapter 3.

A list of assembler level debugging commands supported on a single system (on-console) debugger is shown in *Table 4-1, "On-Console Debugging Commands."*

Table 4-1 On-Console Debugging Commands

Command	Remarks
`continue [count]`	Continue from breakpoint
`step|si [n]`	Single step machine instruction

Table 4-1 On-Console Debugging Commands (Continued)

Command	Remarks
`next|ni [n]`	Single step over function calls
`jump [addr]`	Jump to another address
`bt`	Stack trace

`print[/fmt] expr`	Print value of expression
	Expression could include calls to functions and assignment. Examples: `kwdb[0] print gio_config_state`
	`kwdb[0] print gio_config_state = 2`
	`kwdb[0] print vator (0xe00000000099b8a0)`

`x[/fmt] addr`	Examine memory Allowed formats include hex (`h`), octal (`o`), decimal (`d`), character
`disass [expr]`	Disassembly
`break [*addr| function_name]`	Set a breakpoint at address or function
`tbreak [*addr| function_name}` `break [*addr| function_name}`	tbreak sets temporary breakpoint break sets a permanent breakpoint. For 11.31 kernels, breakpoints are deferred. If a DLKM contains a deferred breakpoint symbol, the breakpoint is automatically enabled during the module load. During module unload, the breakpoint is automatically marked as deferred.
`watch addr [length] | &variable_name`	Set a watchpoint at an address or a variable
`delete n`	Delete breakpoint
`enable n`	Enable breakpoint
`disable n`	Disable breakpoint
`ignore n count`	Set ignore-count for breakpoint or watchpoint Do not stop at the breakpoint/watchpoint n for count number of times. Available for kernel version 11.23 or later.
`finish`	Run to completion of current routine
`set [cpu n|dis]` `set [auto repeat | pagination ] [on|off]`	Sets variables to switch CPUs or enable disassembly In 11.31 kernels, set auto-repeat feature enables auto repeat of the previous command, and the set pagination command enables/disables pagination of the output.
`unset var`	Unset variables
`info reg|break|catch`	Display registers or breakpoints. For 11.31 kernels, info catch displays information about catchpoints.

Table 4-1 On-Console Debugging Commands (Continued)

Command	Remarks
`help [topic]`	Basic help information. In 11.31, if optional *target* argument is specified, it displays help information of the specified topic.
`kill`	Reboot machine
`cpu [select] n`	Switch CPU
`catch load|unload`	Catch loads or unloads of DLKM modules
`uncatch load|unload`	Do not catch loads or unloads of DLKM modules Catch of loads and unloads of DLKM modules are off by default.
`quit`	Quit from the debugger. Upon quit, all breakpoints, catchpoints, and watchpoints are removed from the debugger.
Control-x	Escape into the debugger. other control characters could be set to escape into the debugger.

The console escape character can be changed using KWDB or `adb`. Change kernel memory so there is no need to reboot after making the change. In kernels prior to HPUX 11.31, the console escape character is stored in the variable `kgdb_console_escape` on PA and `kdebug_console_escape` on IPF. For 11.31 and beyond, the kernel variable `kwdb_console_escape_seen` needs to be patched.The commands to change `kgdb_console_escape` from **Ctrl-x** (`0x18`) to **Ctrl-f** (`0x06`) using KWDB are:

```
# kwdb -write /stand/vmunix /dev/kmem
(kwdb) write 0x06 at &kgdb_console_escape using b

Writing a byte at 0xb2fb28 in devmem

Old value : 0x06

New value : 0x18

(kwdb) quit
```

This example assumes that `/stand/vmunix` is booted on the machine. For pre 11.31 IPF, replace the variable `kgdb_console_escape` with `kdebug_console_escape`. For 11.31 and beyond, replace `kgdb_console_escape_seen` with `kwdb_console_escape_seen`.

The following *Table 4-2, "Commands for 11.23 and Beyond,"* lists additional commands available on on-console debugger for kernel 11i version 2.0 (11.23) or later which are not listed in *Table 4-1, "On-Console Debugging Commands."*

Table 4-2 Commands for 11.23 and Beyond

Commands	Remarks
`pfndump phys_mem_tbl`	Prints info about physical memory regions (regular and I/O memory).

Table 4-2 Commands for 11.23 and Beyond (Continued)

Commands	Remarks
`pfndump io_mem_tbl`	Prints info about physical regular memory regions.
`pfndump pgclass [<Page Frame Number>]`	Prints the page classification of a given page. Without arguments, it displays classification of all page.
`pfndump pfdat <Page Frame Number>`	Prints info about a specified page frame number.
`process proc_address`	Prints info about a process from the kernel's `proc` structure. When used without arguments, it prints info about all processes.
`kthread ktid`	Prints info about a kernel thread. When used without arguments, it prints info about threads.
`symbol symbol_name | symbol_address`	Prints the address, type, and size of a kernel symbol.
`symbol -module module_name`	When `-module` option is used, all the symbols in the module specified by `module_name` is printed.
`panictrace event event_num`	Displays the stacktrace in crash path for the event specified by `event_num`.
`panictrace processor processor_index`	The `panictrace` processor will display the stacktrace for the processor specified by `processor_index`.
`module [module_name]`	Displays information about the modules in the kernel. Without the argument, module command prints info about all kernel modules.

Table 4-3 on page 112 lists additional commands available on on-console debugger for kernel 11i version 3.0 (11.31) or later which are not listed in Table 4-1 on page 109, or Table 4-2 on page 111.

Table 4-3 Commands for 11.31 and Beyond

Commands	Remarks
break <func|addr> thread <tid>	Allows to set a breakpoint on a specific kernel thread
break <func|addr> process <pid>	Allows to set a breakpoint on a specific kernel process
break <func|addr> cpu <procid>	Allows to set a breakpoint on a specific processor
catch|uncatch load|unload <modulename>	Allows to set a load or unload catchpoint for a specific module. When used with uncatch, a specific module is uncaught.
maint print unwind <funcname>	Print unwind info of a specified function
maint info break	Print contents of the console debugger breakpoint table

Table 4-3 Commands for 11.31 and Beyond (Continued)

Commands	Remarks
maint info catch	Print contents of the console debugger catchpoint table
ltor <addr|func>	Prints the corresponding physical address given a kernel virtual address
translate <addr|func>	Prints the contents of the Page Directory entry on PA-RISC and Page Table Entry on IPF for the given function or kernel virtual address
< and > keys	Command line history recall (upto 100 commands are buffered and can be recalled by the console debugger)

Debugging PA-RISC 11.0 and Earlier Kernels with KWDB

For PA-RISC systems, KWDB only debugs 11.10 and later kernels. However, also use KWDB to debug older kernels (PA-RISC 11.0 and earlier) that contain support for the older NDDB kernel debugger instead of KWDB. For backwards compatibility, KWDB provides a KWDB/NDDB protocol translator, named `kwnddb`, which translates between the KWDB protocol and the NDDB protocol spoken by the older kernels. Specify this by specifying the KWDB command `target nddb` instead of entering a usual `target` command, as documented in *Chapter 3, "Getting Started with Remote Debugging."* Allows use of the same KWDB interface for all kernel debugging, even for 11.0 and earlier kernel releases.

Use KWDB's NDDB compatibility targets to debug the following target systems and kernels:

- Any target HP-UX kernel supported for NDDB debugging, currently including OS releases 10.0 through post-11.0 i80 release line.
- Any target platform supported by NDDB on that kernel: S700, S800, V-Class, N-Class.
- Any LAN or serial device supported by NDDB on that kernel may be used for communications.

For LAN communications, use the NDDBCS LAN Communications Server to communicate with the target, dedicated LAN connections may not be used with KWDB. See *Chapter 3, "Getting Started with Remote Debugging."*

It is not required, to modify the NDDB-capable target kernel in any way to debug it with KWDB. But, may of course, wish to generate source level debugging information for certain files of interest, or may wish to use the `nddb_config_kern` utility to configure NDDB characteristics of the kernel.

Boot the target as described in *Chapter 3, "Getting Started with Remote Debugging."*

Using KWDB to debug an NDDB target, use most KWDB commands, such as the commands that read and write memory and registers, set and delete breakpoints, continue execution, trace the stack, and so forth.

Operations that may not be performed include — the following KWDB operations not supported by NDDB-capable kernels:

- Can not attach to a running kernel. The kernel must be booted for NDDB debugging using the appropriate boot flags, and must wait for a client connection at bootup time.
- Can not remotely reboot the target with file system buffers flushed. (The KWDB `kill` command will immediately TOC the target if the NDDB target supports this for the NDDB `kill` command, otherwise the target is left suspended.)

- Can not detach the target kernel (even if the NDDB target supports this for the NDDB debugger, due to differences in protocols).
- Can not call a kernel function.

Can not perform the following NDDB operations not currently supported by KWDB:

- Can not use hardware assisted watchpoints.
- The NDDB `ps`, `ktps` and `cpus` commands are not supported by KWDB.
- Some control registers such as RCTR, EIEM and EIRR which could be modified by NDDB can not be modified by KWDB.
- Can not use a dedicated LAN connection (NDDB feature not supported by KWDB).

NDDB-style functionality provided by NDDB compatibility targets that is not provided by regular KWDB targets includes:

- Console `printf`'s are displayed by the debugger.

Debugging Code with KWDB

KWDB can be used to debug most kernel code, with some exceptions discussed in the following sections:

Non-Debugable Code

These are the known kernel code parts that can not be debugged.

- Early boot code before KWDB attaches to the target.
- Low-level interrupt and trap handling code, `$ihandler` and `$thandler` on PA, and `bubbleup` on IA. KWDB uses that code to service its own interrupt and trap events. Debugging can begin on the interrupt and trap paths at `interrupt()` and `trap()`.
- VM code that services a TLB miss. KWDB relies on the code for this while execution of the target is "stopped" by the debugger. No breakpoints can be placed in this path of execution.
- Code that executes with interrupts turned off can not be interrupted, but can stop at breakpoints and may be single stepped.
- On PA, code that executes with `PSW Q = 0` can not have breakpoints and can not be single stepped. This includes emulation code for emulated floating-point instructions on platforms without floating-point coprocessors.

Code with Timeouts in Effect

Because KWDB freezes the state of the system for long periods of time while interactive, kernel code that must execute within a certain amount of time before "timing out" can be a problem to debug. In order to be able to debug the code executed with the timer in effect, make some changes to do things differently while debugging the system.

If timer expiration results in the system "panicking" repeatedly printing messages to the system console, or in other ways drastically affects system operation, defeat that behavior when debugging. The panic or lengthy diagnostics should be skipped when debugging.

If there is no need for the timer to be operational when debugging the system, do not set the timer. Some time dependent functionality, such as `clock.c` checking for missed clock ticks or spinlock held too long, is completely useless and is skipped while debugging the kernel.

If the timer should be operational while being debugged, no apparent ill effect occurs if the timer pops due to KWDB freezing the system for too long. This protects both the debugging session of the code for which the timer is in effect, and protects against problems for other developers who may be debugging **Interrupt Server Routines** (ISRs) that interrupted the code. The other developers ideally should not see any problems if they happen to catch the system in the middle of executing the code with a timer in effect.

To change system behavior when being debugged on a pre 11.31 PA system, use code like the following:

```
#include <machine/kgdb/kgdb_external.h>

if (kgdb_connected)
{
         /*
          * System is being debugged.
          */
}
```

To change system behavior when being debugged on a pre 11.31 IPF system, use code similar to:

```
#include <h/kdebug.h>

if (kdebug_enabled)
(
   /*
    * System is being debugged.
    */
)
```

To change system behavior when being debugged on a 11.31 system, use code similar to:

```
#include <h/kwdb_kernprivate.h>

if (KWDB_ENABLED()
(
   /*
    * System is being debugged.
    */
)
```

Q4 Commands

KWDB supports a superset of commands provided by the crash dump analysis tool, Q4. These are defined in the following sections:

- “Command Structure”
- “Data Types”
- “Numbers”
- “Addresses”
- “KWDB Q4 Mode”
- “Enumerants”
- “Variables”
- “Expressions”
- “Synthetic Fields”
- “Custom Field Formats”
- “History References”
- “Redirecting Input and Output”
- “Command Completion”
- “Getting Version Information”
- “Getting Help”
- “Searching the Catalog of Data Types”
- “Listing the Fields in a Data Structure”
- “Handling typename Clashes”
- “Listing Kernel Symbols”
- “Disassembling Functions”
- “Translating Virtual Addresses”
- “Tracing Stacks”
- “Setting Context”
- “Loading Data From the Crash Dump/Kernel Memory”
- “Naming Piles of Data”
- “Saving Piles of Data”
- “Getting a History of the Loads”
- “Recalling Old Piles”
- “Merging Piles”
- “Forgetting Piles”
- “Saving and Restoring State”

- “Printing Structure Fields”
- “Printing Structure From an Address”
- “Examining Memory”
- “Writing into Kernel Files or Memory”
- “Evaluating Expressions”
- “Listing Constants”
- “Listing Variables”
- “Destroying Variables”
- “Database Operations”
- “Database Operations”
- “Including PERL Program Files”
- “Running PERL Programs”
- “Adding Type Information”
- “Listing DLKM Modules”
- “Processing DLKM Modules”

Command Structure

KWDB implements a line-based debugging language. Commands are terminated by a newline. The exception is that command lines ending with a `\` are continued to the next line.

Data Types

Wherever KWDB requests to enter the name of a data type, it must be prefixed with the proper keyword:

- `enum` if it’s an enumerated type
- `struct` if it’s a structure
- `union` if it’s a union
- nothing (no prefix at all) if it’s a `typedef`

Numbers

Wherever KWDB requests to enter a number, it may be entered in octal, decimal, or hex according to the C convention (begins with 0x for hex, 0 for octal, any other digit for decimal).

KWDB uses this same convention for its output.

Addresses

Wherever KWDB requests to enter an address, enter it in any of the follow forms:

offset	A number taken to be the 64 bits address. The space is taken to be 0.
space.offset	A fully qualified address with both space and offset separated by a dot.

KWDB Q4 Mode

KWDB supports all the commands available in Q4. There are certain commands, like `symbols`, `run`, `print`, and `unset` present both in KWDB and Q4. To invoke as Q4 commands, they must be prefixed with Q4 as in `q4 symbols`, `q4 run`, `q4 print` and `q4 unset`. Instead of prefixing all the Q4 commands with `q4`, it is possible to set KWDB to a Q4 mode by using the following command:

```
set kwdb q4 on
```

Once this mode is set all the Q4 commands will be prefixed with `q4` internally and the user need not do this manually. Setting this mode for the crash and `devmem` targets provides the user with the standard `q4>` prompt. Turn the Q4 mode off by using the following command.

```
set kwdb q4 off
```

NOTE Once the `kwdb/q4` mode is set to ON, all of the symbols in the succeeding commands are taken from the current pile. Only if a symbol is not found in the current pile will it search in the symbol table.

KWDB supports a command line option `-q4`. Traditional Q4 users can invoke KWDB with this `-q4` command line option to automatically set `kwdb q4 mode` ON and to get the same look and feel of Q4.

Enumerants

KWDB prints enumerated types using a symbolic format.

If the value corresponds exactly to a member of the enumerated type, the name of that value is printed.

If the value is a composite of several members of the type, it is decomposed into the smallest number of members which, when or'ed together, produce that value.

If there are bits in the value that are not covered by any members of the type, a hex number representing those bits is added to the end of the string of named enumerants.

Example:

```
q4> print p_space p_vaddr p_type p_flags
p_space    p_vaddr  p_type  p_flags
 32386          0 PT_MMAP  PF_ACTIVE|PF_EXACT|PF_ALLOC
 8381 1073745920 PT_DATA  PF_ACTIVE|PF_EXACT|PF_ALLOC
 8381 2063605760 PT_MMAP F_WRITABLE|PF_ACTIVE|PF_EXACT|PF_ALLOC
 8381 2063613952 PT_MMAP PF_WRITABLE|PF_ACTIVE|PF_EXACT|
 PF_ALLOC
 8381 2063683584 PT_MMAP PF_WRITABLE|PF_ACTIVE|PF_EXACT|
 PF_ALLOC
```

See a list of the enumerants defined in the kernel by using the `constants` command.

Variables

KWDB defines variables and assigns 32- or 64-bit values to them. The usual C language rules apply to variable names and the syntax used to assign them values and use them.

To create a KWDB variable, decide on a name and assign a value to it with an expression. In Q4 mode, the variable assignment can be done by entering the command "`variable_name = value_expression`". If KWDB is not in Q4 mode this has to be specified as "`eval variable_name = value_expression`".

The `variable_name` may not start with `$q4`.

See a list of the variables created by using the `variables` command.

Delete any variables by using the `unset` command.

Any KWDB commands or their aliases can not be used as a variable name. The following KWDB control variables:

`q4UnwLevel`, `q4PrintDecimal`, `q4PrintHex`, `q4PrintOctal`, and `q4PrintRadix`

Have special meanings to control the output of commands. They will be discussed in later sections.

Example:

1. The print command to use hex (instead of decimal) by default.

```
$ kwdb -q4 ...
q4> q4PrintRadix=16
```

2. Define a variable called `myVariable1` with the value `10` and display it.

```
q4> myVaribale1 = 10
012100xa
q4> variables
NAME         OCTAL   DECIMAL  HEX
MyVariable1  012     10       0xa

Note that in this example KWDB is in Q4 mode as shown by the "<q4>" prompt.
If KWDB is not in Q4 mode the same thing has to be done as:

(kwdb) eval myVariable1 = 10
  10
(kwdb) variables
NAME         OCTAL   DECIMAL  HEX
MyVariable1  012     10       0xa
```

Expressions

Anywhere KWDB input calls for a number or address, an expression can be used.

Type an expression that is not part of some other command, KWDB, in Q4 mode, evaluates it and prints the result in three forms (octal, decimal and hex). The decimal, hex or octal output may be suppressed by setting the KWDB variable(s) *`q4PrintDecimal`*, *`q4PrintHex`* or *`q4PrintOctal`*, respectively, to zero. Any of them may be suppressed. The `evaluate` command can also be used to evaluate any expression.

Example:

```
q4> 1+1
02      2       0x2

q4> eval 1+1
2

(kwdb) eval 1+1
2
```

When KWDB encounters an identifier in an expression there are four possibilities. It tries to resolve the reference by checking each of these categories until it finds a match:

- A field in the structure of the current pile.
- A user-defined variable.

- A kernel-defined enumerant (constant).
- A kernel global variable.

To use field names in the current structure of the current pile, there must be a current pile (that is, at least one `load` command) and that pile must have at least one structure in it. If there are no structures in it, there will be no values to get. If there is more than one structure in it, the value from the first structure will be used.

The exceptions to this are the `keep` and `discard` commands. They operate on an entire pile, one structure at a time.

It is possible to define a user variable that obscures a kernel defined enumerant or global variable. This can be useful or hazardous, depending upon the circumstances. Use the `constants` and `variables` commands to find out if this was done.

KWDB's expression syntax is lifted almost verbatim from the C language. Most of the standard operators have been implemented and a few new ones have been added.

The following monadic (one operand) operators are supported (with the usual precedence):

```
-
~ !
++ --
& *
sizeof()
tooffset() tospace()
ltor()
```

The following dyadic (two operand) operators are supported (with the usual precedence):

```
+ - * / %
<<>
<> <= = == !=
& ^ |
&& ||
= *= /= %= += -= <<= = &= ^= |=
,
```

The following triadic (three operand) operators are supported (with the usual precedence):

```
?:
```

Expressions in KWDB deal mostly with long integers. If processing a 64 bit kernel a long integer will have 64 bits of value. If processing a 32 bit kernel a long integer will have 32 bits of value.

Most of the previous operators only work on both 32-bit and 64 bit integers. The rules are:

dyadic + and -	At most one operand may have a nonzero space. That space is preserved in the result. The offset parts of the operands are combined (without carry or borrow) to form the result.
dyadic *, / and %	Both operands may be simple 64-bit numbers. They are combined (without carry or borrow) to form the result.
<< and	The left operand may have a nonzero space. The right operand must not. The offset part of the left operand is shifted as requested without affecting the space part.
<, , <= and =	Both operands may be simple 64-bit numbers.
== and !=	Either or both operands may be 64-bit quantities.
dyadic &, ^ and |	At most one operand may have a nonzero space. That space is preserved in the result. The offset parts of the operands are combined to form the result.

&& and ||	Either or both operands may be 64-bit quantities. They are only checked for zero/nonzero values. The right operand is only evaluated if necessary.
?:	Any or all of the operands may be 64-bit quantities. They are only checked for zero/nonzero values. The middle and right operands are only evaluated if necessary.
`ltor()`	The operand may be any 64-bit address. The address will be translated to a physical address and stored in the offset of the result. The space of the result will be zero.
`sizeof()`	The operand must be the name of a type defined in the kernel's symbolic debug area. The result is the size of that type in bytes.
`tooffset()`	The operand may be any 64-bit address. The offset of the result will be the space of the operand. The space of the result will be zero.
`tospace()`	The operand may be any 64-bit address. The space of the result will be the offset of the operand. The offset of the result will be zero.
monadic &	The operand may be the name of any kernel global variable. The result will be the address of that variable.
monadic *	The operand may be any 64-bit address. The result will be the long integer contents of that location in the crash dump (after address translation has been performed).
monadic +	The operand may be any 64-bit quantity. The result will be the operand verbatim.
monadic -	The operand may be any 64-bit quantity. The space of the result will be the space of the operand. The offset of the result will be the negation of the offset of the operand.
~	The operand may be any 64-bit quantity. The space of the result will be the space of the operand. The offset of the result will be the bit-wise complement of the offset of the operand.
!	The operand may be any 64-bit quantity. The space of the result will be zero. The offset of the result will be 1 if the offset of the operand was 0, 0 otherwise.
,	The operands may be any 64-bit quantities. The result will be the right operand. The left operand is always evaluated.
++ and --	The operand may be any 64-bit quantity. The result will be the operand after the increment or decrement. If the operand is a user-defined variable it is saved either before or after the increment or decrement operation, as appropriate.

Synthetic Fields

In addition to the fields of each kernel data structure that were defined in the source code, KWDB pretends there were a few extra fields. (It adds these because they are often useful when debugging.)

These so-called *synthetic fields* can be printed or used in expressions just like any of the fields defined in the kernel source. They are:

`indexof`	Index of the item in the current pile (origin is 0).
`mapped`	It is 1 if the structure was successfully located and read from the dump, otherwise 0.
`spaceof`	Space bits of the structure's virtual address.
`addrof`	Offset bits of the structure's virtual address.
`physaddrof`	Structure's physical address (actually only the physical address of the first word, the rest could fall on some other noncontiguous page).
`realmode`	It is 1 if the structure was loaded from an address without using address translation, otherwise 0.

Custom Field Formats

The `print` command supplies a default format for every kind of field it can print.

The default formats can be overridden for numeric fields (only) by following the field name on the command line with any numeric format specification lifted from the *printf* (3C) manual page. (Since overrides are permitted only for numeric fields, the `c`, `s`, and `%` formats are not available.)

An additional format (not supported by `printf`) is supplied. The `p` format prints integer types as symbolic kernel addresses.

Example:

```
q4> load kthread_t from kthread_list next kt_global_kthread max 5
loaded 5 struct kthreads as a linked list (stopped by max count)
q4> print kt_lastrun_time kt_rlink kt_wchan %p
kt_lastrun_time  kt_rlink  kt_wchan
   12527            0         ticks_since_boot
   2366             0         streams_up_runq
   2366             0         SB$obj#str_memory+0x18
   2366             0         weldq_runq
   2366             0         str_freeb_idle
q4>
```

History References

Piles in the history are referred to in these ways:

a positive integer
: This refers to a pile by its history number as shown by the `history` command.

a negative integer
: This refers to a pile relative to the current pile in the history list. The pile before the current pile is -1, the one before that is -2, and so on. The history numbers shown by the `history` command have a bearing on relative references so forgotten piles that leave gaps in the numbering have an effect on this.

zero
: This refers to the current pile.

a name
: This refers to a pile by its nickname. Nicknames are assigned to piles using the name command. Nicknames are also assigned with brand command. Piles that have not been named have no nickname.

Redirecting Input and Output

When KWDB senses its input and output are connected to a terminal it assumes to run it interactively so it prompts for commands and prints status messages about its progress.

Redirecting Input

Redirect KWDB's input if to read from a script. It will automatically suppress prompting. Once within KWDB, input commands can be made to read from a script file using the `source` command.

Redirecting Output Once Inside KWDB

When running KWDB interactively output can be redirected to many of the commands, to files or pipe them into other commands.

The syntax is just expected. Use > to create or overwrite a file. Use >> to create or append a file. Use | to pipe to a command. (The command may include additional pipe stages and redirection.)

Use output redirection with any of the following commands: `catalog`, `code`, `constants`, `disassemble`, `examine`, `fields`, `help`, `history`, `print`, `run`, `symbol`, `trace`, `translate`, `variables`, `version`.

Command Completion

KWDB allows partial commands to be entered rather than typing the entire command name, as long as there is no ambiguity. For example entering "lo" is equivalent to the command `load`. But it can not resolve when there is ambiguity. For example entering "l" will not be resolved to any command as there are two commands, `load` and `list`, starting with "l".

Special characters for command completion provided by shells are also supported by KWDB as shown in the following example.

(kwdb) **lo<tab>**	Will complete the command to q4> **load**
q4> **li<tab>**	Will complete the command to q4> **list**

q4> **l<tab>**	Will not be able to complete the command as there are two commands, `list` and `load`, starting with 'l'. Pressing **Tab** will show a list of commands to select from, such as:
	`list load`
	`q4>`

KWDB work with *ied* (1M) only in perl mode (i.e., WDB invoked with -p). Make an alias like:

```
alias q4=ied -h ~/.q4history kwdb -q4 -q -p
```

Command editing and history are available at all times. The history file even makes the commands typed in previous sessions available in current session.

To record command history in a file for using in a future session use the command:

```
(kwdb 0:0) set history save on
```

To stop recording the command history use the command:

```
(kwdb 0:0) set history save off
```

For more information on the history commands, refer to the *GDB User* manual.

Getting Version Information

Type `version` to get the KWDB version string. This command supports output redirection.

Getting Help

Type `help` to get a short message describing how to get more help.

Type `help class` to get detailed help on list of commands in that class.

Type `help topic` to get detailed help on topic.

Every command keyword appears in the help directory as a topic.

This command supports output redirection.

Synonyms: `h`

Searching the Catalog of Data Types

Every kernel supported by KWDB contains symbolic debug information describing some or all of the data types compiled into the code. In fact, KWDB supports any kernel containing at least some of this data.

The `catalog` command prints a list of these data types. The listing includes the shape and size of each type as well as the:

- Number of top level fields it contains (if it's a struct or union type).
- Number of enumerants it contains (if it's an enum type).

Usage:

```
catalog [ flags ] re
```

Where *re* is a regular expression. The regular expression is not automatically anchored so use **^** or **$** to anchor the match to the head or tail (respectively) of the string.

Flags:

```
-h
```

Column headings are normally suppressed when output is sent to a noninteractive destination (like a file or pipe). This option forces headers to be printed regardless of the destination.

```
-v
```

This flag prints the filename in which the structure is defined.

Example:

```
q4> catalog callout
BYTES FIELDS SHAPE   NAME
   40     10 struct  callout
    4     12 enum    callout_flags
    4     12 typedef callout_flags_t
   40     10 typedef callout_t

q4> catalog -v struct kwdb_catalog_test2_s
BYTES FIELDS SHAPE   NAME                 FILENAME

8      2  struct kwdb_catalog_test2_s kwdb_test_3.c
8      2  struct kwdb_catalog_test2_s kwdb_test_1.c
```

This command supports output redirection.

Listing the Fields in a Data Structure

List the fields in a data type using the `fields` command.

Usage:

```
fields [ flags ] type_name
```

Where `type_name` is the name of any data type appearing in the catalog. The `type_name` must be fully qualified.

Flags:

`-c`	Output is normally printed as a table of names and numbers. This option makes the output look like a (compilable) C-style definition.
`-h`	Column headings are normally suppressed when output is sent to a noninteractive destination (like a file or pipe). This option forces headers to be printed regardless of the destination.
`-v`	Useful only with the `-c` option, this option adds comments to the C code which describe the offset and size of each field.
`-x`	Useful only with the `-c` option, this option expands every embedded structure and union reference inline making the complete definition of the type visible.

Example: What's in a struct callout?

```
q4> fields struct callout
OFFSET        SIZE       FLAVOR NAME
 bytes +bits bytes +bits
     0     0     1     0 u_char c_cookie
     1     0     1     0 u_char c_pad
     4     0     4     0 enum4  c_flag
     8     0     4     0 u_int  c_abs_time_hi
    12     0     4     0 u_int  c_abs_time_lo
    16     0     4     0 *      c_time_next
    20     0     4     0 *      c_time_prev
    24     0     4     0 *      c_hash_next
    28     0     4     0 *      c_hash_prev
    32     0     4     0 *      var.real_callout.cc_func
    36     0     4     0 *      var.real_callout.cc_arg
    32     0     4     0 *      var.time_header.
                                tc_thdr_next
    32     0     4     0 u_int  var.hash_header.
                                hc_walkcount
    36     0     4     0 u_int  var.hash_header.
                                hc_walklength
```

Bit fields may have nonzero bit offsets, but all other fields will not. The same is true for field sizes.

The FLAVOR field may not be exact, but it will be the right size and basic underlying type, and will be correct.

Decode the FLAVOR field as follows:

`int`	Signed integer (consult the SIZE column for detail).
`u_int`	Unsigned integer (consult the SIZE column for detail).
`char`	An 8-bit signed integer.
`short`	A 16-bit signed integer.
`long`	A 32-bit or 64-bit signed integer.
`u_char`	An 8-bit unsigned integer.
`u_short`	A 16-bit unsigned integer.
`u_long`	A 32-bit or 64-bit unsigned integer.

`enum1`	An 8-bit signed enumerated.
`enum2`	A 16-bit signed enumerated.
enum4	A 32-bit signed enumerated.
`float`	A 32-bit signed IEEE 754 single-precision floating-point.
`double`	A 64-bit signed IEEE 754 double-precision floating-point.
*	A 32-bit or 64-bit signed pointer.

The entire path to the field is given as its NAME. Every field and subfield of the type is listed.

Example: What's in a `struct sigevent`?

```
q4> fields struct sigevent
OFFSET        SIZE       FLAVOR   NAME
 bytes +bits bytes +bits
     0     0     4     0 int     __sigev_notify
     4     0     4     0 int     __sigev_signo
     8     0     4     0 int     __sigev_value.
                                 __svi_int_s.__svi_pad
    12     0     4     0 int     __sigev_value.
                                 __svi_int_s.__svi_int
     8     0     8     0 *       __sigev_value.__sival_ptr
    16     0     8     0 *       __sigev_notify_function
    24     0     8     0 *       __sigev_notify_attributes
    32     0     4     0 int     __sigev_reserved[0]
    36     0     4     0 int     __sigev_reserved[1]
    40     0     4     0 int     __sigev_reserved[2]
    44     0     4     0 int     __sigev_reserved[3]
    48     0     4     0 int     __sigev_reserved[4]
    52     0     4     0 int     __sigev_reserved[5]
    56     0     4     0 int     __sigev_reserved[6]
    60     0     4     0 int     __sigev_reserved[7]
q4>
```

Example: Produce a declaration for `struct sigevent`'s.

```
q4> fields -c struct sigevent
struct sigevent {
    int __sigev_notify;
    int __sigev_signo;
    union sigval __sigev_value;
    char (*__sigev_notify_function)( );
    int *__sigev_notify_attributes;
    int __sigev_reserved[8];
}
q4>
```

Example: Add offsets and sizes to the previous example.

```
q4> fields -cv struct sigevent
struct sigevent {                 /* off 0 bytes, len 64
                                     bytes */
  int __sigev_notify;            /* off 0 bytes, len 4
                                     bytes */
  int __sigev_signo;             /* off 4 bytes, len 4
```

```
                                    bytes */
  union sigval __sigev_value;   /* off 8 bytes, len 8
                                    bytes */
  char (*__sigev_notify_function)( ); /* off 16 bytes, len
                                         8 bytes */
  int *__sigev_notify_attributes;/* off 24 bytes, len 8
                                     bytes */
  int __sigev_reserved[8];      /* off 32 bytes, len 32
                                    bytes */
}
q4>
```

Example: Expand all embedded structures/unions in the previous example.

```
q4> fields -cx struct sigevent
struct sigevent {
    int __sigev_notify;
    int __sigev_signo;
    union sigval {
        struct {
            int __svi_pad;
            int __svi_int;
        } __svi_int_s;
        char *__sival_ptr;
    } __sigev_value;
    char (*__sigev_notify_function)( );
    int *__sigev_notify_attributes;
    int __sigev_reserved[8];
}
q4>
```

For enumeration types, `fields` command shows all enumerants and their values as shown in the following example.

Example: What is in the enumeration type `proc_state`.

```
q4> fields enum proc_state
 NAME                          VALUE
SUNUSED                          0
SWAIT                            1
SIDL                             2
SZOMB                            3
SSTOP                            4
SINUSE                           5
q4>
```

This command supports output redirection.

Handling Typename Clashes

The commands "`catalog`" and "`info types`" will list type names. The details of any type can be displayed using the commands "`fields`" and "`ptype`". The same type name may have different definitions in different compilation units. When the same type name has two of more definitions there is said to be a "clash" in q4 terminology. KWDB does not generate the clash information by default. There are two ways for a kwdb user to generate these type clashes:

1. Invoke kwdb with the command line option "`-type-clash`"

2. When kwdb is running, use the command: "`info type-clash <RE>`"

When there is a type clash, one type name will be the original name and the others will be the original name with "`_CLASH_<clash#>`" appended. There is currently no way to force kwdb to associate the original type name with any particular clashing type definition. Once KWDB has generated the type `clashes`, the names with "`_CLASH_<clash#>`" can be used wherever type names are used.

Examples:

```
# kwdb -q /dump/dumps/ia/orca
q4> catalog mblk_t
BYTES   FIELDS   SHAPE    NAME
128     16       typedef  mblk_t
q4> info type-clash mblk_t
BYTES   FIELDS   SHAPE    NAME
128     16       typedef  mblk_t
192      17       typedef  mblk_t-CLASH0
q4> fields -c mblk_t
struct msgb {
     struct msgb *b_next;
     struct msgb *b_prev;
     struct msgb *b_cont;
     u_char *b_rptr;
     u_char *b_wptr;
     struct datab *b_datap;
     char *b_pad_osr;
     u_char *b_band;
     u_char *b_pad1;
     u_short b_flag;
     u_char b_pad[4];
     u_long b_quad[4];
     u_int b_flag_priv;
     u_int b_flag_extn;
     void *b_msgb_extn;
     void *b_cachepad[2];
}
q4> fields -c mblk_tCLASH0
struct msgb {
     struct msgb *b_next;
     struct msgb *b_prev;
     struct msgb *b_cont;
     u_char *b_rptr;
     u_char *b_wptr;
     struct datab *b_datap;
     char *b_pad_osr;
     u_char *b_band;
     u_char *b_pad1;
     u_short b_flag;
     u_char b_pad[4];
     u_long b_quad[4];
     u_int b_flag_priv;
     u_int b_flag_extn;
     void *b_msgb_extn;
     void *b_cachepad[2];
     struck sqe_s b_sq;
}
q4>
```

Listing Kernel Symbols

The `symbols` command prints a list of kernel symbols and their address. The listing includes the distance to the next symbol in addition to each symbol's location and type.

Usage:

```
symbols re
```

Where *re* is a regular expression. The regular expression is not automatically anchored so use **^** or **$** to anchor the match to the head or tail (respectively) of the string.

flags is an optional parameter whose value can be -v. If this value is given, then the output of the symbols command contains the filename in which the symbol is found.

Example: Look up all the symbols with `semaphore` in their name.

```
q4> symbols semaphore
  OCTAL       DECIMAL      HEX        DIST  TYPE     NAME
017531260     4108976   0x3eb2b0     132   FUNC
                                             init_semaphores
017534460     4110640   0x3eb930      20   FUNC
                                      kthread_owns_semaphore
017717230     4169368   0x3f9e98      56   FUNC
                                      mq_init_semaphores
020452130     4346968   0x425458      40   FUNC
                                   msemaphore_to_msemaphore_32
020452200     4347008   0x425480      40   FUNC
                                   msemaphore_32_to_msemaphore
020466210     4353160   0x426c88     124   FUNC
                                     CopyInMsemaphore
020466410     4353288   0x426d08     104   FUNC
                                     CopyOutMsemaphore
050733400    10729216   0xa3b700       8   OBJT
                                      semaphore_log_lock
```

The `DIST` field gives the distance (in bytes) to the next symbol. This can be useful for deciding whether or not the symbol points to a structure or is the structure itself.

The `TYPE` field indicates what kind of symbol it is. These types are as shown by nm.

This command supports output redirection.

```
q4> symbols -v kwdb_test_1_int_data
static   0126154150    22599784  0x158d868       4  OBJT
/ux/core/kern/common/util/kwdb/kwdb_test_1.c:kwdb_test_1_int_data
```

Disassembling Functions

The `disassemble` command prints the assembly code for any kernel function.

Usage:

```
disassemble [ flags ] CODESPEC

or

code [ flags ] CODESPEC
```

Where CODESPEC is the name of a kernel function or an address or two addresses. If a function name is specified, the command finds the named function and prints listing of disassembled code. If an address is specified, the function surrounding that address is dumped. If two addresses are specified, disassembled code for the range of address between those two addresses is displayed.

Starting with kwdb-3.1.7, the function name can be preceeded by a filename and a colon. The disassembly will then give the disassembly of the code for the function belonging to the file specified by the filename. If the specified file does not contain the function specified then the function will be looked up in the vmunix.

It uses the default disassembler of KWDB to do the disassembling. Substitute an alternative disassembler to use via the environment variable *q4Disassemble*. See the getasm command for more details.

Flags:

-o Normally, KWDB gets the code from the crash dump for crash target or from the remote copy for remote targets. If this flag is used, KWDB will get the code from the local kernel file instead.

Example: Print the assembly code for link.

```
q4> disassemble link
Dump of assembler code for function link:
0x178680 <link>:        std %rp,-0x10(%sp)
0x178684 <link+0x4>:    ldo 0x80(%sp),%sp
0x178688 <link+0x8>:    addil L'-0x176000,%dp,%r1
0x17868c <link+0xc>:    ldd 0x130(%r1),%r24
0x178690 <link+0x10>:   ldd 0x440(%r24),%r31
0x178694 <link+0x14>:   ldd 0(%r31),%r26
0x178698 <link+0x18>:   ldi 0,%r24
0x17869c <link+0x1c>:   ldo -0x30(%sp),%ret1
0x1786a0 <link+0x20>:   b,l 0x1768c8 <vn_link>,%r2
0x1786a4 <link+0x24>:   ldd 8(%r31),%r25
0x1786a8 <link+0x28>:   addil L'-0x176000,%dp,%r1
0x1786ac <link+0x2c>:   ldd 0x130(%r1),%r23
0x1786b0 <link+0x30>:   sth %ret0,0x53a(%r23)
0x1786b4 <link+0x34>:   ldd -0x90(%sp),%rp
0x1786b8 <link+0x38>:   bve (%rp)
0x1786bc <link+0x3c>:   ldo -0x80(%sp),%sp
0x1786c0 <link+0x40>:   b,n 0x1786c0 <link+0x40>
0x1786c4 <link+0x44>:   break 0,0
End of assembler dump.
q4>
```

Example: Print the assembly code for an address range.

```
q4> disas 0x1786a0 0x1786b8
Dump of assembler code from 0x1786a0 to 0x1786b8:
0x1786a0 <link+0x20>:   b,l 0x1768c8 <vn_link>,%r2
0x1786a4 <link+0x24>:   ldd 8(%r31),%r25
0x1786a8 <link+0x28>:   addil L'-0x176000,%dp,%r1
0x1786ac <link+0x2c>:   ldd 0x130(%r1),%r23
0x1786b0 <link+0x30>:   sth %ret0,0x53a(%r23)
0x1786b4 <link+0x34>:   ldd -0x90(%sp),%rp
End of assembler dump.
q4>
```

If the source file is compiled with debug option, disassemble command will display each source line and corresponding assembly code interspersed. The following example shows the disassemble output for the function `set_sched_sa()` defined as:

```
int set_sched_sa( kthread_t *kt, caddr_t *arg )
{
    proc_t *p = (proc_t *)arg;

    if ( ISASCHEDACT(kt) ) {
       (void) changepri_policy( kt, p->p_pri,
                                p->p_schedpolicy );
    }
    return 0;
}

q4> disassemble set_sched_sa
Dump of assembler code for function set_sched_sa:
;;; File: pm_rtsched.c
;;; {
0x3d3688 <set_sched_sa>:        std %rp,-0x10(%sp)
0x3d368c <set_sched_sa+0x4>:    std,ma %r3,0xa0(%sp)
0x3d3690 <set_sched_sa+0x8>:    std %r4,-0x98(%sp)
0x3d3694 <set_sched_sa+0xc>:    std %r5,-0x90(%sp)
0x3d3698 <set_sched_sa+0x10>:   copy %ret1,%r3
0x3d369c <set_sched_sa+0x14>:   nop
0x3d36a0 <set_sched_sa+0x18>:   copy %ret1,%r5
0x3d36a4 <set_sched_sa+0x1c>:   std %r26,-0x40(%r5)
0x3d36a8 <set_sched_sa+0x20>:   std %r25,-0x38(%r5)
;;;     proc_t *p = (proc_t *)arg;
0x3d36ac <set_sched_sa+0x24>:   ldd -0x38(%r5),%r19
0x3d36b0 <set_sched_sa+0x28>:   std %r19,-0x78(%sp)
;;;     if ( ISASCHEDACT(kt) ) {
0x3d36b4 <set_sched_sa+0x2c>:   ldd -0x40(%r5),%r26
0x3d36b8 <set_sched_sa+0x30>:   b,l 0x4189d0 <IsASchedact>,%r2
0x3d36bc <set_sched_sa+0x34>:   ldo -0x30(%sp),%ret1
0x3d36c0 <set_sched_sa+0x38>:   cmpib,=,n 0,%ret0,0x3d36e8 <set_sched_sa+0x60>
;;;             (void) changepri_policy( kt, p->p_pri, p->p_schedpolicy );
0x3d36c4 <set_sched_sa+0x3c>:   ldd -0x40(%r5),%r19
0x3d36c8 <set_sched_sa+0x40>:   ldd -0x78(%sp),%r20
0x3d36cc <set_sched_sa+0x44>:   ldh 0x64(%r20),%r20
0x3d36d0 <set_sched_sa+0x48>:   ldd -0x78(%sp),%r21
0x3d36d4 <set_sched_sa+0x4c>:   ldw 0x230(%r21),%r24
0x3d36d8 <set_sched_sa+0x50>:   copy %r19,%r26
0x3d36dc <set_sched_sa+0x54>:   copy %r20,%r25
0x3d36e0 <set_sched_sa+0x58>:   b,l 0x3bd328 <changepri_policy>,%r2
0x3d36e4 <set_sched_sa+0x5c>:   ldo -0x30(%sp),%ret1
;;;     return 0;
0x3d36e8 <set_sched_sa+0x60>:   ldi 0,%ret0
;;; }
0x3d36ec <set_sched_sa+0x64>:   copy %ret0,%ret0
0x3d36f0 <set_sched_sa+0x68>:   ldd -0xb0(%sp),%rp
0x3d36f4 <set_sched_sa+0x6c>:   ldd -0x90(%sp),%r5
0x3d36f8 <set_sched_sa+0x70>:   ldd -0x98(%sp),%r4
0x3d36fc <set_sched_sa+0x74>:   bve (%rp)
End of assembler dump.
q4>

q4>disass kwdb_test.c:kwdb_test
```

```
0x58e6b8 : stw %rp,-0x14(%sr0,%sp)
0x58e6bc :       stw,ma %r3,0x78(%sr0,%sp)
0x58e6c0 :       stw %r26,-0x9c(%sr0,%sp)
0x58e6c4 :       stw %r25,-0xa0(%sr0,%sp)
;;; kwdb_test_1();
0x58e6c8 :       ldi 0,%r20
0x58e6cc :       ldi 0,%r21
0x58e6d0 :       stw %r20,-0x60(%sr0,%sp)
0x58e6d4 :       stw %r21,-0x5c(%sr0,%sp)
;;; kwdb_test_2();
[...]
q4>
```

This command supports output redirection.

Translating Virtual Addresses

The `translate` command prints the page directory entry (PDE) or page table entry (PTE) or translation registers (TR) for any virtual address. (If only the physical address is wanted, the function `ltor` is a little easier to use.)

Usage:

```
translate address
```

Where *address* is an expression that evaluates to a virtual address.

Example: PDE for `&proc_list` on PA system

```
q4> translate &proc_list
                        indexof  0
                         mapped  0
                        spaceof  0
                         addrof  0x40148a0
                     physaddrof  0x40148a0
                       realmode  0x1
                    pde_invalid  0
                      pde_vpage  0xa45
                      pde_space  0
                      pde_rtrap  0
                      pde_dirty  0x1
                       pde_dbrk  0
                         pde_ar  0x10
                    pde_uncache  0
                      pde_order  0x1
                  pde_br_predict  0
                 pde_ref_trickle  0
                pde_block_mapped  0
                    pde_executed  0x1
                         pde_ref  0x1
                    pde_accessed  0x1
                    pde_modified  0x1
                         pde_uip  0
                      pde_protid  0
                          pde_os  0x1
                       pde_alias  0
                   pde_wx_demote  0
                      pde_phys_u  0
```

```
                        pde_phys  0xa45
                        var_page  0x4
                        pde_next  0xa390d40
```

Example: TR for `&proc_list` on IPF system

```
q4> translate &proc_list
                          indexof  0
                           mapped  0
                          spaceof  0
                           addrof  0x887b348
                       physaddrof  0x887b348
                         realmode  0x1
                           tr_num  0x1
                          tr_type  0x2
                         tr_state  0x2
                        reserved1  0
                    tr_tpa.bits.uip  0
                    tr_tpa.bits.mod  0
                  tr_tpa.bits.alias  0
                    tr_tpa.bits.ig1  0
                     tr_tpa.bits.ed  0x1
                    tr_tpa.bits.rv1  0
                    tr_tpa.bits.ppn  0x8000
                  tr_tpa.bits.ar_pl  0x8
                      tr_tpa.bits.d  0x1
                      tr_tpa.bits.a  0x1
                     tr_tpa.bits.ma  0
                    tr_tpa.bits.rv2  0
                      tr_tpa.bits.p  0x1
                         tr_tpa.val  0x10000008000461
                   tr_itir.bits.rv1  0
                   tr_itir.bits.key  0xbeef
                    tr_itir.bits.ps  0x1a
                   tr_itir.bits.rv2  0
                        tr_itir.val  0xbeef68
                             tr_tva  0xe000000100000000
                      tr_rr.bits.rv1  0
                      tr_rr.bits.rid  0xdead
                       tr_rr.bits.ps  0xc
                      tr_rr.bits.rv2  0
                       tr_rr.bits.ve  0x1
                           tr_rr.val  0xdead31
q4>
```

Example: PTE for the address 0x208031.0x8003ffff7ffe8000 on IPF system

```
q4> trans 0x208031.0x8003ffff7ffe8000
                          indexof  0
                           mapped  0
                          spaceof  0
                           addrof  0x8fbed00
                       physaddrof  0x8fbed00
                         realmode  0x1
                       tpa.bits.uip  0
                       tpa.bits.mod  0x1
                     tpa.bits.alias  0
                       tpa.bits.ig1  0
```

```
                      tpa.bits.ed  0x1
                     tpa.bits.rv1  0
                     tpa.bits.ppn  0x3c880
                   tpa.bits.ar_pl  0x8
                       tpa.bits.d  0x1
                       tpa.bits.a  0x1
                      tpa.bits.ma  0
                     tpa.bits.rv2  0
                       tpa.bits.p  0x1
                          tpa.val  0x9000003c880461
                    itir.bits.rv1  0
                    itir.bits.key  0xbeef
                     itir.bits.ps  0xc
                    itir.bits.rv2  0
                         itir.val  0xbeef30
                 pte_tag.bits.ti  0
                pte_tag.bits.tag  0x10403ffff7ffe8
                     pte_tag.val  0x10403ffff7ffe8
                            next  0
q4>
```

The PDE or PTE or TR that's printed can be used to determine the physical address as well as other things like page ownership and access permissions.

This command supports output redirection.

Tracing Stacks

The `trace` command prints stack traces.

Usage:

```
trace [ flags ] pc sp    (for PA only)
trace [ flags ] event #
trace [ flags ] processor #
trace [ flags ] process at addr
trace [ flags ] savestate at addr
trace [ flags ] thread at addr
trace [ flags ] pile
```

Where *pc* is the starting value of the program counter, *sp* is the starting (top) value of the stack pointer, # is the index of a crash event or processor, and *addr* is the address of a process or kernel thread.

pc, *sp*, and *addr* may be expressions that evaluate to addresses. # may be an expression that evaluates to an integer.

Flags:

`-u` Normally, the `trace` command only prints level, return point, function names and offsets, one per line of output. This option adds a display of all register values that can be recovered at the first level or the level specified by the *q4UnwLevel* variable and up to eight arguments passed. The registers and argument values displayed may not be valid always.

`-v` Print a verbose trace. Normally, the `trace` command only prints level, return point, function names and offsets, one per line of output. This option adds the following to each line:

— stack pointer

— `bsp` (for IPF only)

— frame pointer (for PA only)

— save state pointer, if any.

`-f` `trace` command with `-f` option will show input, local and output registers for every frame in the stack trace output. Options `-frame` or `-args` has the same meaning as option `-f`.

Output of the `trace` commands can be controlled by setting following Q4 variables:

`q4PrintArgs`	Setting this to a non-zero value print arguments for each level and registers for first level. This is equivalent to using the flag -u.
`q4UnwLevel`	Start unwinding stack from the level set by q4UnwLevel.
`q4MaxStackDepth`	Maximum number of levels displayed during stack trace. The default is 250.

The `trace event` form prints a stack trace for the numbered crash event (a small non-negative integer). Event zero is the original thing that took the system down. Common first events include:

- panic
- transfer of control (often called an INIT or TOC)
- high priority machine check (often called an HPMC)

Crash events recorded after the initial event are often caused by the first event. Some common reasons for subsequent crash events are:

- recursive panic (a processor panics while trying to process a panic)
- transfer of control (the first processor to panic tells the others to TOC)
- high priority machine check (this is caused by hardware)

Example: print a stack trace for crash event 1 on a PA crash dump.

```
q4> trace event 1
crash event was a TOC
stack trace for event 1
#0  0x1b5e3c in wait_for_lock+0x314 ()
#1  0x34c68 in slu_retry+0x1c ()
#2  0x1ab654 in clean_str_spu_sw_q+0xc4 ()
#3  0x1a3880 in osr_pop_subr+0xf0 ()
#4  0x1a5438 in osr_close_subr+0xe90 ()
#5  0x1aaf80 in hpstreams_close_int+0x300 ()
#6  0x1b16f4 in streams_close+0x14 ()
#7  0x156314 in soclose+0x5ac ()
#8  0x192e80 in soo_close+0x90 ()
#9  0x19c984 in closef+0x64 ()
#10 0x19cda0 in close+0x98 ()
#11 0x14c874 in syscall+0x62c ()
#12 0x33f5c in $syscallrtn+0x0 ()
```

Example: print a stack trace for crash event 0 on an IPF crash dump along with input, local and output registers at every frame.

```
q4> trace -args event 0
Event selected is 0. It was a panic
#0 0xe000000000f527c0:0 in
   panic_save_regs_switchstack+0x130 ()
```

```
#1 0xe000000000723dd0:0 in panic+0x300 ()
r32: 0xe00000000018a9f0 in0
r33: 0x0000000000000e9f loc0
r34: 0xe00000000042fa30 loc1
r35: 0x0000000000000005 loc2
r36: 0x00fff03c6c616a05 loc3
r37: 0x8003ffff7fffa5c0 loc4
r38: 0xe000000000723ed0 loc5
r39: 0xe000000100441420 loc6
r40: 0xe00000010020d578 loc7
r41: 0xe00000010020d570 loc8
r42: 0xe00000010020d568 loc9
r43: 0xe000000000189748 loc10
r44: 0xe000000100203f6c loc11
r45: 0x000064cbdc0e79cd loc12
r46: 0xe0000001002041cc loc13
r47: 0xe000000100203f60 loc14
r48: 0xe000000100017800 loc15
r49: 0xe000000100203f90 loc16
r50: 0x00000000ffffffff loc17
r51: 0x0000000000000000 out0
r52: 0x0000000000000000 out1
r53: 0x0000000000000997 out2
r54: 0xe000000000723da0 out3
#2 0xe00000000042fa30:0 in post_hndlr+0x8f0 ()
r32: 0x8003ffff7fffa600 in0
r33: 0x000000000000000b in1
r34: 0x0000000000000003 in2
r35: 0x000000000000001c in3
r36: 0x0000000000000b1b loc0
r37: 0xe000000000430860 loc1
r38: 0x00fff03c6c616b5d loc2
r39: 0x8003ffff7fffa5e0 loc3
r40: 0x0000000000000001 loc4
r41: 0x8003ffff7fffa7d0 loc5
r42: 0xe000000116cde3f8 loc6
r43: 0x000000000000000b loc7
r44: 0x8003ffff7ffe84e0 loc8
r45: 0xe000000100017800 loc9
r46: 0x0000000000000002 loc10
r47: 0x00000000ffffffff loc11
r48: 0xe000000100204c88 loc12
r49: 0x0000000000000000 loc13
r50: 0x0000000000000003 loc14
r51: 0xe000000108389b80 loc15
r52: 0x0000000000000997 loc16
r53: 0xe000000100020dc4 loc17
r54: 0xe000000100203ff8 loc18
r55: 0xe00000000041fcc0 loc19
r56: 0x8003ffff7ffe84e0 loc20
r57: 0x8003ffff7fffa5c0 loc21
r58: 0xe00000010a25e7d0 loc22
r59: 0xe00000010a25e7ce loc23
r60: 0x8003ffff7ffe84e8 loc24
r61: 0xe00000000018a9f0 out0
r62: 0x0000000000000e9f out1
#3 0xe000000000430860:0 in vm_hndlr+0x240 ()
r32: 0x8003ffff7fffa600 in0
```

```
r33: 0x0000000000000018 in1
r34: 0x8003ffff7ffe8000 in2
r35: 0x0000000000000288 loc0
r36: 0xe000000000732f90 loc1
r37: 0x8003ffff7ffe8000 loc2
r38: 0x0000000000000002 loc3
r39: 0x0000000000000000 loc4
r40: 0x0000000000000001 loc5
r41: 0x0000000000000003 loc6
r42: 0x8003ffff7ffe84f8 loc7
r43: 0x8003ffff7ffe84e0 loc8
r44: 0x8003ffff7ffe8f24 loc9
r45: 0x8003ffff7ffe84f8 loc10
r46: 0x8003ffff7ffe84e0 loc11
r47: 0x8003ffff7ffe8f24 loc12
r48: 0xe000000100204180 loc13
r49: 0x8003ffff7fffa7cb loc14
r50: 0x000000000000001c loc15
r51: 0x8003ffff7ffe84e0 loc16
r52: 0x0000000000124b31 loc17
r53: 0x0000000000000018 loc18
r54: 0x8003ffff7fffa600 out0
r55: 0x000000000000000b out1
r56: 0x0000000000000003 out2
r57: 0x000000000000001c out3
r58: 0x0000000000000b1b out4
#4 0xe000000000732f90:0 in bubbleup+0xab0 ()
+------------------------- TRAP -------------------------
| Data Key Miss Fault in kernel mode at pc =
     0xe00000000041a070:1
| save state pointer = 0x2534331.0x8003ffff7fffa600
+--------------------------------------------------------
#5 0xe00000000041a070:1 in allocpfd_from_pond+0x3d0 ()
r32: 0xe000000100993c08 in0
r33: 0x8003ffff7fffb2e0 in1
r34: 0x0000000000000001 in2
r35: 0xffffffffffffffff in3
r36: 0x0000000000000997 loc0
r37: 0xe0000000004191e0 loc1
r38: 0xf0ffffff3ffc6b1b loc2
r39: 0x8003ffff7fffb290 loc3
(---------output truncated here-----------)
```

The `trace process at` form prints a stack trace for the process whose process table entry starts at the specified address. If there were multiple kernel threads a trace is printed for *every* thread. (Use the `trace thread at` form to print a trace of one specific kernel thread. In this case, the address specified is that of the `kthread` structure. This command only works for kernels that support kernel threads.)

There are a few reasons why a process may not be traceable:

- There is no process in that process slot (is this the right one?).
- The process is deactivated (its user area has been pushed to disk).
- The process was running at the instant the crash dump was initiated.

Example: Print a stack trace for the process at `0x41978040`.

```
q4> trace process at 0x41978040
Stack trace for process "vxfsd" at 0x41978040 (pid 35)
Thread at 0x41979040 (tid 35)
Process was not running on any processor
#0  0x2caaa0 in _swtch+0x1b8 ()
#1  0x2d22b8 in 1f_6a7b_cl_real_sleep+0x868 ()
#2  0x2c63d4 in _sleep+0x14c ()
#3  0x2c6d9c in sleep_spinunlock+0x104 ()
#4  0x6f33ac in vx_event_wait+0xdc ()
#5  0x6f26ac in vx_delay2+0x64 ()
#6  0x702cdc in vx_sched_thread+0x174 ()
#7  0x6f3ac0 in vx_postinit+0x168 ()
#8  0x7508c4 in vx_sync+0x24 ()
#9  0x18c3bc in update+0x74 ()
#10 0x18c338 in sync+0x60 ()
#11 0x35b554 in syscall+0x5fc ()
#12 0x33d64 in syscallinit+0x554 ()

Stack trace for process "vxfsd" at 0x41978040 (pid 35)
Thread at 0x41986040 (tid 36)
Process was not running on any processor
#0  0x2caaa0 in _swtch+0x1b8 ()
#1  0x2d1860 in 1c_6a7b_cl_real_sleep+0x1430 ()
#2  0x2c6534 in _sleep_one+0x14c ()
#3  0x703280 in vx_worklist_thread+0x40 ()
#4  0x2a4f44 in kthread_daemon_startup+0x24 ()
#5  0x2a4f20 in kthread_daemon_startup+0x0 ()
#6  0xa9ec0 in trap+0xcc8 ()
Stack trace for process "vxfsd" at 0x41978040 (pid 35)
Thread at 0x4197e040 (tid 37)
. .  . .  . .  // Output truncated here
```

In the previous example, process `vxfsd` has many threads and output contains stack trace for all those threads.

The `trace processor` form prints a stack trace for the numbered processor. (Use the index of the processor in the `mpproc_info` table or the index of the `spu` in the `spu_info` table.)

Example: Print a stack trace for the monarch processor (processor 0).

```
q4> trace processor 0
Processor 0 was running process "syslogd" at 0x4193e040 (pid 319)
Thread at 0x42246040 (tid 338)
Event selected is 1. It was a TOC
#0  0xa8d10 in check_panic_loop+0x38 ()
#1  0xa9ec0 in trap+0xcc8 ()
#2  0x7bcd8 in kgdb_pre_trap+0xa8 ()
#3  0xc1a00 in thandler+0xd14 ()
#4  0xc20a0 in splx+0x70 ()    <--- Trap in Kernel mode
#5  0xc20b4 in splx+0x84 ()
#6  0xc237c in spluser+0x14 ()
#7  0x35b7c4 in syscall+0x86c ()
#8  0x33d64 in syscallinit+0x554 ()
```

The trace output shows that there was a trap in kernel mode. Run the previous trace with `-v` option to show the details of the trap.

```
q4> trace -v processor 0
Processor 0 was running process "syslogd" at 0x4193e040 (pid
                                                          319)
Thread at 0x42246040 (tid 338)
Event selected is 1. It was a TOC
#0  0xa8d10 in check_panic_loop+0x38 ()       (sp:fmp
    0x5038c00.0x400003ffffff15a8 0x5038c00.0x400003ffffff1598)
#1  0xa9ec0 in trap+0xcc8 ()    (sp:fmp
    0x5038c00.0x400003ffffff15a8 0x5038c00.0x400003ffffff1598)
#2  0x7bcd8 in kgdb_pre_trap+0xa8 ()    (sp:fmp
    0x5038c00.0x400003ffffff1438 0x5038c00.0x400003ffffff1428)
#3  0xc1a00 in thandler+0xd14 ()    (sp:fmp
    0x5038c00.0x400003ffffff1398 0x5038c00.0x400003ffffff1388)
+-------------------------  TRAP  --------------------------
|  Trap type 31 in Kernel mode at  pc=0xc20a0 splx
|   save state pointer = 0x5038c00.0x400003ffffff0ec8
+-----------------------------------------------------------
#4  0xc20a0 in splx+0x70 ()    (sp:fmp
    0x5038c00.0x400003ffffff0ec8 0x5038c00.0x400003ffffff0eb8)
#5  0xc20b4 in splx+0x84 ()    (sp:fmp
    0x5038c00.0x400003ffffff0ec8 0x5038c00.0x400003ffffff0eb8)
#6  0xc237c in spluser+0x14 ()    (sp:fmp
    0x5038c00.0x400003ffffff0e48 0x5038c00.0x400003ffffff0e38)
#7  0x35b7c4 in syscall+0x86c ()    (sp:fmp
    0x5038c00.0x400003ffffff0dd8 0x5038c00.0x400003ffffff0dc8)
#8  0x33d64 in syscallinit+0x554 ()    (sp:fmp
    0x5038c00.0x400003ffffff0c78 0x5038c00.0x400003ffffff0c68)
q4>
```

The `trace savestate at` form prints a stack trace for the `savestate` at the specified address.

```
q4> trace savestate at 0xdead31.0xe000000100016a00
#0  0xe00000000042f370:1 in kfree+0x76 ()
#1  0xe0000000003726a0:0 in vx_worklist_process+0x160 ()
#2  0xe0000000003e42c0:0 in vx_thread_process+0x140 ()
#3  0xe0000000003781c0:0 in vx_fsetupdate+0x70 ()
#4  0xe000000000366ac0:0 in vx_sync1+0x80 ()
#5  0xe0000000003629f0:0 in vx_sync0+0x30 ()
#6  0xe0000000003a8280:0 in vx_walk_fslist+0xe0 ()
#7  0xe0000000003221c0:0 in vx_sync_thread+0x50 ()
#8  0xe0000000003727e0:0 in vx_worklist_process+0x2a0 ()
#9  0xe000000000372480:0 in vx_worklist_thread+0x70 ()
q4>
```

The `trace pile` form prints a stack trace for every item in the current pile. The underlying data type of the pile must be one of the following:

- `struct crash_event_table_struct` (for PA)
- `struct crash_event` (for IPF)
- `struct kthread`
- `struct mpinfo`
- `struct proc`

or any `typedef` that evaluates to one of these types. For example:

- `crash_event_t`
- `kthread_t`

- mpinfo_t
- proc_t

Example: print a stack trace for every active process.

```
#Invoke kwdb
$ kwdb -q4 -q /var/adm/crash/crash.0
# get all active proc's
q4> load proc_t from proc_list next p_factp max nproc
loaded 35 struct procs as a linked list (stopped by null pointer)
# keep active proc's
q4> keep p_stat
kept 35 of 35 struct proc's, discarded 0
#they were all active
# trace them all
q4> trace pile |more
Stack trace for process "swapper" at 0xb08b00 (pid 0)
Thread at 0xb087c0 (tid 0)
Process was not running on any processor
#0  0x2caaa0 in _swtch+0x1b8 ()
#1  0x2d22b8 in 1f_6a7b_cl_real_sleep+0x868 ()
#2  0x2c63d4 in _sleep+0x14c ()
#3  0x436ae4 in sched+0xcc ()
#4  0x1e4224 in im_launch_sched+0x54 ()
#5  0x417908 in DoCalllist+0xc0 ()
#6  0x1e2c10 in main+0x28 ()
#7  0xbe22c in $vstart+0x48 ()
#8  0x3a760 in $locore+0x94 ()

Stack trace for process "fgrep" at 0x41e93040 (pid 399)
Thread at 0x421f3040 (tid 418)
Process was not running on any processor
#0  0x2caaa0 in _swtch+0x1b8 ()
#1  0x2d1d8c in 1f_6a7b_cl_real_sleep+0x33c ()
#2  0x2c63d4 in _sleep+0x14c ()
#3  0x174b5c in fifo_rdwr+0x3cc ()
#4  0x17e314 in vno_rw+0x104 ()
#5  0x8441ec in read+0x2e4 ()
#6  0x35b554 in syscall+0x5fc ()
#7  0x33d64 in syscallinit+0x554 ()
...
```

This command supports output redirection.

Setting Context

KWDB supports setting the context to a specific CPU, thread or crash event using commands `set cpu`, `set thread`, and `set crash event`, respectively. These commands are discussed in the following sections.

Set CPU

Command to select a processor as the view CPU.

Usage:

```
set cpu n
or
cpu select n
```

While debugging a kernel, KWDB displays the environment of the CPU that was running when the target stopped due to some event, such as execution of a breakpoint, single step completion, or a **Ctrl-c** interrupt of execution. This CPU is known as the "foreground CPU". Change the foreground CPU using the `cpu select#` (or `set cpu #`) command. This will set the context to the new processor so that any context sensitive commands like `bt`, `frame`, and so forth will be for the new context. This command can be used to set processor context on crash dumps as well. It is not possible to select a CPU when analyzing a live system using `devmem` target.

Set Thread

Command to select a thread at a given address as the current thread context

Usage:

```
set thread addr
```

Where *addr* is the thread address. This command can only be used to set context to a sleeping thread.

Set Crash Event

Command to select an event as the current context

Usage:

```
set crash event n
```

Where *n* is the index of the event in `crash_event` table. This command is applicable to crash target only.

Loading Data From the Crash Dump/Kernel Memory

KWDB only loads data from the crash dump (if target is crash) or kernel memory (if target is `devmem` or remote target) when asked to. The result of each load into the KWDB local memory is called a "pile". Piles are kept separate from each other.

A list of the piles loaded during the current session can be displayed using the `history` command.

Values of each field in the current pile can be printed using the `print` command. Only the pile at the top of the history list can be printed or otherwise operated on. Any pile in the history can be copied to the top using the `recall` command.

Piles can be named to make it easier to remember which is which. Use the `name` command to do this.

Piles can be named and set aside to preserve them. Use the `brand` command to do this.

Piles can be merged (provided they are piles of the same type). Use the `merge` command to do this.

Piles can be deleted once they're no longer needed. Use the `forget` command to do this.

The state of the pile history can be saved and later restored using the `pushhistory` and `pophistory` commands.

To load data from the crash dump or kernel memory use the `load` command.

Usage:

```
load [ flags ] [ type ] from address [ options ]
```

Where *type* names a data type in the catalog and *address* is an expression that evaluates to the starting address of the data. If *type* is not the name of a `typedef`, it must be preceded by either the keyword "struct" or "union", as appropriate. The *type* field can be omitted, if type information can be obtained from the type of *from address*.

Flags:

`-r`	Real mode, read this data without address translation. The default is to use address translation.

Options:

`skip` *`count`*	Skip count items before loading anything. The count can be an expression. The default is 0.
`max` *`count`*	Load at most count items. The count can be an expression. The default is 1.
`until` *`address`*	Stop reading if address is reached (as the start address of the next item). The address can be an expression. The default is not to do this.
`next` *`field`*	Normally when KWDB loads multiple items at a single command, it reads as if from an array. That is, it loads from sequential structure locations. When a `next` clause is used, it loads as if from a linked list, using the specified *`field`* as its next pointer. Loading stops automatically if any of the following conditions are met:
`null pointer`	KWDB does not try to read from location 0.
`bad read`	KWDB was not able to read the required number of bytes at the required address.
`interrupt`	KWDB stops reading if interrupted.
`max count`	KWDB stops reading if it reaches the limit set by the `max` option.
`until clause`	KWDB stops reading if it reaches a structure starting at the address set with the `until` option.
`loop in linked list`	KWDB stops reading if it reaches a structure it has already loaded in the current pile.

Example: Load the entire process table.

```
q4> load struct proc from proc_list next p_global_proc max nproc
loaded 35 struct procs as a linked list(stopped by null pointer)
```

Starting with kwdb-3.1.7, the `eload` command is supported. This command has the same syntax as that of `load` command. The advantage of this command is that it first searches the pile cache directory for the pile data that the user is currently requesting to be loaded. If it is present, then the pile data is read from the file instead of from the crash dump. In addition to this, if the number of structures loaded is greater than a pre-defined limit, then the pile contents are written to a file in the pile cache directory. Also a mapping file is present which contains the command from which the respective file in the pile cache directory is created. This is used to identify the file from which data has to be read the next time a pile command is executed. The pile cache directory (directory where the pile data is stored) is usually the <*crash-dump-directory*>/.kwdb/piles for crash dump or can be configured to any other path using the following command:

`q4> set kwdb pile-cache-dir <`*`directory-name`*`>`

As mentioned before there is a predefined limit, exceeding which the pile data is written to a file in the pile cache directory. This limit can be configured using the command:

`q4>set kwdb pile-cache-limit <`*`value`*`>`

The `pileon` command can be used to load data from crash dump or kernel memory based on field from current data structure.

Usage:

```
pileon [type] from  field_name
```

The `pileon` command is an extension to the `load` command. It will add a new pile based on the current pile at the top of the stack. *`field_name`* is a field in the structure of the current pile. Q4 will simulate a `print` *`field_name`* and `load` *`type`*. *`type`* refers to any cataloged type (see the `catalog` command). If *`type`* is not the name of a `typedef`, it must be preceded by either the keyword `struct` or `union`, as appropriate. If *`type`* is not given type of the *`field_name`* will be used.

```
q4> load proc_t from proc_list next p_factp max 5
loaded 5 struct procs as a linked list (stopped by max
count)
q4> hist
HIST  NAME    LAYOUT  COUNT  TYPE          COMMENTS
   1  <none>  List    5      struct proc   stopped by max
                                           count
q4>  pileon from p_firstthreadp
loaded 5 struct kthreads
q4> hist
HIST  NAME    LAYOUT COUNT  TYPE           COMMENTS
   1  <none>  List   5      struct proc    stopped by max
                                           count
   2  <none>  List   5      struct kthread pileon from
                                           p_firstthreadp
q4>
```

Starting with kwdb-3.1.5, the `load` and `pileon` commands can operate on embedded structures. For example, if we have the following structure definitions in the kernel:

```
struct test {
     int a;
     char c;

};

struct parent_embed {

     struct test t;

     char z;
     struct parent_embed *parent_embed_next;

};
struct parent_embed *p1;

With kwdb-3.1.5 it is possible to execute commands like
q4>load struct parent_embed from p1 next parent_embed_next max 10
loaded 10 struct parent_embed as a linked list(stopped by max count)

q4>pileon struct test from t

loaded 5 struct test
```

Starting with kwdb-3.1.7, the `epileon` command is supported. This command has the same syntax as the `pileon` command. The advantage of this command is that it first searches the pile cache directory for the pile data that the user is currently requesting to be loaded. If it is present, then the pile data is read from the file instead of from the crash dump.

Naming Piles of Data

Usage:

```
name [pile] nickname
```

Where *pile* is a history reference to any pile created by a `load`, `merge` or `recall` command. If pile is not specified current pile is assumed.

The command attaches *nickname* to current or specified pile. This name is printed by the `history` command and can be used with the `merge` and `recall` commands to refer to the pile. Nicknames are often easier to remember than history numbers. Their only use is as an alternative to remembering which history items are which based only on their ID number.

The *nickname* is any identifier. It should start with one of these [a–z A–Z_$] and may be followed by some of these [a–z A–Z 0–9_$]. The *nickname* must be unique.

```
$ kwdb -q4 -q /var/adm/crash/crash.0
q4> load proc_t  from proc_list
loaded 1 struct proc as an array (stopped by max count)
q4> load from p_firstthreadp
loaded 1 struct kthread as an array (stopped by max count)
q4> hist
    HIST NAME   LAYOUT COUNT TYPE           COMMENTS
    1    <none> Array  1   struct proc    stopped by max
                                          count
    2    <none> Array  1   struct kthread stopped by
                                          max count
q4> name 1 PROC
so named
q4> name THREAD
so named
q4> hist
    HIST NAME   LAYOUT COUNT TYPE           COMMENTS
    1    PROC   Array  1   struct proc    stopped by max
                                          count
    2    THREAD Array  1   struct kthread stopped by
                                          max count
q4>
```

Saving Piles of Data

Usage:

```
brand [pile] nickname
```

Where pile is a history reference to any pile created by a `load`, `merge` or `recall` command. If *pile* is not specified current pile is assumed. *nickname* is any identifier as discussed in the previous section.

The `brand` command attaches *nickname* to the current or specified pile and moves it to the bottom of history stack, and creates a copy of that pile at the top of the history stack. The branded pile will be outside of the range of the `pophistory` commands and to delete it must be explicitly forgotten.

Due to memory consideration KWDB keeps at most 100 piles at any time in its local memory. When there are maximum number of piles already loaded, any new load will delete the oldest pile to make room for the new. If the oldest pile is a branded pile, it won't be deleted. To preserve a pile for long, it should be branded.

Example:

```
q4> load proc_t from proc_list
loaded 1 struct proc as an array (stopped by max count)
q4> load from p_firstthreadp
```

```
loaded 1 struct kthread as an array (stopped by max count)
q4> hist
    HIST  NAME   LAYOUT COUNT TYPE           COMMENTS
    1     <none> Array  1     struct proc    stopped by
                                             max count
    2     <none> Array  1     struct kthread
                                             stopped by
                                             max count
q4> brand THREAD
so named
copied a pile
q4> hist
    HIST  NAME   LAYOUT COUNT TYPE            COMMENTS
    -2    THREAD Array  1     struct kthread  stopped by
                                              max count
    1     <none> Array  1     struct proc     stopped by
                                              max count
    3     <none> Array  1     struct kthread  copy of
                                              THREAD
q4> brand 1 PROC
so named
copied a pile
q4> hist
    HIST  NAME   LAYOUT COUNT TYPE            COMMENTS
    -2    THREAD Array  1     struct kthread  stopped
                                              by max count
    -1    PROC   Array  1     struct proc     stopped by
                                              max count
    3     <none> Array  1     struct kthread  copy
                                              of THREAD
    4     <none> Array  1     struct proc     copy of
                                              PROC
q4>
```

Saving and Restoring Piles on a File

Using the `savepile` and `restorepile` commands, users can save piles to a file for later use in another kwdb session. This is particularly useful when analyzing very large crashdumps where it might take over half an hour to load all threads in a crashdump. The pile containing these threads can be saved to a file in a few seconds, and can be read from the file in a few seconds in a subsequent kwdb/q4 session. This can significantly speed up analysis of a crashdump over several debugging sessions by one or more users. These commands allow for saving and restoring individual piles or the entire stack of piles.

savepile

Command for saving piles to a file.

Usage:

```
savepile [<pile_number>|<pile_name>|all] to <filename>
```

Pile to be saved can be specified by <*pile_number*> or <*pile_name*>. the keyword `all` will save all the piles to the <*filename*>. If the pile to be saved is not specified, current pile will be saved to the <*filename*>. The piles saved using the `savepile` command can be restored later by the `restorepile` command.

restorepile

Command for restoring piles to a file.

The `restorepile` create piles by reading pile data from a given file. The file had to be created earlier by the `savepile` command.

Usage:

```
restorepile [<pile_number>|<pile_name>|all] from <filename>
```

Pile to be restored can be specified by <*pile_number*> or <*pile_name*>. the keyword `all` will restore all the piles from the <*filename*> and `all` is the default. Branded piles will be saved and restored as normal piles and after restoring it will no longer be branded.

Example:

```
# kwdb -quiet crash.0
q4> load proc_t from proc_list max nproc next p_factp
loaded 5723 struct procs as a linked list (stopped by)
null pointer)
q4> nameit allproc
so named
q4> history
HIST   NAME     LAYOUT    COUNT    TYPE           COMMENTS
 1     allproc  List      5723     struct proc    stopped
by null pointer
q4> savepile allproc to file1
   Saved the pile to file file1
q4> quit

# kwdb -quiet crash.0
q4> restorepile from file1
Restored all piles from file file1
q4> history
HIST   NAME     LAYOUT    COUNT    TYPE           COMMENTS
 1     allproc  List      5723     struct proc    stopped
by null pointer
q4>
```

Getting a History of the Loads

Usage:

```
history
```

This command prints a list of the piles loaded during the current session. The oldest pile is listed first, the most recent last. (The current pile is always the most recently loaded one.)

The following information is printed about each history item:

- History number (an integer from 1 through n, 1 for the oldest pile, n for the current pile). Branded piles are denoted by negative history number.
- Nickname of the pile (if any).
- Organization of the pile (if a pure array or list).
- Number of items in the pile.

- Data type of the items in the pile.
- Reason the read terminated (if known).
- Source of the pile's data (if the pile is a copy of a previous pile or a combination of two previous piles).

Example:

```
q4> history
HIST NAME   LAYOUT COUNT TYPE           COMMENTS
 1 <none>  array   276 struct proc    stopped by max count
 2 <none>   list   161 struct pregion stopped by loop
 3 <none>  array     1 struct proc    stopped by max count
 4 <none>  array   277 struct proc    merge of 1 and 3
```

This command supports output redirection.

Recalling Old Piles

Printing and database operations are only defined on the current pile (the one with the highest number in the `history` list). To operate on a pile other than the current one, would use the `recall` command to make that pile current.

Usage:

```
recall pile
```

Where *`pile`* is a history reference to any pile created by a `load`, `merge` or `recall` command. This command copies a specified pile to the current pile.

Merging Piles

Merge an old pile with the current one using the `merge` command.

A new pile is produced consisting of a union of the two old piles. (That is, every item in either of the original piles is copied into the result, but none of the items will appear twice.)

The new pile is made the current pile and neither of the original piles is disturbed.

Usage:

```
merge pile
```

Where *pile* is a history reference to any pile created by a `load`, `merge` or `recall` command.

Forgetting Piles

Delete any pile using the `forget` command.

The forgotten pile is removed along with any *`nickname`* it may have had and memory in KWDB's address space is freed.

If the forgotten pile was the current pile the previous pile is made current again.

Usage:

```
forget pile | all
```

Where *pile* is a history reference to any pile created by a `load`, `merge` or `recall` command. Branded piles have to be deleted specifically using the *`nickname`*. When the keyword all is used, all the loaded piles are forgotten (except for branded piles, which need to be forgotten explicitly).

Saving and Restoring State

The state of the history pile can be saved and restored so that piles created between the two events are deleted automatically.

Usage:

```
pushhistory
```

Notes the current pile. Any piles created after this command is issued will be deleted by the matching `pophistory`.

Usage:

```
pophistory
```

Pops back to the matching `pushhistory`. Any piles created since then will be deleted.

The `pushhistory` and `pophistory` commands may be nested. The usual rules about nesting anything apply.

NOTE Piles explicitly deleted with `forget` are not restored by `pophistory`.

The implementation of kwdb prior to kwdb-3.1.5 had a restriction in the total number of piles that could be accessed at a given point in time. The limit was 100, and there was no tunable mechanism to change that limit. This was not causing a problem in day-to-day usage; however, this was causing some of the q4 perl scripts to fail and abort. This restriction has been overcome in kwdb 3.1.5 after the pile rearchitecture work. In addition to this, earlier kwdb was storing all of the piles in memory while running. This was causing kwdb to consume more memory during running, especially while debugging large dumps. The new implementation stores only up to a threshold in memory, and, once the limit is crossed, it flushes the older piles onto the disk automatically without any intervention by the user. Those (flushed) piles are brought back to memory as soon as the user does a recall of the older piles. The user can configure the threshold memory limit for pile storage through the "`set kwdb pile-memory-limit`" command.

Printing Structure Fields

The `print` command prints all or part of the current pile. This is the usual way to see the result of a `load` (and possible database operations). In addition to printing fields from current pile, `print` command can also print variables and symbols.

Usage:

```
print [ options ... ] [ field [custom_field_format] ... ]
or
print [ options ... ] type from addr
```

The options may be chosen from this list:

`-d` Integer fields are normally printed in decimal unless overridden by the KWDB variable *`q4PrintRadix`* or a custom field format. This option overrides *`q4PrintRadix`* for every integer field for the duration of this one `print` command. Custom field formats can be used to override this flag on a field-by-field basis.

`-H` Column headings are normally printed when the standard output is connected to a tty and suppressed when it is not. This option turns off column headings regardless.

`-h` Column headings are normally printed when the standard output is connected to a tty and suppressed when it is not. This option turns on column headings regardless.

`-o` Sets a default octal format. See `-d` for more details.

`-t` Normally output is printed as a table with each structure on its own line and each field in its own column. This option (sort of) "transposes" the output. All of the fields for each structure are grouped together, one field per line, with a blank line between the last field of each structure and the first field of the next. Each line of data is composed of the name of the field and the field's value, respectively.

`-x` Sets a default hex format. See `-d` for more details.

The *`fields`* may be zero or more of the following:

- Any field defined for the structure or union type that comprises the current pile.
- Any KWDB variable
- Any KWDB constant

Any of the *`fields`* may be followed by a custom field format to modify its appearance in the output.

The default format for integer types is decimal. Here are the ways this can be overridden, listed from lowest to highest precedence:

- *`q4PrintRadix`* set (to 8, 10, or 16) inside KWDB
- the `-d`, `-o`, or `-x` options given with the `print` command
- a custom field format used on a specific field

The default format for enumerated types is symbolic.

The default format for "embedded" arrays of characters is as a string. There is no direct support for printing strings that are pointed to by structure fields.

The default format for floating point types is a one of the standard floating point formats.

Any `print` command that names no fields explicitly prints every element of every array in the underlying type by default.

Example: Print certain specific fields (*`lbolt`* is a kernel symbol).

```
q4> print p_stat p_flag p_flag%#x p_cntxt_flags p_lastrun_time lbolt
p_stat     p_flag p_flag    p_cntxt_flags p_lastrun_time lbolt
SSLEEP SSYS|SLOAD    0x3                0          29326 29415
SSLEEP SSYS|SLOAD    0x3                0          29326 29415
SSLEEP SSYS|SLOAD    0x3                0          29326 29415
SSLEEP SSYS|SLOAD    0x3                0          29409 29415
SSLEEP SSYS|SLOAD    0x3                0          29355 29415
SSLEEP SSYS|SLOAD    0x3          SSIGABL          29401 29415
SSLEEP SSYS|SLOAD    0x3          SSIGABL          29411 29415
SSLEEP SSYS|SLOAD    0x3          SSIGABL          29408 29415
SSLEEP      SLOAD    0x1          SSIGABL          29409 29415
SSLEEP      SLOAD    0x1          SSIGABL          29353 29415
  SRUN      SLOAD    0x1 SSIGABL|SRUNPROC          29412 29415
```

Example: Print every field (including synthetic fields).

```
q4> load struct utsname from &utsname
loaded 1 struct utsname as an array (stopped by max count)
q4> print -t
                          indexof  0
                           mapped  1
                          spaceof  0
                           addrof  11818360
                       physaddrof  11818360
                         realmode  0
                          sysname  "HP-UX"
                         nodename  "hpadl628"
                          release  "B.11.11"
                          version  "A"
                          machine  "9000/800"
                        __idnumber  "849377401"
```

Printing Structure From an Address

The second form of `print` command:

```
print  [ options . . . ]  type  from  addr
```

Can be used to print fields of a structure from a given address. The structure is printed in C-style with address, type, name and value for each fields. The argument type refers to any cataloged type (see the `catalog` command). If *type* is not the name of a `typedef`, it must be preceded by either the keyword "struct" or "union", as appropriate. The *type* field is optional, if type information can be obtained from the type of *addr*. Reading begins at *addr*, which can be an expression as in `load` command. All the options supported in the first form of the `print` command, discussed in the previous section, is available for this format as well.

Example:

```
q4>  print   intl100_ift_t   from   0xe000000109835040

0xe000000109835040   struct intl100_ift {
0xe000000109835040       struct lan_ift_s {
0xe000000109835040           struct hw_ift {
0xe000000109835040               struct  {
0xe000000109835040                   char   *drv_data                0xe000000109835040
0xe000000109835048                   intptr_t   (*dlpi_output)()
                                              intl100_resolved_output
0xe000000109835050                   int   (*dlpi_build_hdr)()    0
0xe000000109835058                   intptr_t   (*dlpi_ioctl)()     hp_dlpi_ioctl
0xe000000109835060                   char   *mib_ptr        0xe000000109835384
0xe000000109835068                   int   mib_len          0x100
0xe00000010983506c                   unsigned int   reserved1  0
0xe000000109835070                   unsigned int   reserved2  0
0xe000000109835074                   unsigned int   reserved3  0
0xe000000109835078               } hp_dlpi
0xe000000109835078               unsigned int   mac_type    0x4
0xe00000010983507c               unsigned int   llc_flags   0x1f
0xe000000109835080               unsigned int   mjr_num     0x77
0xe000000109835084               unsigned int   nm_id       0x1
0xe000000109835088               unsigned int   instance_num  0
0xe00000010983508c               unsigned int   mtu         0x5dc
0xe000000109835090               char   *name               0xe0000000001b8af8
0xe000000109835098               unsigned char   hdw_path   "0/16/1/5/0"
0xe0000001098350fc               unsigned int   hdw_state   0
0xe000000109835100               unsigned int   mac_addr_len  0x6
0xe000000109835104               unsigned char   mac_addr   ""
0xe000000109835118               unsigned int   features    0x4807
0xe000000109835120               uint8_t   *arpmod_name     0xe0000000001b8e1d
0xe000000109835128               unsigned int   ppa         0
0xe00000010983512c               unsigned int   watch_timer  0x1
0xe000000109835130               unsigned int   reserved2   0
0xe000000109835138               lock_t   *hwift_lock       0xe00000010980d400
0xe000000109835140               struct hw_ift   *next      0
0xe000000109835148           } hwift
0xe000000109835148           int   af_supported             0
0xe00000010983514c           struct  {
0xe00000010983514c               int   flag                 0
0xe000000109835150               int   timer                0x4
0xe000000109835154           } lantimer
0xe000000109835158           intptr_t   (*hw_req)()        intl100_hw_req
0xe000000109835160           int   (*dma_time)()            intl100_DMA_timeout
0xe000000109835168           unsigned int   BAD_CONTROL     0
0xe00000010983516c           unsigned int   UNKNOWN_PROTO 0xa3
0xe000000109835170           unsigned int   RXD_XID         0
    . .  . .  . .  // Output truncated here
```

This command supports output redirection.

Examining Memory

Usage:

```
examine [ flags ] [ addr ] [ for lines ] [ using format ]
```

Where *addr* is an expression that evaluates to the starting virtual address of the data, *lines* is an expression that evaluates to the number of lines of output wanted, and *format* is a list of format characters that controls printing of each item in the output line.

Flags:

`-o`	Normally, KWDB gets the data from the crash dump or the kernel memory depending on the target. With this option, KWDB will get the data from the kernel file instead. This is like the difference between the *adb* operators `?` and `/`.
`-r`	Real mode, read this data without address translation. The default is to use address translation.

If *addr* is not given, the value of dot leftover from the previous `examine` command is used.

If *lines* is not given, the value from the previous `examine` command is used. The default value for the first time is 1. If *lines* is not given, but *addr* is, the first time default for *lines* is used.

If *format* is not given, the value from the previous `examine` command is used. The default value for the first time is `D`. If *format* is not given, but *addr* is, the first time default for *format* is used.

The format characters are mostly borrowed from *adb*. They are:

o	Print a half-word in octal, increment dot by 2.
O	Print a word in octal, increment dot by 4.
d	Print a half-word in decimal, increment dot by 2.
D	Print a word in decimal, increment dot by 4.
x	Print a half-word in hex, increment dot by 2.
X	Print a word in hex, increment dot by 4.
u	Print a half-word in unsigned decimal, increment dot by 2.
U	Print a word in unsigned decimal, increment dot by 4.
f	Print an IEEE float, increment dot by 4.
F	Print an IEEE double, increment dot by 8.
b	Print a byte in hex, increment dot by 1.
B	Print a byte in octal, increment dot by 1.
c	Print a character, increment dot by 1.
C	Print a character with enough backslash escapes to make it readable, increment dot by 1.
s	Print a string, increment dot by the length of the string (including the trailing null character).
S	Print a string with enough backslash escapes to make it readable, increment dot by the length of the string (including the trailing null character).
Y	Print a word as a date-and-time string, increment dot by 4 (see *ctime* (3C)).
a	Print the value of dot as a symbolic kernel address, dot is not incremented.

A	Print the value of dot as a decimal number, dot is not incremented.
p	Print the word dot points to as a symbolic kernel address, increment dot by 4.
^	Decrement dot by the current increment (that is, back up over the previous value retrieved), nothing is printed.
+	Increment dot by 1, nothing is printed.
-	Decrement dot by 1, nothing is printed.
L	Print 64 bits in hex.
i	Print an instruction, address is incremented by size of instruction.
I	Print a bundle of instructions, address is incremented by size of a bundle.

Any format character preceded by a positive integer is repeated that many times.

Example: What was the panic message?

```
q4> examine panicstr using s
Data segmentation fault
```

Example: What was in the console message buffer?

```
q4> examine &msgbuf+8 using s
WARNING: Bad magic in file /stand/ioconfig (0x2122494f)
                                    expected 0x21224941
    Block TLB kernel mapping enabled
16 lanmux0
16.1 lan3
52 scsi1
52.0 target
52.0.0 tape2
52.5 target
...
```

Example: What time was it when the system dumped memory?

```
q4> examine &time using Y
Sun Jun  5 17:50:00 1994
```

Example: How many processors did the system have?

```
q4> examine &runningprocs using aD
runningprocs 2
```

Example: Print instruction at a given address.

Examine instruction at an address in a PA crash dump:

```
$ kwdb -q4 -quiet
Detected PA 64-bit executable.
Invoking /CLO/Components/WDB/Src/gdb/gdb/kwdb64.
q4> ex 0x66a6ec using i
0x66a6ec <pty_init+0x4>:        addil L'-0x27c000,%dp,%r1
q4>
```

Examine instruction at an address in an IA crash dump:

```
$ kwdb -q4 -quiet
Detected IA64 executable.
Invoking /CLO/Components/WDB/Src/gdb/gdb/kwdb.ia64.
/CLO/Components/WDB/Src/gdb/gdb/kwdb
q4> ex 0xe000000000f2a450 using i
0xe000000000f2a450:0 <pty_init+0x10:0>: [MLX]       mov r37=14
q4>
```

Examine bundle of instructions in an IA crash dump:

```
q4> ex 0xe000000000f2a450 using I
Dump of assembler code from 0xe000000000f2a450:0 to 0xe000000000f2a460:0:
End of assembler dump.
0xe000000000f2a450:0<pty_init+0x10:0>:[MLX]mov  r37=14
0xe000000000f2a450:1<pty_init+0x10:1>:     movl r38=0xe0000000001dd838;;

q4> ex
Dump of assembler code from 0xe000000000f2a460:0 to 0xe000000000f2a470:0:
0xe000000000f2a460:0 <pty_init+0x20:0>:[MMB]   adds r36=96,r32
0xe000000000f2a460:1 <pty_init+0x20:1>:        adds r35=88,r32
0xe000000000f2a460:2 <pty_init+0x20:2>:
           br.call.sptk.few b0=0xe00000000047da00:0 <alloc_spinlock>;;
End of assembler dump.

q4>
```

This command supports output redirection.

Writing into Kernel Files or Memory

KWDB can modify data in kernel files or kernel memory using the `write` command. The `print` and `set` commands can also be used to modify data in kernel files or memory.

The syntax of the `write` command is:

```
write [flags] data at addr [using format]
```

or

```
write [flags] {data1, data2, ...} at addr [using format]
```

The `write` command writes the given *data* into memory or kernel file at the address specified by *addr*.

flags:

`-o`	Write into kernel file (`vmunix`), instead of memory. This option is similar to using "?" in `adb` instead of "/".
`-r`	Write without address translation (real-mode).

The *addr* can be a C-style expression resulting in either a 32- or 64-bit address. It may also include space in the form `space.offset`. When used with the second format (within curly brackets), addr is assumed to represent an array, and the number of comma elements specified within the braces are written starting from *addr*. Writing to an array feature is available from KWDB 3.1.3 onwards.

The term format is one of the characters `b`, `w`, `W`, `L`, `c` and `s`. It specifies the type (length) of data to be written as shown in *Table 4-4, "Kernel File/Memory Write Formats."*

Table 4-4 Kernel File/Memory Write Formats

FMT	DETAIL	Number of Bytes Written
b	write a byte	1 byte
w	write a half word	2 bytes
W	write a word	4 bytes
L	write a long word	8 bytes
c	write a character	1 byte
s	write a string	length of string

The default format character for numeric data is W. Data enclosed in double quotes ("") will be taken as string by default and data enclosed in single quotes (' ') will be taken by default as character. The delimiter character "\" is not allowed in the string. Any special character in the string has to be written using other formats like character format. Maximum length of the string is limited to 4KB. While writing numeric data, alignment is not considered. However, KWDB displays the warning message `"Warning: data not aligned at proper address boundary."` When data is not aligned at proper address boundary. The `write` command prints the value before modification and the new value after the successful write. The format specified is given higher precedence over the type information of the variable (when debug information is available) and it overrides the type information.

To allow writing into kernel file or memory KWDB has to be invoked with the `-write` option. KWDB can not modify the kernel file or crash dump when the target is `crash`. If the `write` or `print` or `set` command is issued before selecting any target using the `target` command, writing will be done in the kernel file. After issuing the `target` command, all writes will be to memory by default. To write to the kernel file after selecting a target use the `write` command with `-o` option. While debugging a remote target, any data written using `write -o` will modify only the local copy of the kernel file and not the kernel file on the remote target.

NOTE Any modification in the kernel file will be permanent until overwritten with new data. Turn on logging, using the command `set kwdb log on`.

Writing into Kernel Files

To write into the kernel file invoke `kwdb` with the kernel file and use the `write`, `print` or `set` command. Since the `target` command has not been issued, the `-o` option for `write` command is not needed. A set of examples is provided.

Example: Write a string at a particular address in the kernel file (local `vmunix` file).

```
$ kwdb -q -write ./vmunix
(kwdb) write " -PF ./linkorder -P -noshared -k mapfile
    +nodefaultmap +Accept typeMismatch" at 0xb476b8
Writing 76 characters at 0xb476b8 in kernel file
Old value: "xxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxx"
New value: " -PF ./linforder -P -noshared -k mapfile
    +nodefaultmap +Accept typeMismatch"
(kwdb)
```

Example: Write eight bytes of data at a particular address in kernel file.

```
(kwdb) write 0xae21f9 at 0xb476c0 using L
Writing 8 bytes at 0xb476c0 in kernel file
Old value: 0x00ae21f972646572
New value: 0x0000000000ae21f9
(kwdb)
```

As shown in the previous example, if data specified is shorter in length it is right justified (that is, padded with zeros on the left side).

Example: Write two bytes of data at a particular address in `vmunix`.

```
(kwdb) write 0xae21f9 at 0xb476bc using w
Wrong value 0xae21f9 for format w
```

As shown in the previous example, if the data specified is larger in size than that specified by the format character it is reported as an error.

```
(kwdb) write 0xae21 at 0xb476bc using w
Writing 2 bytes at 0xb476bc in kernel file
Old value: 0x0000
New value: 0xae21
```

Writing into Kernel Files or Memory During Live Memory Analysis

During live memory analysis (or after issuing a `target` command) all writes using a `write`, `print`, or `set` command will be to the memory by default. To write to the kernel file use the `write` command with the `-o` option. The `print` or `set` command can not be used to write into a kernel file after issuing the `target` command.

Example: Write a string data at a particular address in memory (`/dev/kmem`).

```
# kwdb -q4 -q -write/stand/vmunix /dev/kmem
(kwdb) write "hpadl879" at 0xac64e1
Writing 9 characters at 0xac64e1 in devmem
Old value: "unknown"
New value: "hpadl879"
(kwdb) ex 0xac64e1 using s
hpadl879                    /* from memory*/
(kwdb) ex -o 0xac64e1 using s
unknown                   /* from vmunix file*/
```

Example: Write a string data at a particular address in the kernel file.

```
(kwdb) write -o "hpadl879" at 0xac64e1
Writing 9 characters at 0xac64e1 in kernel file
Old value: "unknown"
New value: "hpadl879"
(kwdb) ex 0xac64e1 using s
hpadl879                    /* from memory*/
(kwdb) ex -o 0xac64e1 using s
hpadl879                     /* from vmunix file */
(kwdb)
```

Example: Modify the value of a kernel symbol in memory using the write, print or set command on a live system.

```
# kwdb -q4 -q -write /stand/vmunix /dev/kmem
q4> ex &kgdb_debug_flags
0
```

```
q4> print kgdb_debug_flags = 1
$1 = 1
q4> ex &kgdb_debug_flags
1
q4> set kgdb_debug_flags = 2
q4> ex &kgdb_debug_flags
2
q4> write 3 at &kgdb_debug_flags
Writing 4 bytes at 0xb2ed34 in devmem
Old value: 0x00000002
New value: 0x00000003
q4> ex &kgdb_debug_flags
3
```

Example: Modify the value of a symbol in the kernel file using the `write` command on a live system.

```
q4> write -o 4 at &kgdb_debug_flags
Writing 4 bytes at 0xb2ed34 in kernel file
Old value: 0x00000000
New value: 0x00000004
q4> ex &kgdb_debug_flags
3        /* from memory */
q4> ex -o &kgdb_debug_flags
4        /* from vmunix file */
```

During the remote kernel debugging all writes using the `write`, `print` or `set` command will be to the remote target memory by default. To write to the local kernel file use the `write` command with the `-o` option. The `print` or `set` command can not be used to write into the local kernel file after issuing the `target` command.

Evaluating Expressions

Usage:

```
evaluate expr
```

Where *expr* is an expression.

This command evaluates *expr* and prints the result in decimal. This command is more useful for scripting as well as to evaluate expression when KWDB is not in Q4 mode.

The output of this command is never affected by any of the commands, control variables used to set user preferences. As a result, KWDB programs can use this command to evaluate expressions without fear of the result being returned in some unexpected format and interactive users can change output formats as they please without fear of confusing scripts they might be running.

Listing Constants

Generate a list of all of the enumerants defined in the kernel's symbolic debug area using the `constants` command.

Usage:

```
constants
```

Example: Produce a list of the enumerants defined by the kernel.

```
q4> constants -h | head -10
AUTH_OK                  0x0
AUTH_BADCRED             0x1
AUTH_REJECTEDCRED        0x2
```

```
AUTH_BADVERF              0x3
AUTH_REJECTEDVERF         0x4
AUTH_TOOWEAK              0x5
AUTH_INVALIDRESP          0x6
AUTH_FAILED               0x7
AUTH_KERB_GENERIC         0x8
AUTH_TIMEEXPIRE       0x90x10
```

This command supports output redirection.

Listing Variables

Generate a list of all of the variables that have been defined using the `variables` command. Some odd conflicts in the name space between variables and KWDB commands may be found. KWDB commands or an initial part of a command which KWDB tries to complete as a command or command aliases can not be used as a variable name. Use variable names that are either meaningful or avoid command name conflicts. For example “n” or “x” can not be used as a variable name as they are aliases to next command and examine command respectively. Instead use variable names like *number_of_procs* or *my_var* or *x1* which don’t conflict with KWDB command names.

Usage:

```
variables [ flags ]
```

Flags:

`-h`	Column headings are normally suppressed when output is sent to a non-interactive destination (like a file or pipe). This option forces headers to be printed regardless of the destination.

Example: Produce a list of the defined variables.

```
q4>  a1 = 1
01       1        0x1
q4>  b2 = 2
02       2        0x2
q4> c3 = a1 + b2
03       3        0x3
q4> variables
NAME   OCTAL   DECIMAL   HEX
a1        01         1   0x1
b2        02         2   0x2
c3        03         3   0x3
```

The decimal, hex, or octal output may be suppressed by setting the KWDB variable *q4PrintDecimal*, *q4PrintHex*, or *q4PrintOctal*, respectively, to zero. Any one or two (or none) of them may be suppressed.

This command supports output redirection.

Destroying Variables

Delete any variables created using the `unset` command.

Usage:

```
unset names
```

Where *names* refers to one or more variable names that have been previously created separated by space.

Any kernel global variable obscured by the creation of a new variable will be accessible again after this variable has been deleted.

Database Operations

Subset piles that have been loaded from the crash dump using the keep and discard commands.

Usage:

```
keep expr
discard expr
```

Where *expr* is any expression.

Both of these commands look at the current pile and produce a new pile based on the expression. The new pile becomes current. The original is not changed.

The `keep` command evaluates *expr* in the context of each item in the current pile. If *expr* is true, that item is kept. If it is false, that item is discarded.

The `discard` command works the same way except that the logic is reversed.

Example: Find all of the processes in process group 751.

```
q4> load struct proc from proc_list max nproc next p_global_proc
loaded 10795 struct procs as a linked list (stopped by null pointer)
q4> keep p_pgrp==751
kept 4 of 276 struct proc's, discarded 272
q4> print p_pgrp p_pid p_ppid
p_pgrp p_pid p_ppid
  751    754    751
  751    753    751
  751    751      1
  751    756    751
q4> discard p_ppid != 751
kept 3 of 4 struct proc's, discarded 1
q4> print p_pgrp p_pid p_ppid
p_pgrp p_pid p_ppid
  751    754    751
  751    753    751
  751    756    751
```

KWDB support string comparison using == and != with `keep` and `discard` commands. It can be used in simple conditional expressions (expression containing only one condition). Both "char *" and "char []" types are supported.

Example:

```
q4> load proc_t from proc_list max 2c next p_factp
loaded 2 struct procs as a linked list (stopped by
max count)
q4> print -H p_comm
"swapper"
"ksh"
q4> keep p_comm == "swapper"
kept 1 of 2 struct proc's, discarded 1
q4> print -H p_comm
"swapper"
q4> recall 1
```

```
copied a pile
q4> keep p_comm != "swapper"
kept 1 of 2 struct proc's, discarded 1
q4> print -H p_comm
"ksh"
```

Database Operations

Create piles based on data already loaded using the `pileon` command.

Usage:

```
pileon [ typename ] from field_name
```

Where `typename` is any structure available to KWDB and `field_name` is a field in the structure of the current pile. If type name is not specified the type of the `field_name` will be used.

This command looks at the current pile and produces a new pile based on de referencing the `field_name`. The new pile becomes current. The original is not changed.

Before `pileon`, keep only those structures with a valid reference. KWDB will not skip if reference is zero. If the references are zero any operation on fields from the pile created by the `pileon` command may give memory access error.

Example: Find all processes of sleeping `kthreads` in a process group 10163.

```
q4> load kthread_t from kthread_list max nkthread next
                                          kt_global_
loaded 11263 struct kthreads as a linked list (stopped by
                                             null pointer)
q4> keep kt_stat==TSSLEEP
kept 9507 of 11263 struct kthread's, discarded
q4> keep kt_procp
kept 9507 of 9507 struct kthread's, discarded 0
q4> pileon proc_t from kt_procp
loaded 9507  proc_ts
q4> keep p_pgrp == 10163
kept 48 of 9507 struct proc's, discarded 9459
q4> print p_stat p_pgrp p_pid p_ppid p_firstthreadp%llx
p_stat  p_pgrp  p_pid  p_ppid  p_firstthreadp
SINUSE  10163   10851   10163   0x52c27040
SINUSE  10163   10858   10163   0x52ff4040
SINUSE  10163   10811   10163   0x5619d040
SINUSE  10163   10832   10163   0x564fc040
SINUSE  10163   10841   10163   0x5673c040
SINUSE  10163   10823   10163   0x55e43040
SINUSE  10163   10839   10163   0x5c448040
SINUSE  10163   10835   10163   0x644d9040
SINUSE  10163   10808   10163   0x57690040
SINUSE  10163   10813   10163   0x57040040
. . .  //output truncated here
```

Including PERL Program Files

This command pulls in a PERL script file making the functions and data defined in it available for use.

Usage:

```
include filename
```

Where *filename* is the name of any program file in KWDB's include path.

See *Chapter 7, "KWDB PERL Programming Reference,"* for more details.

Running PERL Programs

This command runs any function from the PERL scripts already pulled in via the `include` command.

Usage:

```
run function [ arguments ... ]
```

Where *function* is the name of any function from the PERL scripts already pulled in and the *arguments* are anything wanted to pass to it. Arguments are concatenated together with whitespace separators and passed to the function as a single PERL string.

See *Chapter 7, "KWDB PERL Programming Reference,"* for more details.

This command supports output redirection.

Adding Type Information

The `adddebug` command adds type information from a given object file.

Usage:

```
adddebug  filename
```

This command reads type information from the named file. The file must be a relocatable file and should contain debug information. If the *filename* doesn't contain the absolute path, it will be searched for in the current directory and directories specified by shell `PATH`.

Example:

```
$ cat mystruct.c

/* define some struct for demo */
struct foo
{
    int i;
    long l;
}

$ kwdb -q4 -q /var/adm/crash/crash.0
q4> cat   ^foo$
BYTES    FIELDS    SHAPE   NAME

q4> adddebug  mystruct-lp64.o
Processing file mystruct-lp64.o
warning: File not processed by pxdb--about to process now.

 Procedures: 0
q4> cat ^foo$
BYTES   FIELDS  SHAPE   NAME
     16           2            struct     foo
q4> fields -c struct foo
struct foo {
    int i;
```

```
    long l;
}
q4>
```

Listing DLKM Modules

The command module lists currently loaded DLKM modules.

Usage:

```
modules
```

The `modules` command prints module ID, name, load path, space, BSS, name of dependent modules, and if the module is processed for debugging or not for every loaded DLKM module.

Example:

```
$ kwdb -q4  -q .

q4> modules

Module Name:      iscsi
Module Id:        4
Module Load Path: /stand/dlkm/mod.d/iscsi
Module Space:     0xd3b000
Module BSS:       0x0
Module Processed: no
Module loaded dependent(s):  ssii  is

Module Name:      ssii
Module Id:        3
Module Load Path: /stand/dlkm/mod.d/ssii
Module Space:     0xd23000
Module BSS:       0xccf000
Module Processed: no
Module loaded dependent(s):  is

Module Name:      is
Module Id:        2
Module Load Path: /stand/dlkm/mod.d/is
Module Space:     0xcc9000
Module BSS:       0xcce000
Module Processed: no
```

This crash dump consists of 3 modules `is`, `ssii` and `iscsi` with dependencies among them.

Processing DLKM Modules

The command `addmodule` processes DLKM modules for debugging.

Usage:

```
addmodule module
```

Where `module` is the name of the module. If the crash dump or the live system (using `devmem` target) has loaded DLKM modules, they can be selectively processed for debugging by using this command. If the given module is dependent on other modules, those modules will be processed first and then the given module will be processed. KWDB can be invoked with the `-m` option for processing all the loaded modules. For more details on how to process DLKM modules on a remote live system see the *"Debugging DLKMs"* section.

The same example discussed in the previous section is continued here. Look for a symbol `iscsi_wrapper`.

Example:

```
q4> sym iscsi_wrapper
    OCTAL      DECIMAL        HEX   DIST TYPE  NAME
```

There is no symbol by the name `iscsi_wrapper`. Add the module `iscsi`.

```
q4> addmodule iscsi
Processing DLKM module is
warning: File not processed by pxdb--about to process now.
.
 Procedures: 9
Processing DLKM module ssii
warning: File not processed by pxdb--about to process now.
..
 Procedures: 32
Processing DLKM module iscsi
warning: File not processed by pxdb--about to process now.
.
 Procedures: 11
```

The module `iscsi` depends on `is` and `ssii` so they are also processed before `iscsi`.

```
q4> sym iscsi_wrapper

       OCTAL    DECIMAL       HEX  DIST TYPE  NAME
     063154110  13424712 0xccd848  48   OBJT  iscsi_wrapper
```

The symbol `iscsi_wrapper` is listed and has come from the module `iscsi`. List the modules once again.

```
q4> modules

Module Name:      iscsi
Module Id:        4
Module Load Path: /stand/dlkm/mod.d/iscsi
Module Space:     0xd3b000
Module BSS:       0x0
Module Processed: yes
Module loaded dependent(s):  ssii  is

Module Name:      ssii
Module Id:        3
Module Load Path: /stand/dlkm/mod.d/ssii
Module Space:     0xd23000
Module BSS:       0xccf000
Module Processed: yes
Module loaded dependent(s):  is

Module Name:      is
Module Id:        2
Module Load Path: /stand/dlkm/mod.d/is
```

```
   Module Space:     0xcc9000
   Module BSS:       0xcce000
   Module Processed: yes
```

All three modules are listed as processed.

If a module doesn't contain type information, while processing that module KWDB will display the message `no debugging symbols found in DLKM module`, as shown in the following example. It will still be able to do symbolic debugging.

```
$  kwdb -q4  -q  ./crash.0 -m
Processing DLKM module sdsp
(no debugging symbols found in DLKM module)...
Processing DLKM module udpio
(no debugging symbols found in DLKM module)...
Processing DLKM module sonet_proxy
(no debugging symbols found in DLKM module)...
Processing DLKM module sdsp_imaexp
(no debugging symbols found in DLKM module)...
Processing DLKM module sdsp_imacomp
(no debugging symbols found in DLKM module)...
Processing DLKM module sdsp_muexp
Event selected is 0. It was a TOC
#0  0x95b318 in proxy_ctrl_func ()
q4>
```

The `show envvars` Command

In 11.31, kwdb supports the `show envvars` command, which lists the value of environment variables and their values supported by kwdb.The following are the environment variables listed by the `show envvars` command :-

`KWDB_TEXT_START` This environment variable is used to override __text_start address. This is particularly useful when user wants to start kwdb on a corrupted vmunix/dump.

`KWDB_DATA_START` This environment variable is used to override __text_data address. This is particularly useful when user wants to start kwdb on a corrupted vmunix/dump.

`PXDB` This environment variable can be set to the path of pxdb on the current machine.

`KWDB_CONFIG_FILE` This environment variable can be set to the path of the kwdb configuration file name for lantron and console targets. Default value is /etc/opt/kwdb/kwdb.conf

`P4_SITE` This environment variable can be set to specify the path where the kwdb shared libraries are present. Default value is /usr/contrib/kwdb/lib.

`KWDB_CHECK_PTE_CHAIN` This environment variable should be set to detect chains in the PTE traversal. The value can range between 10 to 10000.

`LIBCRASH_ENABLE_CACHE` This environment variable is set to 1 in order to enable caching inside the libcrash for better performance during crash dump debugging. Default value is 1.

`KWDBCR_PATH` The path of the kwdbcr can be set by this variable. Default path is /usr/contrib/kwdb/bin/kwdbcr.

`KWDBCR_LOGPATH` The path where log files generated by kwdbcr should be stored is set in this variable. Default value is /var/opt/kwdb/kwdbcr.log.

`DYNFILE` This environment variable is set to the path where a pre-processed kernel module should be saved while processing DLKM's.

`KWDB_SUPPORTS_LARGE_DUMP` This environment variable can be set to 1 to configure kwdb for reading large crash dump. When this variable is set kwdb uses larger memory cache.

`Q4_STARTUP_SCRIPT` The path of the q4 startup script can be specified by this variable. Default value is $HOME/.q4rc.pl

`Q4_PERL_PATH` The path of the perl installed on the machine can be set by this environment variable. Default value is /opt/perl/bin/perl.

`q4Disassembler` The environment variable is set to the path of the disassembler which is used by getasm command to obtain the assembly level code.

5 Analyzing Crash Dumps

This chapter shows the reader how to use KWDB to analyze a crash dump.

What Kind of Dump is This?

There are basically only two different kinds of Crash Dumps, those where the system crashed, and those where the system hung.

Crash type dumps are usually caused by kernel panics or **High Priority Machine Checks** (HPMC). Hang type dumps are usually caused by a user initiated **Transfer of Control** (TOC) of an unresponsive system.

First thing to do is to determine what release of the system and what kind of machine. After that, check to see what kind of dump it is.

What release and what kind of machine was it?

```
$ kwdb -q4  /var/adm/crash/crash.6

KWDB 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 KWDB; type "show warranty" for details.

Hewlett-Packard KWDB 2.0.1 12-Jun-2002 10:00 (based on GDB 4.16)
(built for PA-RISC 2.0 (wide), HP-UX 11.00)
Copyright 1996, 1997 Free Software Foundation, Inc...
crash dump information:
  hostname  hpfcs322
  model     9000/800/L2000-44
  panic     Data memory protection fault
  release   @(#)B2352B/9245XB HP-UX (B.11.00) #1:
            Wed Nov  5 22:38:19 PST 1997
  dumptime  964463280 Mon Jul  24 11:28:00 PDT 2000
  savetime  964463811 Mon Jul  24 11:36:51 PDT 2000
Event selected is 0. It was a panic
#0  0x2d76a4 in panic ()

q4> load struct utsname from &utsname
loaded 1 utsname as an array (stopped by max count)
q4> print -t
      indexof  0
       mapped  1
      spaceof  0
       addrof  6983512
   physaddrof  6983512
     realMode  0
      sysname  "HP-UX"
     nodename  "hpfcs322"
      release  "B.11.00"
      version  "A"
      machine  "9000/800"
   __idnumber  "138901557"
q4>
```

The address of `utsname` is used because it's declared as a structure in the kernel, not a pointer to a structure. For pointers to structures leave off the & symbol before the variable name.

From the previous message, it was learned that the system is an S800 A-class server running HP-UX 11.0. The next question is "was there a panic message?"

```
q4> examine panicstr using s
Data memory protection fault
```

Since there was a panic message, this was a crash, apply the crash debugging techniques.

If this was a hang (which the user TOC'd), the previous command output will look more like this:

```
   q4> examine panicstr using s
   TOC, pcsq.pcoq = 7f8a.a4df, isr.ior = 5411.40006a50
*********************************************************
assertion failed (spinlock: failed I-bit checks) at line
683 in /ux/core/kern/pa/sync/spinlock.c
*********************************************************
```

Another more direct way to check is to ask for a stack trace of the first crash event. Q4 prints the crash type before the trace and this will tell if it was a panic or HPMC (suggesting a crash), or a TOC (suggesting a hang).

Crashes

Assume the system panicked, at this point a stack trace of the panic is wanted. For that, consult the crash event table. This is a static table in low memory that records each crash event in the order they occur. Look at the first crash event. (That's the one that caused the dump in the first place.)

```
q4> trace event 0
Event selected is 0. It was a panic
#0  0x6a654 in panic+0x6c ()
#1  0xcb374 in report_trap_or_int_and_panic+0x94 ()
#2  0xccaf0 in trap+0x11f0 ()
#3  0x9d6e0 in kgdb_pre_trap+0xa8 ()
#4  0xe49ec in $call_trap+0x2c ()
#5  0x3d3738 in rtprio+0x30 ()
    at /ux/core/kern/common/pm/sched/pm_rtsched.c:1048
#6  0x439f28 in syscall+0x790 ()
#7  0x33a1c in $syscallrtn+0x0 ()
```

A process was in the system call `rtprio` when it got the data segmentation fault we saw in the panic string. It panicked there because of the deliberate de-referencing of a null pointer to get this dump,

When one processor panics it tells all of the other processors to TOC. Each of these TOCs generates another crash event. See them all.

```
q4> load crash_event_t from &crash_event_table until
    crash_event_ptr max 100
loaded 5 crash_event_t's as an array (stopped by "until"
    clause)
q4> print cet_hpa %#x cet_event
cet_hpa  cet_event
0xfffa4000      1
0xfffa4000      1
0xfffa0000      2
0xfffa6000      2
0xfffa2000      2
```

There are five crash events, but four are unique **Hard Physical Addresses** (HPAs). Be aware that on IPF the field `cet_handle` has to be used instead of `cet_hps`. That suggests there were only four processors.

```
q4> runningprocs
04      4       0x4
```

That's consistent. Since there are more crash events than processors, one of the processors must have gotten into even more trouble. Look at the second crash event.

```
q4> trace event 1
Event selected is 1. It was a panic
#0  0x6a654 in panic+0x6c ()
#1  0x6aab4 in assfail+0x3c ()
#2  0x6ac6c in _assfail+0x2c ()
#3  0x3697ac in psema+0x12c ()
#4  0x369a38 in pxsema+0xa8 ()
#5  0x4c4fd4 in ufs_sync+0x5c ()
#6  0x2136c4 in update+0x74 ()
```

```
#7  0x6c074 in panic_boot+0x15c ()
#8  0x6b220 in boot+0x320 ()
#9  0x6a73c in panic+0x154 ()
#10 0xcb374 in report_trap_or_int_and_panic+0x94 ()
#11 0xccaf0 in trap+0x11f0 ()
#12 0x9d6e0 in kgdb_pre_trap+0xa8 ()
#13 0xe49ec in $call_trap+0x2c ()
#14 0x3d3738 in rtprio+0x30 ()
    at /ux/core/kern/common/pm/sched/pm_rtsched.c:1048
#15 0x439f28 in syscall+0x790 ()
#16 0x33a1c in $syscallrtn+0x0 ()
```

The bottom of this trace looks like the first trace. It probably means the panicking processor suffered a recursive panic. Thinking back on the list of crash events received earlier, this makes sense. The first two crash event's were associated with the same processor and were both of type `CT_PANIC` (1). The others were associated with the other processors and were of type `CT_TOC` (2).

Systems with Threads

To check the running threads to see what they're doing on an 11.0 dump:

```
q4> load struct utsname from &utsname
loaded 1 utsname as an array (stopped by max count)
q4> print -t
             indexof  0
             mapped   1
             spaceof  0
             addrof  6983512
     physaddrof  6983512
             realMode  0
             sysname  "HP-UX"
             nodename  "hpfcs322"
             release  "B.11.00"
             version  "A"
             machine  "9000/800"
     __idnumber  "138901557"
q4>
```

In 11.0 an array of `kthread` structures pointed at by `kthread` contains the memory resident portion of the thread status: so to look at threads we look at the `kthread` data. Let's load it from the dump.

```
q4> load kthread_t from kthread max nkthread
loaded 499 struct kthreads as an array (stopped by max count)
```

After 11.10 this load command is performed this way:

```
q4> load kthread_t from kthread_list max nkthread next kt_factp
loaded 54 struct kthreads as a linked list (stopped by null pointer)
```

But out of all of those, only the running threads are wanted, so in both cases discard the others.

```
q4> keep kt_cntxt_flags & TSRUNPROC
kept 1 of 54 struct kthread's, discarded 53
```

Now down to 1 thread! Dump the kernel stack for this thread only:

```
q4> trace pile
process was running on processor 0
processor 0 was running process at 0x4193e040 (pid 319) , thread at 0x42246040 (tid 338)
Event selected is 1. It was a TOC
#0  0xa8d10 in check_panic_loop+0x38 ()
#1  0xa9ec0 in trap+0xcc8 ()
#2  0x7bcd8 in kgdb_pre_trap+0xa8 ()
#3  0xc1a00 in $RDB_trap_patch+0x2c ()
#4  0xc20a0 in splx+0x70 ()
#5  0xc237c in spluser+0x14 ()
#6  0x35b7c4 in syscall+0x86c ()
#7  0x33d64 in $syscallrtn+0x0 ()
```

Which process was associated with this thread and on what processor was it running? Look at the `kt_procp` and the `kt_spu` fields for this structure.

```
q4> print -tx kt_stat kt_cntxt_flags kt_flag kt_spu
              addrof kt_procp

       kt_stat  TSRUN
kt_cntxt_flags  TSSIGABL|TSRUNPROC
       kt_flag  TSFIRSTTHREAD
        kt_spu  0
        addrof  0x42246040
      kt_procp  0x4193e040
```

Hangs

The following procedure describes how to analyze a crash dump caused by a system hang. A summary of steps follows:

- "Check Status of System"
- "Analyze Run Queues"
- "Analyze Threads"
- "Check Key System Daemons"
- "Determine if Memory is Low"
- "What to Do if System Does Not Look Hung"

Each of these procedures is explained in detail following. Throughout the sections, the sample output was not always generated from the same core dump.

Check Status of System

1. How many processors are on this system?

```
q4> runningprocs
    4
```

2. Check the state of the processors. Are they busily running threads or are they idle?

```
q4> load mpinfo_t from mpproc_info max nmpinfo
   loaded 4 mpinfo_t's as an array (stopped by max
      count)
```

NOTE The previous command has to be replaced with the following two commands on kernel versions later than 11.11.

```
q4> load mpinfou_t from &spu_info max nmpinfo
q4> pileon mpinfo_t from pikptr


q4> call it mpinfo
   so named

q4> print indexof addrof threadp curstate
   indexof    addrof      threadp      curstate
      0      0x129b000   0x2ed80b0    SPUSTATE_SYSTEM
      0x1    0x129e2c8   0x2e98498    SPUSTATE_SYSTEM
      0x2    0x12a1590   0xffffffff   SPUSTATE_IDLE
      0x3    0x12a4858   0x2eca1f0    SPUSTATE_SYSTEM
```

As shown in the preceding example, there are four processors on this system. All of them are busy except for processor two, which is idle. `threadp` indicates the `kthread` address for the currently executing thread on a running processor.

3. Determine the load average for each of the processors.

```
q4> exam &mp_avenrun for nmpinfo using 3F
22.172    25.523    28.152
34.753    35.934    32.481
0.5532    0.5726     0.569
36.513    37.616    32.497
```

   The preceding example shows the load average of executable processes on each processor in the last 1, 5, and 15 minutes. It is ordered by processor number. This looks like a fairly busy system, with the exception of processor two which is idle. Idle processors typically show load averages of less than 1.

4. Determine if any spinlocks are held.

```
q4> print indexof addrof held_spinlock spinlock_depth
 indexof  addrof       held_spinlock spinlock_depth
    0     0x129b000     0             0
    0x1   0x129e2c8     0x129a4c0     0x1
    0x2   0x12a1590     0             0
    0x3   0x12a4858     0             0
```

   Processor 1 is holding a `spinlock` at address 0x129a4c0. Since its `spinlock_depth` is 1, it is the only `spinlock` it is holding.

   Note that `held_spinlock` is only good on debug kernels.

5. Get information about this `spinlock`.

```
q4> load lock_t from 0x129a4c0
    loaded 1 lock_t as an array (stopped by max count)

q4> print -x sl_owner sl_lock_caller sl_unlock_caller
    sl_owner     sl_lock_caller     sl_unlock_caller
   0x129e2c8           0x43bd1c             0x43c8e8
```

   In the previous examples `sl_owner` is the `mpinfo_t` struct address of the processor owning the spinlock. Note that it's the address for processor one's `mpinfo_t` (0x129e2c8).

   The `sl_lock_caller` and `sl_unlock_caller` are the last locker and unlocker's return pointer. (On a non-debug kernel, it will only have `sl_owner`.)

6. Identify the lock caller and unlock caller.

```
q4> exam sl_lock_caller using a
    migrate_swap+0x2c
q4> exam sl_unlock_caller using a
    steal_swap+0x3b8
```

7. Determine if the spu(s) are enabled.

```
q4> recall mpinfo
    copied 4 items

q4> print indexof spu_state

    indexof    spu_state
          0          0x1
        0x1          0x1
```

```
          0x2          0x1
          0x3          0x1
```

The `spu_state`(s) are defined as follows: 1 is `SPU_ENABLED`, 2 is `SPU_DISABLED` (Most of the time users don't disable their processors, but check just in case.)

8. Get more details on activity, such as ticks since last idle, and ticks since resumed non-real-time thread.

```
q4> print indexof last_idletime last_tsharetime
      indexof last_idletime    last_tsharetime
            0     0x158a64           0x15ac3e
          0x1     0x15a590           0x15ac3e
          0x2     0x153eaf           0x15ac3e
          0x3     0x15a8a4           0x15ac3e
```

Compare the preceding numbers with `lbolt` (also known as `ticks_since_boot`), the time in ticks when the system was brought down:

```
q4> lbolt
   05326102 1420354 0x15ac42
```

As previously shown, processor 0 was last idle at time 0x158a64, which is calculated as follows:

```
0x15ac42 - 0x158a64 = 8670 ticks ago
8670 ticks / 100 ticks/sec = 86.7 secs ago
```

So processor 0 was last idle 86.7 seconds ago.

A low `last_idletime` (relative to `lbolt`) would indicate a very busy system, since it means it hasn't been idle for a long time. A low `last_tsharetime` (relative to `lbolt`) means that real-time threads have been using that processor for a long time, possibly starving timeshare threads.

Analyze Run Queues

This section discusses the steps to examine run queues. In examining the run queues, look for anomalies that might cause a thread to never be found and scheduled to run. For example:

- Fair and even distribution of threads across processors. Stapled threads and gang scheduled threads can distort this distribution (more on this later).
- Any corruption in run queue links.
- Reasonable `bestq` values. the `besqvalue` should be set to where next to be looking for threads.

1. Check the run queues to see how full they are.

```
q4> recall mpinfo
    copied 4 items

q4> print mp_rq.nready_free mp_rq.nready_locked


   mp_rq.nready_free mp_rq.nready_locked
          12                 0
           9                 0
          13                 1
          25                 1
```

NOTE length of run queue = mp_rq.nready_free + mp_rq.nready_locked

The mp_rq.nready_free is the count of threads in the run queue (for that processor) that *can* be moved. In contrast, mp_rq.nready_locked is the count of threads that are "stapled" to that processor and *can not* be moved to another one.

Also have mp_rq.nready_free_alpha and mp_rq.nready_locked_alpha, which are similar except that these threads require an alpha semaphore before they can run. They are not under first consideration when selecting threads to run. Since alpha semaphores are being phased out, these should be less frequently used.

2. Examine the per-processor run queues.

   Threads with scheduling policies including SCHED_HPUX(2), which is timeshare threads, and SCHED_RTPRIO (6), which is real-time threads, appear in the pre-processor run queues. It's best to redirect this due to the amount of output:

   ```
   q4> print -t | grep mp_rq > mprq.out
   ```

   The mp_rq.bestq is the next runq to be examined:

   ```
   mp_rq.bestq 141
   ```

   Each run queue corresponds to a priority. The lower the priority, the lower the run queue index, and the sooner a chance to run. Zero through 127 correspond to real-time run queues. For non-real-time priorities, there is a range of four priorities mapped to each run queue.

   If the run queue is empty, it points back to itself:

   ```
   mp_rq.qs[8].th_link 19511872
   mp_rq.qs[8].th_rlink 19511872
   ```

   Otherwise, it points to a kthread entry, as in this run queue for mp_rq.bestq:

   ```
   mp_rq.qs[141].th_link 49515336
   mp_rq.qs[141].th_rlink 49782960
   ```

   The threads are doubly linked through kt_link and kt_rlink. So 49515336's kt_link will point to the next thread in run queue 141. The last thread in this run queue is 49782960 (th_rlink).

3. Check out the POSIX real-time run queues, used for SCHED_FIFO (0), SCHED_RR (1), and SCHED_RR2 (5). These are global run queues, used by all processors for POSIX real-time scheduling policy threads:

   ```
   q4> load rtsched_info_t from &rtsched_info

       loaded 1 rtsched_info_t as an array (stopped by max
       count)


   q4> print rts_nready rts_bestq rts_qp rts_numpri

       rts_nready    rts_bestq         rts_qp     rts_numpri

           1           0           1073811456             32
   ```

   As previously shown, rts_nready is 1, so there is only one thread ready to run. There are 32 priority levels, which correspond to 32 run queues. The next queue to be searched (which happens to be the only non-empty one here) is queue 0.

```
q4> load struct mp_threadhd from rts_qp max rts_numpri
    loaded 32 struct mp_threadhd's as an array
       (stopped by max count)

q4> print -t

     indexof         0
     mapped          1
     spaceof         0
     addrof          1073811456
     physaddrof      83955712
     realmode        0
     th_link         42081416
     th_rlink        42081416
     /* output truncated ...*/
```

Interested in the first entry only, since it's the only non-empty run queue. `th_link` and `th_rlink` are the forward and backward pointers to `kthread` entries, just like in the `mpinfo_t` run queues. The one and only thread in the `rtsched` run queues is 42081416. Look at that thread's `kt_link`, it will be 1073811456 (the `mp_threadhd`).

Analyze Threads

This section deals with analyzing the threads themselves, both on and off the run queue.

1. Load up the thread entries.

```
q4> load kthread_t from kthread max nkthread
   loaded 32767 kthread_t's as an array
   (stopped by max count)
```

NOTE The previous command has to be replaced with the following command on kernel versions HP-UX 11.11 and later.

```
q4> load kthread_t from kthread_list max nkthread next kt_factp

q4> keep kt_stat
   kept 1991 of 32767 kthread_t's, discarded 30776

q4> call it kinuse
   so named
```

2. Next, separate the threads into piles depending on state. (Note that pile names can be anything, as long as they are unique

```
q4> recall kinuse
      copied 1991 items
q4> keep kt_stat == TSRUN
      kept 75 of 1991 kthread_t's, discarded 1916
q4> call it krun
      so named
```

The preceding example shows the number of threads that are either currently running or are waiting in the run queue to be scheduled to run. The executing threads are distinguished by the `TSRUNPROC` flag in `kt_cntxt_flags`.

Zero or very few `TSRUN` threads would tend to indicate a hung system, unless the system is idle. Recall that an idle system would be evidenced by `SPUSTATE_IDLE` in most or all processors' `mpinfo_t.curstate`.

```
q4> recall kinuse
   copied 1991 items
q4> keep kt_stat == TSSLEEP
   kept 1825 of 1991 kthread_t's, discarded 166
q4> call it ksleep
   so named
```

The previous example shows the number of threads that are sleeping, waiting for an event. They will not be on the run queue until they get a `wakeup`. Excessive numbers of sleeping threads (significantly more than half) may point to a hung system, unless it is idle.

```
q4> recall kinuse
   copied 1991 items
q4> keep kt_stat == TSZOMB
   kept 87 of 1991 kthread_t's, discarded 1904
q4> call it kzomb
   so named
```

The previous example shows the count of threads in `exit()`, waiting to be reaped by their parents. The parent must call `wait()` or `waitpid()` to clean up these zombies. If this is not happening, examine the stack trace of the parent processes to see what they are doing. An example will be given later.

```
q4> recall kinuse
   copied 1991 items
q4> keep kt_stat == TSSTOP
   kept 2 of 1991 kthread_t's, discarded 1989
q4> call it kstop
   so named
```

The previous example shows the number of threads in a stopped state, as a result of job control stop, terminal control, or being traced. Stopped threads are not covered in detail in this discussion since they are usually only responsible for process hangs, not system hangs. A system hang is possible if a stopped thread holds a critical system resource, but this is rarely the case.

3. Determine how many threads have run in the last second.

```
q4> recall kinuse
   copied 1991 items
q4> keep kt_lastrun_time > lbolt-hz
   kept 127 of 1991 kthread_t's, discarded 1864
```

If this many threads have run in the last second, this system can't be completely hung. Investigate other issues.

4. Determine if the currently running threads have been sitting on the processors for a long time.

```
q4> recall krun
   /* Retrieve the pile of running and runnable
       threads */
   copied 75 items
q4> keep kt_cntxt_flags & TSRUNPROC
```

```
   /* Extract the running threads only */
   kept 8 of 75 kthread_t(s), discarded 71
q4> print kt_spu kt_lastrun_time
   /* kt_spu is the processor the thread is
   executing on */
   /* kt_lastrun_time is the time that thread was
   dispatched
   on the processor */

       kt_spu     kt_lastrun_time
         4           1325274
         3           1162296
         5           1325265
         7           1325191
         0           1325256
         2           1325274
         6           1325196
         1           1325246
q4> lbolt
   05034333 1325275 0x1438db
```

Compare `kt_lastrun_time` of the running threads against `lbolt`. Normally, the running threads should only be 10 or less ticks than `lbolt`. Look for a value that's unusually low, like the one for `kt_spu` 3.

```
q4> keep kt_spu == 3
     kept 1 0f 8 k_thread_t(s), discarded 7
```

To get an exact idea of how long this thread has been monopolizing processor three, use the previously used method from comparing `lbolt` to `kt_lastrun_time`.

```
q4> lbolt - kt_lastrun_time
    0476243 162979  0x27ca3

q4> 162979/100/60

    033   27   0x1b
```

Twenty-seven minutes is definitely too long to be running on a processor without getting switched out.

Trace processor three to find out what it's spending all its time in:

```
q4> trace processor 3

    processor 3 was running process at 0x0'2ea78cc0
    (pid 2438),
    thread at 0x0'309c0 7f8 (tid 2884)
    stack trace for event 5
    crash event was a TOC
    vmtrace_mlog+0xec
    vmtrace_kfree+0x44c
    kfree_common+0x2ac
    freeb+0x114
    freemsg+0x18
    ar_rput+0x4ac
    csq_turnover_with_lock+0xa4
    putnext+0x2ac
    /* output truncated */
```

Investigate `vmtrace_mlog()` after seeing this.

5. Determine if there are an unusually high number of `TSSLEEP` threads. If so, check to see if there are clusters of threads waiting on a common `kt_wchan`.

```
q4> recall ksleep
   /* Retrieve the pile of sleeping threads */
   copied 1825 items
```

The `kt_wchan` is a "wait channel", a data or code address that a thread is waiting on. It must receive a `wakeup` at this same address to transition from `TSSLEEP` to `TSRUN`. Look for many threads with a common `kt_wchan` value as a possible cause of a hang.

```
q4> print addrof kt_lastrun_time kt_wchan |
sort -k 3n,3   | uniq -c -f2 | grep -v "^   1" |
sort

    /* output truncated at top */
    36  1532300480 3743634 0
    63  1532671136 1538875 5125154408
    94  1532735288 2642062 5088965224
    162 1532375000 1743925 5405857896
    221 1532301128 3743835 4611690416473833472
    232 1532816288 1730533 4967505000
    258 1532338064 1662340 5089268584
```

The first column is the number of threads with this `kt_wchan` as a common value.

The second column is the address of the first thread in the sorted file `ktwchan` which has this `kt_wchan` value.

The third column is the `kt_lastrun_time` of this thread.

The fourth column is the common `kt_wchan` value.

Trace the threads which are in big piles. Threads with the same `kt_wchan` may or may not have the same stack trace, but they will be executing in the same subsystem. Look at the stack trace to find the identity of the first parm to `sleep()`, which becomes `kt_wchan`. Examine the code further and figure out who is responsible for the corresponding `wakeup()` of this `sleep()`. Determine why that thread is not doing the `wakeup()`.

Taking the first thread in the pile of 258 threads waiting on `kt_wchan` 5089268584:

```
q4> trace thread at 1532338064

Stack trace for process "syncer" at 0x235d1c80 (pid 912)
Thread at 0x5b559f90 (tid 969)
process was not running on any processor
#0  0x18db1c in _sleep_one+0x21c ()
#1  0x1533ec in vx_sleep_lock+0xcc ()
#2  0x12f774 in vx_lockmap+0x14 ()
#3  0xbadcc in vx_getsmap+0x44 ()
#4  0xd5954 in vx_esum_unexpand+0x74 ()
#5  0xf10e0 in vx_sumpushfs+0xc8 ()
#6  0x10090c in vx_fsetupdate+0x5c ()
#7  0x2216b8 in vx_sync1+0x78 ()
#8  0x261118 in vx_sync0+0x18 ()
#9  0x1361f0 in vx_walk_aglist+0xa8 ()
#10 0x96f00 in vx_sync+0x50 ()
```

```
#11 0x283dc8 in update+0x48 ()
#12 0x283cd0 in tsync+0x40 ()
#13 0x1687e8 in syscall+0x480 ()
#14 0x34c94 in syscallinit+0x54c ()
```

In this case look at `vx_sleep_lock()` for clues to the sleep channel, since it is passed through to `sleep_one()`.

6. Look for trends in scheduling threads.

   Sort all threads by `kt_lastrun_time`, listing state, `schedpolicy`, and `spu` as shown in the following example. This gives a chronological history of when threads last ran.

```
q4> recall kinuse
   copied 116 items
q4> print addrof kt_lastrun_time kt_stat kt_schedpolicy
          kt_spu | sort -k 2n,2

  addrof  kt_lastrun_time  kt_stat  kt_schedpolicy   kt_spu

  17011136       2163533     TSRUN         2           0
  17016960       2163536     TSRUN         2           1
  17022336       2163536     TSRUN         2           0
  16993216       2163540   TSSLEEP         0           3
  17017856       2163541     TSRUN         2           3
  17018304       2163541     TSRUN         2           2
  17018752       2163541     TSRUN         2           2
  17022784       2163541     TSRUN         2           3
```

   Note that `lbolt = 2163541` in this dump.

   This is what is expected as a “normal” scheduling trend. Many threads have run with `kt_lastrun_time` close to `lbolt`. They are using all available processors (0 through 3 in this case). They are not exclusively real-time threads (Recall that 2 is `SCHED_HPUX`).

   If all the recently run threads have `kt_schedpolicy` = 6, real-time threads are hogging the system. This is corroborated by a low `mpinfo_t.last_tsharetime`, relative to `lbolt`.

   Sort threads by `kt_spu`, then by `kt_lastrun_time`.

```
q4> print addrof kt_lastrun_time kt_spu | sort -k
    3n,3 -k 2n,2
```

   (The output in the previous example has been skipped due to the large number of lines required to detect trends.) These are some issues to watch for:

   - Are all the spu(s) getting scheduled equally? Make sure there are no spu(s) out of commission.
   - Look at the sorted `kt_lastrun_times`, and see if there are gaps in time.
   - Look for a trend of high and evenly distributed activity until a certain transition point, after which only a few selected threads run, or only certain processors get scheduled. If so, look at stack traces of threads which ran near the time of that transition point to find any suspicious activity. Possibilities could be real-time threads hogging the processor, a thread that won’t switch off the processor, or a critical resource being held by a thread (running or sleeping).
   - If there are large numbers of `TSRUN` threads but scheduling looks unevenly balanced, look for “stapled” threads as an explanation. These are threads which request to run on a certain `spu` through processor affinity.

7. Determine the binding policy of the thread.

```
q4> recall krun
   copied 954 items

q4> keep kt_spu_mandatory != 4
   /* Discard all threads which are free to run on any spu */
    kept 23 of 954 kthread_t's, discarded 931

q4> print addrof kt_lastrun_time kt_spu kt_spu_mandatory
          kt_cntxt_flags

addrof kt_lastrun_time kt_spu kt_spu_mandatory kt_cntxt_flags
815387520     1318096      1           1        TSSIGABL
815388816     1162113      9           1        TSSIGABL
815390112     1174835     11           1        TSSIGABL
815390760     1318470     12           1        TSSIGABL
815495736     1163162      4           0               0
815496384     1161873      9           0               0
815509992     1161757     10           0               0
815516472     1162711      6           0               0
815524248     1163602      9           0               0
815526192     1161612     10           0               0
815532024     1162296     10           0       TSRUNPROC
```

The `kt_spu_mandatory` is the binding policy for the thread. Some possible values are `MPC_ADVISORY` (0), `MPC_MANDATORY (1)`, and `MPC_NONE (4)`. The first two indicate that the thread should, and the thread must, respectively, run on processor `kt_spu`.

8. If certain threads don't seem to be getting dispatched even though they are at the top of the run queue, look for gang scheduling.

   Gang scheduling allows multiple threads from a single process or set of processes to be scheduled together as a gang. Threads are "stapled" to processors for scheduling, and they will not execute until all members in the gang are ready (i.e., they are executable, and the processors are available).

   A difficulty may arise in scheduling if the number of members in the gang is equal to the number of processors on the system.

   To determine if the threads on the system are using gang scheduling:

```
q4> recall kinuse
   copied 1991 items
q4> keep kt_gang != 0
   kept 19 of 1991 kthread_t's, discarded 1972
```

   Common `kt_gang` values denote threads in the same gang.

9. Are there an excessive number of zombie threads?

   Zombie threads are not by themselves cause for a hang. They may be an indication of hangs on their parents' part, who are responsible for cleaning them up. But zombies definitely take up `proc` table slots, so check to see that their number is not a significant percentage of `nproc`.

```
q4> nproc
   047064 20020 0x4e34
q4> recall kzomb
   copied 87 items
```

   In the preceding case, zombies are clearly not a significant percentage of `nproc`.

Look to see how long these zombies have been in limbo, and who their parents are. The latter can be a rather cumbersome process.

```
q4> print addrof kt_lastrun_time kt_procp | sort -k 3n,3

      /* output shortened */

      addrof      kt_lastrun_time       kt_procp

      1542870008          1608371     1523048128
      1542931568          1608368     1523048128
      1543737032          1608350     1523048128
      1541375720          1651309     1523216768
      1535316272          1621428     1523402816
      1537698320          1621378     1523402816
      1543604840          1621431     1523402816
```

Notice that `lbolt` = 3743917 in this dump.

With this select group of zombies, `kt_lastrun_time's` are relatively old. Determine what their parents are doing. `kt_procp` is a thread's `proc` pointer. To make it easier, pick threads with a common `kt_procp` such as "1523402816" and load that parent's `proc` entry.

```
q4> load proc_t from 1523402816
   /* load up thread's proc entry */
   loaded 1 proc_t as an array (stopped by max count)

q4> load proc_t from p_pptr
   /* load up parent's proc entry */
   loaded 1 proc_t as an array (stopped by max count)

q4> trace pile
        ...
```

The parent's stack trace should give an indication of why it is failing to reap the zombies. If repeated, this search for a parent with another thread's `kt_procp`, will frequently find that the parent is the same.

If the parent turns out to be `init` (`pid = 1`), the original parent has terminated and given the zombies to `init`. The `init` does not clean up these adopted zombies. They will stay around and take up `proc` and `kthread` table slots, unless terminated with a `kill()`. The premature termination of the parent process should be investigated.

An easier but (less complete) method to find zombies is to use zombie processes instead:

```
q4> load proc_t from proc max nproc
   loaded 20020 proc_t's as an array (stopped by max
   count)
```

NOTE The previous command has to be replaced with the following command on kernel versions HP-UX 11.11 and later.

```
q4> load struct proc from proc list max nproc next p_factp
```

```
q4> keep p_stat == SZOMB
   kept 29 of 20020 proc_t's, discarded 19991

q4> print p_pptr | sort

     1510756992
     1510756992
     1510756992
     1510859264
     1510975680
     1510975680

     ...
```

Using the parent `proc` pointer (`pptr`) allows us to identify common parents among processes. Investigate these parents to see why they are not reaping their zombie children. Keep in mind that this is a less complete method than scanning for zombie threads. This is because all threads in a process must be zombie threads before the process becomes a zombie process.

10. Determine if any of the threads need semaphores or are holding them.

    With alpha semaphores being phased out, these fields are less likely to be in use. Both alpha and beta semaphores use these fields, but not at the same time for a given thread. The definitions are:

    - `kt_sleep_sema` — alpha or beta semaphore thread is blocked on.
    - `kt_needs_sema` — on a `runq` waiting for this alpha semaphore.
    - `kt_sema` — I've got this alpha or beta semaphore.

```
q4> recall kinuse
   copied 1991 items

q4> print addrof kt_sleep_sema kt_needs_sema kt_sema

        addrof    kt_sleep_sema   kt_needs_sema    kt_sema

   1532332880        142923832               0          0
   1532333528        142923832               0          0
   1532334176        140034936               0          0
   1532334824        140034936               0          0
   1532335472                0               0          0
   532336120                 0               0          0
   1532336768                0               0          0
   1532337416                0               0          0
   1532338064                0               0          0
      ...
```

To identify the semaphore:

```
q4> exam 142923832 using a
   streams_mp_sync
```

A large number of sleeping threads on `streams_mp_sync` is a normal scenario. `streams_blk_sync` usually has two sleepers, and runout has one. Any others should be treated as an exception.

Check Key System Daemons

```
q4> load kthread_t from kthread_list max nkthread next
    kt_factp loaded 54 struct kthreads as a linked list
    (stopped by null pointer)

q4> keep kt_kt_stat
    kept 54 of 54 struct kthread's, discarded 0

q4> keep kt_tid < 10
    /* tid assignments to daemons can change, assume
    less than 10*/
       kept 7 of 54 struct kthread's, discarded 47

q4> trace pile
Stack trace for process "swapper" at 0xb08b00 (pid 0)
Thread at 0xb087c0 (tid 0)
#0  0x2caaa0 in _swtch+0x1b8 ()
#1  0x2d22b8 in 1f_6a7b_cl_real_sleep+0x868 ()
#2  0x2c63d4 in _sleep+0x14c ()
#3  0x436ae4 in sched+0xcc ()
#4  0x1e4224 in im_launch_sched+0x54 ()
#5  0x417908 in DoCalllist+0xc0 ()
#6  0x1e2c10 in main+0x28 ()
#7  0xbe22c in $vstart+0x48 ()
#8  0x3a760 in $locore+0x94 ()

Stack trace for process "init" at 0x417f7040 (pid 1)
Thread at 0x417f8040 (tid 1)
#0  0x2caaa0 in _swtch+0x1b8 ()
#1  0x2d1d8c in 1f_6a7b_cl_real_sleep+0x33c ()
#2  0x2c63d4 in _sleep+0x14c ()
#3  0x31e120 in sigsuspend+0x1a0 ()
#4  0x35b554 in syscall+0x5fc ()
#5  0x33d64 in syscallinit+0x554 ()

Stack trace for process "statdaemon" at 0x417e8040 (pid 3)
Thread at 0x417ea040 (tid 3)
#0  0x2caaa0 in _swtch+0x1b8 ()
#1  0x2d22b8 in 1f_6a7b_cl_real_sleep+0x868 ()
#2  0x2c63d4 in _sleep+0x14c ()
#3  0x2b1834 in statdaemon+0xa4 ()
#4  0x1e31cc in im_statdaemon+0xfc ()
#5  0x417908 in DoCalllist+0xc0 ()
#6  0x1e2c10 in main+0x28 ()
#7  0xbe22c in $vstart+0x48 ()
#8  0x3a760 in $locore+0x94 ()

Stack trace for process "vhand" at 0x417e6040 (pid 2)
Thread at 0x417e7040 (tid 2)
#0  0x2caaa0 in _swtch+0x1b8 ()
#1  0x2d22b8 in 1f_6a7b_cl_real_sleep+0x868 ()
#2  0x2c63d4 in _sleep+0x14c ()
#3  0x417bcc in vhand+0x23c ()
#4  0x1e30c0 in im_vhand+0xf8 ()
#5  0x417908 in DoCalllist+0xc0 ()
#6  0x1e2c10 in main+0x28 ()
```

```
#7  0xbe22c in $vstart+0x48 ()
#8  0x3a760 in $locore+0x94 ()
```

Stack traces for `swapper (tid 0)`, `init (tid 1)`, `vhand (tid 2)`, and `statdaemon (tid 3)` have been selected from the preceding example. The `swapper` and `vhand` are responsible for paging. `statdaemon` is responsible for balancing the run queues. `init` usually doesn't do much once the system comes up.

```
q4> print kt_tid kt_lastrun_time

    kt_tid    kt_lastrun_time

       0          3743634
       1          3743835
       2          3742935
       3          3743834
       4          3743834
       8            11130
       9            11132
```

Note that `lbolt` is 3743917.

The key system daemons (`tid` 0–3) all seem to have run fairly recently. Their stack traces are also typical of when they are doing their job properly.

Determine if Memory is Low

Memory problems can be detected by:

- `vhand` not running recently (described in the previous section)
- Zero or very low `freemem`
- Deactivated threads

The kernel global variable `freemem` is the amount of free memory in pages. Zero or a very low value may point to lack of memory resources as a cause for a hang. `freemem` should be at least the value of `minfree`, the threshold at which deactivation starts, and `desfree`, the threshold where the paging daemon starts stealing pages.

```
q4> freemem
   03376 1790 0x6fe

q4> minfree
   032000 13312 0x3400

q4> desfree
    014400 6400 0x1900
```

If `freemem` dips below `minfree`, deactivation of processes is initiated. `deactive_cnt` is the number of deactivated processes.

```
q4> deactive_cnt
   0177 127 0x7f
```

All the threads of a deactivated process are in turn deactivated, and have their `kthread_t->kt_flag`'s TSDEACT bit set. Deactivated threads can be TSRUN `(kthread_t->kt_stat)`, but are not on the run queue until they are re-activated.

Seeing the above data, this system would appear to have memory problems.

What to Do if System Does Not Look Hung

The system probably is not hung if all of the following are true:

- The processors are all busy
- No threads have been hogging the processors
- The run queues are full
- The load averages are high
- No critical resources are being held
- Key system daemons have run recently
- Memory resources are sufficient

Once its established that the system was most likely not hung, explore other possible issues. Did the system respond to the `ping` command? If not, there was a fundamental networking problem. On the other hand, perhaps the console was not responding, or certain key processes were not making progress, giving the perception of a hung system. Investigate further.

Stack Tracing Tricks

Examples of how to trace every crash event, how to trace every processor, and how to trace all processes on a crash dump.

Trace Every Crash Event

Load the part of the crash event table that contains valid entries and trace them.

```
q4> load crash_event_t from &crash_event_table until crash_event_ptr  max 100
loaded 4 struct crash_event_table_structs as an array (stopped by "until" clause)
q4> trace pile
Event selected is 0. It was a panic
#0  0x4dd04 in panic+0x14 ()
#1  0x4e18c in assfail+0x3c ()
#2  0x4e344 in _assfail+0x2c ()
#3  0xc2c80 in sl_pre_check+0x120 ()
#4  0xc2a60 in spinlock+0x18 ()
#5  0x2b9420 in lock_try_read+0x40 ()
#6  0x1eb000 in psi_log_event+0xc8 ()
#7  0x4e530 in reboot_system_state+0x68 ()
#8  0x4e674 in boot+0x9c ()
#9  0x75c08 in kgdb_trap+0xcf8 ()
#10 0x7bef4 in kgdb_pre_int+0x1d4 ()
#11 0xc07f0 in skip_int_save_crs2_0+0x38 ()
#12 0x2cb858 in idle+0x5a0 ()

Event selected is 1. It was a TOC

#0  0xa8d10 in check_panic_loop+0x38 ()
#1  0xa9ec0 in trap+0xcc8 ()
#2  0x7bcd8 in kgdb_pre_trap+0xa8 ()
#3  0xc1a00 in $RDB_trap_patch+0x2c ()
#4  0xc20a0 in splx+0x70 ()
#5  0xc237c in spluser+0x14 ()
#6  0x35b7c4 in syscall+0x86c ()
#7  0x33d64 in $syscallrtn+0x0 ()

Event selected is 2. It was a TOC

#0  0x48658 in iodc_wait_n_msec+0x98 ()
#1  0x82894 in kgdb_lan_lasi_ready_check+0x84 ()
#2  0x82cdc in kgdb_lan_lasi_attention+0x44 ()
#3  0x82d78 in kgdb_lan_lasi_read+0x88 ()
#4  0x72cc8 in kgdb_do_poll+0x30 ()
#5  0x7fef10 in clock_int+0x88 ()
#6  0xac934 in mp_ext_interrupt+0x394 ()
#7  0x7be74 in kgdb_pre_int+0x154 ()
#8  0xc07f0 in skip_int_save_crs2_0+0x38 ()
#9  0x2cb72c in idle+0x474 ()

Event selected is 3. It was a TOC

#0  0x48ea8 in iodc_mfctl+0x24 ()
#1  0x48654 in iodc_wait_n_msec+0x94 ()
```

```
#2  0x82894 in kgdb_lan_lasi_ready_check+0x84 ()
#3  0x82cdc in kgdb_lan_lasi_attention+0x44 ()
#4  0x82d78 in kgdb_lan_lasi_read+0x88 ()
#5  0x72cc8 in kgdb_do_poll+0x30 ()
#6  0x7fef10 in clock_int+0x88 ()
#7  0xac934 in mp_ext_interrupt+0x394 ()
#8  0x7be74 in kgdb_pre_int+0x154 ()
#9  0xc07f0 in skip_int_save_crs2_0+0x38 ()
#10 0x2cb72c in idle+0x474 ()
```

Trace Every Processor on a PA System

Load the processor info table and trace every processor.

```
q4> load mpinfo_t from mpproc_info max nmpinfo
loaded 4 struct mpinfos as an array (stopped by max count)
```

NOTE The previous command has to be replaced with the following two commands on kernel versions later than 11.11

```
q4> load mpinfou_t from &spu_info max nmpinfo
q4> pileon mpinfo_t from pikptr
```

```
q4> trace pile

processor 0 was running process at 0x4193e040 (pid 319), thread at 0x42246040 (tid 338)

Event selected is 1. It was a TOC

#0  0xa8d10 in check_panic_loop+0x38 ()
#1  0xa9ec0 in trap+0xcc8 ()
#2  0x7bcd8 in kgdb_pre_trap+0xa8 ()
#3  0xc1a00 in $RDB_trap_patch+0x2c ()
#4  0xc20a0 in splx+0x70 ()
#5  0xc237c in spluser+0x14 ()
#6  0x35b7c4 in syscall+0x86c ()
#7  0x33d64 in $syscallrtn+0x0 ()

processor 1 claims to be idle

Event selected is 0. It was a panic

#0  0x4dd04 in panic+0x14 ()
#1  0x4e18c in assfail+0x3c ()
#2  0x4e344 in _assfail+0x2c ()
#3  0xc2c80 in sl_pre_check+0x120 ()
#4  0xc2a60 in spinlock+0x18 ()
#5  0x2b9420 in lock_try_read+0x40 ()
#6  0x1eb000 in psi_log_event+0xc8 ()
#7  0x4e530 in reboot_system_state+0x68 ()
#8  0x4e674 in boot+0x9c ()
#9  0x75c08 in kgdb_trap+0xcf8 ()
#10 0x7bef4 in kgdb_pre_int+0x1d4 ()
```

```
#11 0xc07f0 in skip_int_save_crs2_0+0x38 ()
#12 0x2cb858 in idle+0x5a0 ()

processor 2 claims to be idle

Event selected is 3. It was a TOC

#0  0x48ea8 in iodc_mfctl+0x24 ()
#1  0x48654 in iodc_wait_n_msec+0x94 ()
#2  0x82894 in kgdb_lan_lasi_ready_check+0x84 ()
#3  0x82cdc in kgdb_lan_lasi_attention+0x44 ()
#4  0x82d78 in kgdb_lan_lasi_read+0x88 ()
#5  0x72cc8 in kgdb_do_poll+0x30 ()
#6  0x7fef10 in clock_int+0x88 ()
#7  0xac934 in mp_ext_interrupt+0x394 ()
#8  0x7be74 in kgdb_pre_int+0x154 ()
#9  0xc07f0 in skip_int_save_crs2_0+0x38 ()
#10 0x2cb72c in idle+0x474 ()

processor 3 claims to be idle

Event selected is 2. It was a TOC

#0  0x48658 in iodc_wait_n_msec+0x98 ()
#1  0x82894 in kgdb_lan_lasi_ready_check+0x84 ()
#2  0x82cdc in kgdb_lan_lasi_attention+0x44 ()
#3  0x82d78 in kgdb_lan_lasi_read+0x88 ()
#4  0x72cc8 in kgdb_do_poll+0x30 ()
#5  0x7fef10 in clock_int+0x88 ()
#6  0xac934 in mp_ext_interrupt+0x394 ()
#7  0x7be74 in kgdb_pre_int+0x154 ()
#8  0xc07f0 in skip_int_save_crs2_0+0x38 ()
#9  0x2cb72c in idle+0x474 ()
q4>
```

Trace Every Processor on IPF System

Load the processor information table and trace every processor.

```
q4> load mpinfou_t from &spu_info max nmpinfo
loaded 1 union mpinfou as an array (stopped by max count)
q4> pileon mpinfo_t from pikptr
loaded 1 struct mpinfo
q4> trace pile
processor 0 claims to be idle
Event selected is 0. It was a panic
#0  0xe0000000002b1ac0:0 in change_stack_end+0x0 ()
#1  0xe0000000003babd0:0 in panic+0x360 ()
#2  0xe0000000003bbfe0:0 in assfail+0x50 ()
#3  0xe000000000756d60:0 in increment_callout_time+0x280 ()
#4  0xe00000000075a1f0:0 in expire_callouts+0x300 ()
#5  0xe0000000007520f0:0 in hardclock+0x130 ()
#6  0xe000000000295da0:0 in clock_int+0x7e0 ()
#7  0xe0000000003db430:0 in external_interrupt+0x300 ()
#8  0xe0000000003e7630:0 in bubbledown+0x0 ()
```

```
#9  0xe0000000006ba820:0 in idle+0x17c0 ()
q4>
```

Trace Every Process

Loading the process table:

Pre 11.10:

```
q4> load struct proc from proc max nproc
loaded 276 struct proc's as an array (stopped by max count)
q4>
```

Post 11.10

```
q4> load struct proc from proc_list max nproc next
p_factp

loaded 35 struct procs as a linked list
(stopped by null pointer)
q4>
```

To load at every process structure on the system including those not on the active list:

```
q4> load struct proc from proc_list max nproc next
p_global_proc

loaded 35 struct procs as a linked list
(stopped by null pointer)
q4>
```

Keep only the active processes.

```
q4> keep p_stat != 0
kept 35 of 35 struct proc's, discarded 0
```

Trace the stacks

```
q4> trace pile

stack trace for process at 0xb08b00 (pid 0), thread at 0xb087c0 (tid 0)
process was not running on any processor

#0  0x2caaa0 in _swtch+0x1b8 ()
#1  0x2d22b8 in 1f_6a7b_cl_real_sleep+0x868 ()
#2  0x2c63d4 in _sleep+0x14c ()
#3  0x436ae4 in sched+0xcc ()
#4  0x1e4224 in im_launch_sched+0x54 ()
#5  0x417908 in DoCalllist+0xc0 ()
#6  0x1e2c10 in main+0x28 ()
#7  0xbe22c in $vstart+0x48 ()
#8  0x3a760 in istackatbase+0x84 ()

stack trace for process at 0x41e93040 (pid 399), thread at 0x421f3040 (tid 418)
process was not running on any processor
```

```
#0  0x2caaa0 in _swtch+0x1b8 ()
#1  0x2d1d8c in 1f_6a7b_cl_real_sleep+0x33c ()
#2  0x2c63d4 in _sleep+0x14c ()
#3  0x174b5c in fifo_rdwr+0x3cc ()
#4  0x17e314 in vno_rw+0x104 ()
#5  0x8441ec in read+0x2e4 ()
#6  0x35b554 in syscall+0x5fc ()
#7  0x33d64 in $syscallrtn+0x0 ()

stack trace for process at 0x4228f040 (pid 398), thread at 0x42291040 (tid 417)
process was not running on any processor

#0  0x2caaa0 in _swtch+0x1b8 ()
#1  0x2d1d8c in 1f_6a7b_cl_real_sleep+0x33c ()
#2  0x2c63d4 in _sleep+0x14c ()
#3  0x1902ec in select+0x111c ()
#4  0x35b554 in syscall+0x5fc ()
#5  0x33d64 in $syscallrtn+0x0 ()

stack trace for process at 0x42234040 (pid 397), thread at 0x42235040 (tid 416)
process was not running on any processor

#0  0x2caaa0 in _swtch+0x1b8 ()
#1  0x2d1d8c in 1f_6a7b_cl_real_sleep+0x33c ()
#2  0x2c63d4 in _sleep+0x14c ()
#3  0x1902ec in select+0x111c ()
#4  0x35b554 in syscall+0x5fc ()
#5  0x33d64 in $syscallrtn+0x0 ()

        ...

stack trace for process at 0x417d5040 (pid 8), thread at 0x417d7040 (tid 8)
process was not running on any processor

#0  0x2caaa0 in _swtch+0x1b8 ()
#1  0x2d22b8 in 1f_6a7b_cl_real_sleep+0x868 ()
#2  0x2c63d4 in _sleep+0x14c ()
#3  0x644f0c in str_sched_up_daemon+0xec ()
#4  0x644a40 in str_sched_daemon+0x1b0 ()
#5  0x1e40ec in im_strsched+0x1c ()
#6  0x417908 in DoCalllist+0xc0 ()
#7  0x1e2c10 in main+0x28 ()
#8  0xbe22c in $vstart+0x48 ()
#9  0x3a760 in istackatbase+0x84 ()
q4>
```

Other Techniques

Examples of other commands show information from crash, such as how to print the console message buffer, how to print the time the system crashed and how to print how long the system had been up before the crash and more.

Print Console Message Buffer

```
q4> examine &msgbuf+8 using s
WARNING: Kernel symbol table verification failed
gate64: sysvec_vaddr = 0xc0002000 for 1 pages
NOTICE: nfs3_link(): File system was registered at index 3.
NOTICE: autofs_link(): File system was registered at index 6.
0 sba
0/0 lba
I/O hardware probe timed out at path 0/0/0/0
0/0/1/0 c720
0/0/1/0.7 tgt
0/0/1/0.7.0 sctl
0/0/1/1 c720
0/0/1/1.2 tgt
0/0/1/1.2.0 sdisk
0/0/1/1.7 tgt
0/0/1/1.7.0 sctl
0/0/2/0 c720
0/0/2/0.2 tgt
0/0/2/0.2.0 sdisk
0/0/2/0.7 tgt
0/0/2/0.7.0 sctl
0/0/2/1 c720
0/0/2/1.2 tgt
0/0/2/1.2.0 sdisk
0/0/2/1.7 tgt
0/0/2/1.7.0 sctl
0/0/4/0 asio0
0/0/5/0 asio0
0/1 lba
  ...
linkstamp:          Wed Jul 19 14:57:30 PDT 2000
_release_version:   @(#)B2352B/9245XB HP-UX (B.11.00) #1: Wed Nov  5 22:38:19 PS
T 1997
__kern_ci_revision: $Header: kern_sequence.c,v 1.6.106.512 97/11/05 18:01:46 mso
sa Exp $
panic: Data memory protection fault
PC-Offset Stack Trace (read across, top of stack is 1st):
  0x002d76e4  0x002eb538  0x002eac44
  0x0010b130  0x0040359c  0x00403764
  0x00403950  0x00346970  0x00108324
  0x0010a504  0x00346b24  0x0010b0ac
  0x001022e0  0x00104f24
End Of Stack
NOT sync'ing disks (on the ICS) (5 buffers to flush): 5 5 5 5 5 5 5 5 5 5 5 5 5
5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5 5
5 5 5 5 5 5 5 5
5 buffers not flushed
```

```
1 buffer still dirty
q4>
```

When Did the System Crash?

```
q4> examine &time using Y
Mon Jul 24 11:28:00 2000
```

How Long Had the System Been Up Before the Crash

```
q4> ticks_since_boot/hz
0175    125    0x7d
```

The system had been up a little over 125 seconds which is a little more than two minutes.

NOTE For 32 bit systems this value can be negative. Refer to `uptime.pl` for up to date information

---

What Was the Load Average?

NOTE These commands are correct for uniprocessor machines but the values need to be divided by the number of processors for multiprocessor machines. Look at the `uptime.pl` script for up to date information.

The system's load average is kept in a three element array in kernel global memory.

```
q4> examine &avenrun using 3F
0.284 0.1068 0.08823
```

This is the same load average that `uptime` prints. The kernel also keeps a load average that does not count stopped or sleeping processes.

```
q4> examine &real_run using 3F
0.2041 0.06558 0.03763
```

In both cases the one minute average is first, the five minute average is second, and the 15 minute average is third. In the previous examples, the trend is toward a higher load average.

What Command Was a Certain Process Running?

Load the process and then examine the `p_cmd` field.

```
q4> load struct proc from 0xb0d240
loaded 1 struct proc as an array (stopped by max count)
q4> examine p_cmnd using s
swapper
```

Pre 11.10 release crash dumps

If the command name is wanted. but not the arguments, there is another parallel table for this.

```
q4> load struct proc from 0xb0d240
loaded 1 struct proc as an array (stopped by max count)
q4> p_pindx
056     46      0x2e
q4> load pst_ucomm_t from pst_ucomms skip p_pindx
loaded 1 pst_ucomm_t as an array (stopped by max count)
q4> print -t s
s  "sendmail"
```

Post 11.10 release crash dumps

After dynamic process and thread allocation implementation, there are two fields that are interesting, `p_comm` and `p_cmnd`. `p_comm` is a 15 character array, and `p_cmnd` is a pointer to a character string, up to 64 characters long. Once loaded, use either `print p_comm` or `print -x p_cmnd`. The pointer value of `p_cmnd` can be examined to see the arguments, `examine 0x12345678 using s`.

```
q4> load struct proc from 0x42234040
loaded 1 struct proc as an array (stopped by max count)
q4> print -xt p_cmnd
p_cmnd  0x41e4db40
q4> examine 0x41e4db40
/usr/lib/netsvc/yp/ypbind -ypset
q4> print p_comm
p_comm
"ypbind"
```

Where Is Per-Processor Information Kept?

Per-processor information is kept in the `mpproc_info` table. It is a dynamic array of `mpinfo_t`'s. Every live processor has exactly one entry in this table. The table is maintained and used even when there is only one processor (the so-called uniprocessor case).

The table may be sparse under rare circumstances. Additionally, the processors may appear in the table in any order, so it's best to use look up a processor by referring to its so-called **Hard Physical Address** (HPA). The field is called `prochpa`.

Use a command like this:

```
q4> load mpinfo_t from mpproc_info max nmpinfo
loaded 4 struct mpinfos as an array (stopped by max count)
```

NOTE The previous command has to be replaced with the following two commands on kernel versions later than 11.11.

```
q4> load mpinfou_t from &spu_info max nmpinfo
q4> pileon mpinfo_t from pikptr
```

To load the entire processor info table.

Where Are the Crash Events Kept?

When a system crashes the first processor to crash makes note of this event in the **Crash Event Table**. If the crash proceeds as it is supposed to, that processor will tell each of the other processors in the machine to do a Transfer of Control (TOC). Each of these TOCs generates another crash event so that, by the time the dump is finished, there should be exactly one crash event per processor. In practice, there are often a few extra crash events recorded in the table. A processor can leave more than one crash event if it suffered a recursive panic.

Use a command like this:

```
q4> load crash_event_t from &crash_event_table until
crash_event_ptr max 100
loaded 4 struct crash_event_table_structs as an array
(stopped by "until" clause)
```

To load the entire crash event table.

NOTE The `cet_savestate` field in the `crash_event_t` type and the `cpt_hpmc_savestate` and `cpt_toc_savestate` fields in the `crash_proc_t` type point to `rpb_t's`, not `save_state_t's` as their names might suggest.

Load the Entire Process Table

For pre 11.10 release crash dumps, the entire process table can be loaded using the following command:

```
q4> load -r struct proc from proc max nproc
loaded 276 struct proc's as an array (stopped by max count)
```

The `-r` flag (real-mode) is used for speed. It doesn't matter so much with a normal-sized process table (like the one in the example), but if the crash dump was produced by a big system the command will run a lot faster if it doesn't have to do address translation.

For post 11.10 release crash dumps, the entire process table can be loaded using the following command:

```
q4> load struct proc from proc_list max nproc next p_factp
loaded 35 struct procs as a linked list (stopped by null
pointer)
```

or use this command to load only the active processes:

```
q4> load struct proc from proc_list max nproc next
p_global_proc
loaded 35 struct procs as a linked list (stopped by null
pointer
```

Load the Entire Stack Unwind Table

The entire stack unwind table can be loaded using the following command:

```
q4> load unwindDesc_t from &$UNWIND_START until
&$UNWIND_END max 100000
loaded 9749 unwindDesc_t's as an array (stopped by "until"
clause)
```

There is a maintenance command on IPF to display the unwind information. Given the address or function name, the command `maint info unwind` *function_name*|*address* prints out the corresponding unwind table entry.

```
q4> maint info unwind panic

panic:

0xe0000000007333a0 .. 0xe0000000007338e0, end_prologue@0xe000000000733400

Info block version:0x1, flags:0x1000, length:4 * 8 == 32

0x000: (12) R1prologue    rlen=18
0x001: (e4) P7rp_when     t=14
0x003: (b0) P3rp_gr       gr=34
0x005: (e6) P7pfs_when    t=0
0x007: (b1) P3pfs_gr      gr=33
0x009: (e8) P7preds_when  t=8
0x00b: (b1) P3preds_gr    gr=36
0x00d: (ea) P7lc_when     t=17
0x00f: (b2) P3lc_gr       gr=35
0x011: (e0) P7mem_stack_f t=2 size=2
0x014: (e2) P7spill_base  pspoff=4
0x016: (61) R3body        rlen=198
0x019: (81) B1label_state label=1
0x01a: (c0) B2epilogue    t=5
0x01c: (61) R3body        rlen=36
0x01e: (a1) B1copy_state  label=1
0x01f: (00) R1prologue    rlen=0
q4>
```

How Was the Kernel Built?

The makefile passes certain flags to the C compiler to control the kernel build. These flags have a significant effect on the way the kernel works. These flags are compiled into the kernel as a debugging aid.

```
q4> examine &_makefile_cflags using s
-D__ROSE__ -D__ROSEVILLE__ -DSYSCALLTRACE -DSTCP   -DSPP_RUNWAY_ERR_ENABLED -DSPP_OBP_BOOT
-DSEMAPHORE_DEBUG   -DSCSI_ALT_IF_DRIVER -DRDB -DPGPROF -DPARISC -DOSDEBUG -DNEW_RDB
-DNEW_MFCTL_W -DMPDEBUG -DLWSYSCALL -DKGDB_ON -DIVT_INTERCEPT
-DIPSEC -DIDDS -DHPONCPLUS -DCOMB_FLIPPER -DAUDIT -DACLS    -D__hp9000s800 -D__TEMP64__
-D__STDC_EXT__ -D__NO_EM_HDRS   -D_XPG4_EXTENDED -D_UNSUPPORTED -D_KERNEL -D_HPUX_SOURCE
-D_CLEAN_BE       -U__hp9000s700    -D_HDRS_FROM_SRC_TREE  -I/ux/core/kern/.include/pa
-I/ux/core/kern/pa/.link   -Iinclude -I/ux/core/kern/common
-Wp,-H300000  +R500 +Omultiprocessor +Hx0 +ESssf +ESsfc  +XixdU +Ofastaccess +Oentrysched
+O2 +ESlit   +ES1.Xindirect_calls
q4>
```

Did Anyone Write to /dev/[k]mem?

The kernel keeps track of writes to `/dev/mem` and `/dev/kmem` because that information may be useful if the system crashes.

The log is a circular buffer of the most recent writes. The total number of writes is kept in a kernel global:

```
q4> kmem_writes
01      1       0x1
```

Each entry in the log contains the:

- `dev_t` of the target device (indicating whether it was `/dev/mem` or `/dev/kmem`)
- kernel address of the write (where the data went)
- length of the write (in bytes)
- first word of the data written (most of these writes are a word or less anyway)
- time of day when the write was performed
- process ID of the process that did the write
- (real) user ID of the process that did the write
- name of the command that did the write

Get the log:

```
q4> load kmem_log_t from &kmem_log max kmem_log_slots
loaded 16 struct _kmem_log_ts as an array (stopped by max
count)
```

Keep only the valid entries:

```
q4> keep kl_len > 0
kept 1 of 16 kmem_log_t's, discarded 15
```

Display the most interesting evidence:

```
q4> print kl_addr %#x kl_len kl_data1 kl_time.tv_sec kl_pid
kl_uid kl_comm
kl_addr kl_len kl_data1 kl_time.tv_sec kl_pid kl_uid
kl_comm
0x3982f8     4        0              0    791      0
  "adb"
```

From this we know that the superuser used adb to poke a zero at location 0x3982f8. Question: Where is that?

```
q4> examine kl_addr using a
onice+0xc0
```

This is the branch stub that was poked to get this sample dump in the first place. Aa `break` instruction was poked into the long branch stub at this address and then made a system call that would step on it.

Remote Dump Analysis

KWDB supports remote dump analysis. Using this feature KWDB can be used to analyze crash dumps located on a remote system. To support this feature a program, `kwdbcr`, has to be run on the remote system where crash dump is located. The `kwdbcr` program handles requests from KWDB client to open and read data from the crash dump. From kwdb 3.1.3 onwards, it is possible to daemonize `kwdbcr` so that it is unnecessary to rerun `kwdbcr` each time to analyze a crash dump from a remote host running kwdb client. Here are the steps involved in analyzing a remote crash dump.

1. Copy the kernel file, usually `vmunix` and DLKM modules if any, from the remote system to the local system where KWDB client is going to be run. KWDB reads all symbols information from these files. Only data from the crash dump is read from the remote system.

NOTE From kwdb 3.1.3 onwards, kwdb, when started on a remote crash dump, automatically copies vmunix and modules from the crash dump and caches them in the host machine under `$HOME/.kwdb/remotefiles`. The contents of this cache are intended for kwdb's own internal usage, and can be removed by kwdb from time to time. The default size of this cache is 120 MB, but can be configurable through kwdb by running the `set kwdb remote_file_cache_size <size_in_MB>` command. It may also be noted that the size of this cache can marginally increase during copying of a remote vmunix/module if total usage of the cache for the current kwdb session is more than 120 MB (or the size specified by running the `set kwdb remote_file_cache_size` command).

2. Invoke `kwdbcr` on the remote system with crash dump directory name as the argument. Specify optional arguments, a port number to use for connection, and a filename, if desired, to log messages. `kwdbcr -help` will display the usage of `kwdbcr` as shown:

```
# kwdbcr -help
kwdbcr : Program to be run on remote system for remote crash dump analysis using kwdb.

Usage : kwdbcr [port] [crash_path] [-l logfile]

port - port number for kwdb to connect.
       By default a free port above 47001 is used.
crash_path - crash dump directory path.
       By default current directory is used.
logfile - filename to log messages.
By default ./kwbcr.log is used.

# kwdbcr -d [-l logfile]
-d option runs kwdbcr as a daemon

#kwdbcr -v
-v option displays the kwdbcr version information
```

After successfully starting, kwdbcr displays a message (including a port number for use by KWDB) for connecting to this server program as shown in the following example:

```
# kwdbcr /var/adm/crash.0
Analysing crash dump at /var/adm/crash.0 through port 47003
Start kwdb on the host using :
kwdb -q4 vmunix  remote system:47003
```

3. Invoke KWDB on the local system using:

```
# kwdb -q4 [-m] vmunix  remote_system:port_number | crash_path in remote system>
```

or

```
# kwdb -q4 [-m] vmunix
(kwdb) target crash remote_system:port_number | crash_path in remote system>
```

where...

vmunix – is the kernel copied from remote system in step 1. From kwdb 3.1.3 onward, specification of vmunix is optional.

remote_system – is the name or IP address of the remote host where `kwdbcr` is running

port_number – is the port number displayed by `kwdbcr` in step 2

From now on, all the commands and features for analyzing local crash dumps are available for analyzing the remote crash dump. `kwdb` uses its own protocol to communicate with the remote crash dump site.

Ending the KWDB session on the local system will terminate the `kwdbcr` program running on the remote system. From kwdb 3.1.3 onward, if the daemon option is used, kwdbcr continues to run in the background (unless explicitly terminated by the user). When executed in daemon mode, kwdbcr creates a logfile at `/var/opt/kwdb/kwdbcr.log`.

6 Live Memory Analysis

KWDB is a tool for source level debugging of HPUX kernels and Q4 is a tool used for analyzing HPUX kernel crash dumps and HPUX systems while they are running. Starting with KWDB version 2.0 all Q4 commands are implemented in KWDB. With the addition of Q4 commands, KWDB can be used to analyze HPUX kernel crash dumps and live systems. This chapter explains how KWDB can be used to analyze live systems. In order to analyze live systems, KWDB uses special device files `/dev/kmem` and `/dev/mem`. Superuser privilege is required to analyze live systems using KWDB.

Why use a live memory analyzer when a remote source level debugger or on-console debugger when studying a system that is not physically connected or booted for debugging. The database aspects of KWDB can make live memory analysis a key activity. Loading and keeping just the right objects out of the many that may exist on a system can be just the thing to do. Develop PERL functions that can be as productive for studying a running system as the `WhatHappened` and `Analyze` function are for working with crash dumps.

Starting KWDB to Perform Live Memory Analysis

Here are the steps to start KWDB to analyze a live system.

1. Sign on as superuser or account with user privilege.
2. Find the running vmunix. If the kmpath command is available on the system, invoke it to find the pathname of the vmunix that is currently running on the system.

   # **kmpath**

   If the file used in loading the running kernel, as shown by the above command, is not /stand/vmunix, the proper file has to be substituted for /stand/vmunix in the following steps. KWDB on PA requires the kernel file to be preprocessed by pxdb. Make sure the kernel file is preprocessed by pxdb before proceeding to the next step.

   ```
   # pxdb /stand/vmunix
   pxdb64: /stand/vmunix is already preprocessed
   PXDB aborted.
   #
   ```

3. Invoke KWDB with the -q4 option, with vmunix and /dev/kmem or /dev/mem

   # **kwdb -q4** /stand/vmunix /dev/kmem

   -q4: automatically puts KWDB into Q4 command mode.

   /stand/vmunix: the running kernel file

   /dev/kmem: indicates performing live memory analysis.

This is equivalent to invoking the Q4 command

```
# q4 /stand/vmunix /dev/kmem
```

The command in step three starts KWDB to debug the kernel file, sets up the devmem target to read from /dev/mem and /dev/kmem and sets the KWDB mode to Q4. On the other hand, what was accomplished by the command in step three can also be done as follows:

```
# kwdb /stand/vmunix
(kwdb) target devmem
(kwdb) set kwdb q4 on
q4>
```

The command set kwdb q4 on is used to set the KWDB in Q4 mode. Setting this mode for the crash and devmem targets provides the user with the standard q4> prompt. There are certain commands, like symbols, run, print and unset, present both in KWDB and Q4. To invoke as Q4 commands, they have to be prefixed with q4 as in q4 symbols, q4 run, q4 print and q4 unset. Once KWDB in Q4 mode these ambiguous commands will be treated as Q4 commands and need not be prefixed with Q4. Turn the Q4 mode off by using the command set kwdb q4 off.

Running Commands to Perform Live Memory Analysis

After starting KWDB to do live memory analysis as explained in the previous section, any of the KWDB or Q4 commands can be executed on the live system. While analyzing crash dumps KWDB reads data from crash dump images. On the other hand while reading data from live system reading will be done from `/dev/kmem` or from `/dev/mem` depending on whether the address is in kernel space or not.

Synchronization between data in kwdb memory and kernel memory is not always correct. While analyzing a live system, KWDB runs as a process on the same system. It is possible that after KWDB reads data from a memory location, it may get changed by another process. Any analysis performed by KWDB using the old data may not correctly represent the system behavior in real-time.

To analyze a system which is very slow or nearly hung, follow the procedure described on how to analyze a crash dump caused by a system hang in *Chapter 5, "Analyzing Crash Dumps."*

The following example shows how KWDB can be used on a live system for looking at different structures and doing data collection. Here KWDB explores various callout structures on a live system. These examples are from a PA-RISC system and outputs will be similar on IPF systems.

Example:

Invoke KWDB on a live system:

```
# kmpath /stand/vmunix
# kwdb -q4 -quiet /stand/vmunix /dev/kmem
q4>
```

Here is how we can get system information:

```
q4> load struct utsname from &utsname
loaded 1 utsname as an array (stopped by max count)
q4> print -tx
               indexof  0
                mapped  0x1
               spaceof  0
                addrof  0x704758
            physaddrof  0x704758
              realmode  0

               sysname  "HP-UX"
              nodename  "hpadl628"
               release  "B.11.00"
               version  "U"
               machine  "9000/800"
             __idnumber  "849377401"
```

Get a listing of all the structures and `typedefs` that contain the string of characters "callout".

```
q4> cat callout
BYTES FIELDS  SHAPE   NAME
   72     11  struct callout
    4     12    enum callout_flags
    4     12 typedef callout_flags_t
   72     11 typedef callout_t
```

The `callout` structure has 11 fields and is 72 bytes in size. Get a listing of all the fields defined in a `callout` structure.

```
q4> fields -cx struct callout
struct callout {
    u_char c_cookie;
    u_char c_pad;
    enum callout_flags {
        DRIVER_CALLOUT = 1,
        MP_CALLOUT = 2,
        PENDING_CALLOUT = 4,
        FREE_CALLOUT = 8,
        ABSTIME_CALLOUT = 16,
        DYNAMIC_CALLOUT = 32,
        HEADER_CALLOUT = 64,
        HEADER_HASH_CALLOUT = 128,
        HEADER_TIME_CALLOUT = 256,
        HEADER_EXPIRED_CALLOUT = 512,
        EXPIRED_CALLOUT = 1024,
        REALTIME_CALLOUT = 2048
    } c_flag;
    u_int c_abs_time_hi;
    u_int c_abs_time_lo;
    struct callout *c_time_next;
    struct callout *c_time_prev;
    struct callout *c_hash_next;
    struct callout *c_hash_prev;
    union {
        struct {
            int (*cc_func)( );
            char *cc_arg;
        } real_callout;
        struct {
            struct callout *tc_thdr_next;
        } time_header;
        struct {
            u_int hc_walkcount;
            u_int hc_walklength;
        } hash_header;
    } var;
    int c_spu;
}
```

Load all the `callout` structures from the callout table.

```
q4> load struct callout from callout max ncallout
loaded 3016 struct callouts as an array (stopped by max count)
```

List all the different flag fields in these structures.

```
q4> print c_flag | sort -u
EXPIRED_CALLOUT|FREE_CALLOUT
FREE_CALLOUT
PENDING_CALLOUT
PENDING_CALLOUT|DRIVER_CALLOUT
PENDING_CALLOUT|MP_CALLOUT
```

Keep only those `callout` structures with the `PENDING_CALLOUT` flag set.

```
q4> keep c_flag & PENDING_CALLOUT
kept 38 of 3016 struct callout's, discarded 2978
```

There are 38 `callout` structures with the flag value `PENDING_CALLOUT`.

List all the different function addresses pointed to by these structures.

```
q4> print -x var.real_callout.cc_func | sort -u
0x191a08
0x19e3e8
0x1bd228
. . . . .  // all lines from output not shown here
0xc2a20
```

Get name of kernel routines found in the previous step.

```
q4> examine 0x191a08 using a
unselect
q4> ex 0x19e3e8 using a
schedttisr
q4> ex 0x8c230 using a
scsi_cleanup_scbs
```

The kernel routines `unselect`, `schedttisr`, and `scsi_cleanup_scbs` are referred to in `callout` structures. Display the instructions of those functions. Choose `unselect`.

```
q4> code unselect
Dump of assembler code for function unselect:
0x191a08 <unselect>:std %rp,-0x10(%sp)
0x191a0c <unselect+0x4>:addil L'-0x2800,%dp,%r1
0x191a10 <unselect+0x8>:std,ma %r3,0x60(%sp)
0x191a14 <unselect+0xc>:copy %r26,%r3
. . . . .  // all lines from output not shown here
0x191b9c <unselect+0x194>:ldo -0x10(%sp),%ret1
0x191ba0 <unselect+0x198>:b 0x191ac4 <unselect+0xbc>
0x191ba4 <unselect+0x19c>:addil L'-0x2800,%dp,%r1
End of assembler dump.
```

Look into the near term, mid term and far future events. Load the near term callout headers and list different types from the flag fields.

```
q4> load struct callout from callout_time_nr max ncallout until callout_time_md
loaded 256 struct callouts as an array (stopped by "until" clause)
q4> print c_flag | sort -u
HEADER_TIME_CALLOUT|HEADER_CALLOUT
```

There are 256 near term structures. They are of the type `HEADER_TIME_CALLOUT|HEADER_CALLOUT`. List the absolute time fields for these headers.

```
q4> print indexof c_abs_time_hi c_abs_time_lo
indexof  c_abs_time_hi  c_abs_time_lo
0              0           76681472
1              0           76681473
2              0           76681474
. . . . .  // all lines from output not shown here
```

```
253             0           76681469
254             0           76681470
255             0           76681471
```

The structures are in the sequence of c_abs_time_lo numbers and the numerical difference between adjacent time fields is 1 (one) which corresponds to one clock tic (10 msec.).

Load the mid term callout headers and print the absolute time fields for these headers.

```
q4> load struct callout from callout_time_md max 256
loaded 256 struct callouts as an array (stopped by max count)
q4> print c_abs_time_hi c_abs_time_lo
c_abs_time_hi  c_abs_time_lo
0              76742656
0              76742912
. . . . .  // all lines from output not shown here
0              76742144
0              76742400
```

The structures are in the sequence of the c_abs_time_lo numbers and the numerical difference between adjacent time fields is 256. Load the callout header for far future events, (there is only single header for all far future events) and display contents.

```
q4> load struct callout from callout_time_ff
loaded 1 struct callout as an array (stopped by max count)
q4> print -tx
                        indexof  0
                         mapped  0x1
                        spaceof  0
                         addrof  0x4097b40
                     physaddrof  0x4097b40
                        realmode  0
                        c_cookie  0x32
                           c_pad  0
                          c_flag  HEADER_TIME_CALLOUT|
                                  HEADER_CALLOUT
                  c_abs_time_hi  0
                  c_abs_time_lo  0x4928e00
                    c_time_next  0x405a370
                    c_time_prev  0x10221f888
                    c_hash_next  0
                    c_hash_prev  0
       var.real_callout.cc_func  0
        var.real_callout.cc_arg  0
   var.time_header.tc_thdr_next  0
   var.hash_header.hc_walkcount  0
  var.hash_header.hc_walklength  0
                           c_spu  0
```

Load the linked list of structures associated with this and print types and absolute times for each of them.

```
q4> load struct callout from c_time_next max ncallout next c_time_next
loaded 15 struct callouts as a linked list (stopped by loop)
q4> print c_abs_time_hi c_abs_time_lo  c_flag
c_abs_time_hi  c_abs_time_lo  c_flag
0              77812143       PENDING_CALLOUT
0              78010793       PENDING_CALLOUT
```

```
0               79255754        PENDING_CALLOUT
0               82548474        PENDING_CALLOUT
0               77760000        PENDING_CALLOUT
0               76824433        DYNAMIC_CALLOUT |
                                PENDING_CALLOUT |
                                MP_CALLOUT
0               79922775        DYNAMIC_CALLOUT |
                                PENDING_CALLOUT |
                                MP_CALLOUT
0               76723818        PENDING_CALLOUT
0               85220363        PENDING_CALLOUT
0               85253174        PENDING_CALLOUT
0               76816943        DYNAMIC_CALLOUT |
                                PENDING_CALLOUT |
                                MP_CALLOUT
0               76731230        PENDING_CALLOUT
0               76714018        DYNAMIC_CALLOUT |
                                PENDING_CALLOUT |
                                MP_CALLOUT
0               77054684        DYNAMIC_CALLOUT |
                                PENDING_CALLOUT |
                                MP_CALLOUT
0               76713472        HEADER_TIME_CALLOUT |
                                HEADER_CALLOUT
```

There were 15 such structures and the last structure is the header structure. The events are not in chronological order. Also it is a circular list, so load was stopped by finding a loop. Load the hash headers and display flags, times and links.

```
q4> load struct callout from callout_hash max 256
loaded 256 struct callouts as an array (stopped by max count)
q4> print -x flag c_abs_time_lo c_time_next c_hash_next
c_flag                   c_abs_time_lo c_time_next c_hash_next
HEADER_HASH_CALLOUT|HEADER_CALLOUT  0      0      0x405a490
HEADER_HASH_CALLOUT|HEADER_CALLOUT  0      0      0x4097bd0
. . . . .  // all lines from output not shown here HEADER_HASH_CALLOUT|HEADER_CALLOUT  0     0
0x409c2f8
HEADER_HASH_CALLOUT|HEADER_CALLOUT  0      0      0x409c340
```

The structures are of type `HEADER_HASH_CALLOUT` and absolute times (`c_abs_time_lo`) are zeros and there are links (`c_hash_next`) to the hash chain. Now let's load two of the expired headers and display all the fields.

```
q4> load struct callout from callout_hash skip 256 max 2
loaded 2 struct callouts as an array (stopped by max count)
q4> print -tx
                        indexof  0
                         mapped  0x1
                        spaceof  0
                         addrof  0x409c388
                     physaddrof  0x409c388
                       realmode  0
                       c_cookie  0x32
                          c_pad  0
                         c_flag  HEADER_EXPIRED_CALLOUT |
                                 HEADER_TIME_CALLOUT |
                                 HEADER_CALLOUT
                  c_abs_time_hi  0
                  c_abs_time_lo  0
```

```
                    c_time_next  0x409c388
                    c_time_prev  0x409c388
                    c_hash_next  0
                    c_hash_prev  0
      var.real_callout.cc_func  0
       var.real_callout.cc_arg  0
  var.time_header.tc_thdr_next  0
  var.hash_header.hc_walkcount  0
 var.hash_header.hc_walklength 0
                         c_spu  0

                        indexof  0x1
                         mapped  0x1
                        spaceof  0
                         addrof  0x409c3d0
                     physaddrof  0x409c3d0
                       realmode  0
                       c_cookie  0x32
                          c_pad  0
                          c_flag  HEADER_EXPIRED_CALLOUT |
                                  HEADER_TIME_CALLOUT |
                                  HEADER_CALLOUT
                  c_abs_time_hi  0
                  c_abs_time_lo  0
                    c_time_next  0x409c3d0
                    c_time_prev  0x409c3d0
                    c_hash_next  0
                    c_hash_prev  0
      var.real_callout.cc_func  0
       var.real_callout.cc_arg  0
  var.time_header.tc_thdr_next  0
  var.hash_header.hc_walkcount  0
 var.hash_header.hc_walklength  0
                         c_spu  0
```

The (`c_flag`) fields show the header type as `HEADER_EXPIRED_CALLOUT`.

Running PERL Scripts on a Live System

Perl scripts can be run on live systems as well as on crash dumps. Use the `-p` option while invoking KWDB to start the PERL session. If the `-p` option is not specified, the PERL session will be started when trying to execute the script related commands `include` or `run`. Here is an example of running a PERL script on a live system. Here the script `Analyze` is run and its output is redirected to the file `analyze.out`. The output file `analyze.out` can be viewed using any editor.

Example:

```
# kwdb -q4 -quiet -p /stand/vmunix /dev/kmem

script /.q4rc.pl
executable /usr/contrib/Q4/bin/perl
version 5.00502
SCRIPT_LIBRARY = /usr/contrib/Q4/lib/q4lib_11.00
perl will try to access scripts from directory
/usr/contrib/Q4/lib/q4lib_11.00

System memory: 1024 MB
Total Dump space configured: 1536.00 MB
Total Dump space actually used: 0.00 MB
Dump space appears to be sufficient : 1536.00 MB extra

q4> run Analyze > analyze.out
processing.....................................................................
.....................
..................... done!
q4>
```

See *Chapter 7, "KWDB PERL Programming Reference,"* for more details.

Reading From Locked Pages

Reading from a locked page will result in “Device Busy” error message. To read from locked pages, reset the `page_lock_required` flag. This may introduce a bit of a cache coherency problem on multiprocessor systems so do the following mindful of the risk. The `page_lock_required` flag can be reset using KWDB.

Example:

```
# kwdb  -q4  -quiet  /stand/vmunix  /dev/kmem
q4> trace thread at 0x3cd4800
Stack trace for process “swapper” at 0x3a15600 (pid 0)
Thread at 0x3cd4800 (tid 0)
Error accessing memory address 0x400003ffffff0008: Device busy.
q4> p page_lock_lock_required = 0
$2 = 0
q4> trace thread at 0x3cd4800
Stack trace for process “swapper” at 0x3a15600 (pid 0)
Thread at 0x3cd4800 (tid 0)
#0  0x10b06c in _swtch+0xd4 ()
#1  0xd1b48 in sema_sleep+0xa0 ()
#2  0xd1a00 in _psync+0x70 ()
#3  0x1dce48 in sched+0x210 ()
#4  0x2a41e4 in main+0x6b4 ()
#5  0x10811c in $vstart+0x48 ()
#6  0x21674c in $locore+0x94 ()
q4> p page_lock_required = 1
$3 = 1
q4>
```

Unsupported Commands

Commands which deal specifically with crash targets will not be supported on live targets. Examples for such commands are `trace event #`, `set crash event #`. KWDB will display an appropriate error message when such commands are attempted on a live system.

Commands like `break`, `continue`, `step next`, etc., are used for debugging may not be used while analyzing a live system. KWDB will report an appropriate error message when these commands are attempted on a live system.

While running KWDB on a live system using the `devmem` target, KWDB does not have control of the running processes on the system. Therefore, it does not make sense to trace a running thread or to set thread context to a running thread. Appropriate error messages will be displayed when such commands are tried while analyzing a live system.

7 KWDB PERL Programming Reference

KWDB is a source level debugger for HP-UX kernel and drivers. KWDB can be used for source level debugging of remote systems or for analyzing crash dumps or for analyzing live systems.

As explained earlier in *Chapter 4, "Command Reference,"* KWDB allows execution of any system commands or executables or shell scripts from within KWDB using the commands `system` or `shell`. Similarly, a set of KWDB commands which has to be executed many times can be stored in a file and invoked from within KWDB using the command `source`. KWDB can also use PERL to input KWDB commands and process KWDB output.

This chapter describes KWDB's PERL programmer's interface. Programs can be written in PERL to analyze crash dumps or live systems or remote systems running under KWDB. To write PERL programs and after reading *Chapter 4, "Command Reference,"* this chapter is the next logical step.

Analyzing crash dumps or live systems can be divided into two sub problems:

- Reconstruction of data types — examining a structure, looking at fields in a structure, and printing a structure are examples of reconstruction.
- Navigation through data structures — collecting a number of related structures by getting an array, walking a linked list, selecting items of interest or traversing a tree are examples of navigation.

Reconstruction is built into KWDB. Reconstruction is fully automatic, and all of the information needed to reconstruct a data type is embedded in the kernel itself.

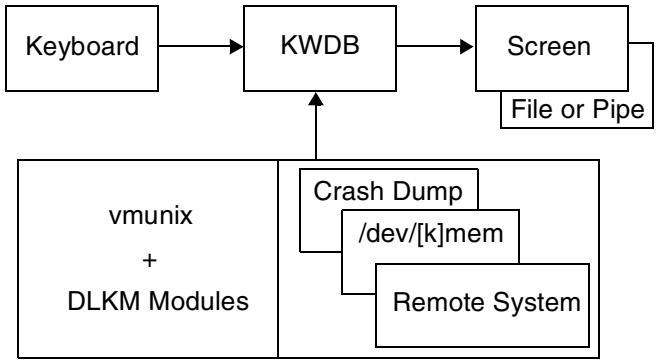
Navigation is provided by an outboard programming language, PERL (the subject of this chapter), and a few simple but carefully chosen support commands embedded within KWDB. By making navigation the responsibility of the PERL scripts, KWDB becomes more portable. As the scripts are not built into KWDB, they can be made part of the kernel source environment. This means the PERL scripts can be owned and maintained by the people who own the kernel code that the scripts navigate.

Before we discuss Running and Writing Scripts, we will compare the data flow in KWDB with and without the PERL option and then cover some installation issues.

How KWDB Works With PERL

In a normal debugging session KWDB is interactive. Type commands that are read by KWDB. KWDB looks up what was asked for in the dump files (`vmunix` and crash dump image for crash target or other sources depending on the target selected) and prints the answer on the screen. If asked for output redirection the answer goes to the file or pipe instead. Normal KWDB flow without using PERL is illustrated in Figure 7-1 on page 214 (the arrows indicate the direction information flows).

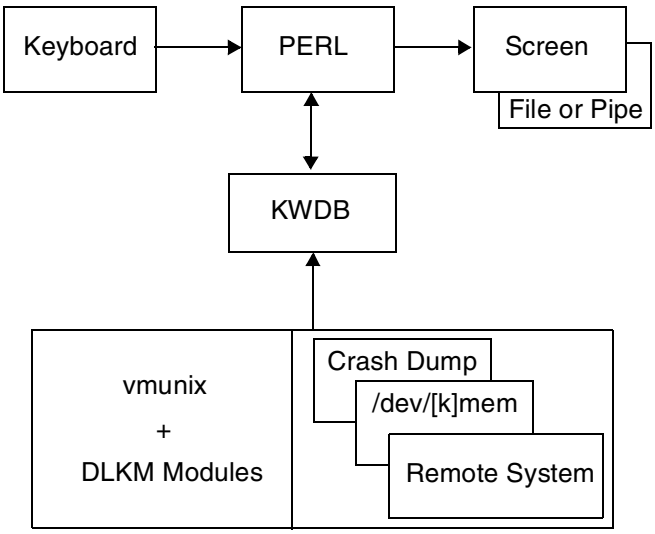
Figure 7-1 Invoking KWDB Without PERL



Things change a little when turning on PERL programming. Instead of talking directly to KWDB talk to PERL (KWDB runs PERL, don't invoke it). PERL sends the commands typed to KWDB. When KWDB responds PERL forwards the output.

When issuing an `include` command PERL loads the named script. When issuing a `run` command PERL invokes the named PERL script. The PERL script does whatever it wants to do, which may include conversing with KWDB and displaying results, and then returns interactive control to the keyboard. This is illustrated in Figure 7-2 on page 215 (the arrows indicate the direction information flows).

Figure 7-2 Invoking KWDB With PERL Option -p



Verify PERL is Installed

To invoke PERL, KWDB searches for an executable file called PERL in the following order:

1. `$Q4_PERL_PATH` (`Q4_PERL_PATH` is an environment variable set by user)
2. `$Q4_ROOT`/bin/`PERL` (`Q4_ROOT` is an environment variable set by user)
3. `/usr/contrib/Q4/bin/PERL`
4. PERL in the directories set by `PATH` environment.

If PERL is already installed on the system, KWDB can be made to use it by setting the environment variable `$Q4_PERL_PATH` or setting the `PATH` appropriately. If PERL in not installed, contact the system administrator to have it installed.

Verify the Scripts are Installed

Scripts are installed as part of KWDB installation. During the installation of KWDB a directory called `/usr/contrib/Q4/lib` will be created. This directory contains a set of directories `q4lib`, `q4lib_10.20`, `q4lib_11.00`, `q4lib_11.11`, `q4lib_11.20`, and so forth. These are the directories where scripts for corresponding versions of HP-UX operating systems are kept. The directory `q4lib` contains scripts for the latest version of HP-UX and is the default directory to be used. During startup KWDB looks for the version of `vmunix` and decides which scripts to use.

The last step before starting KWDB with PERL session is to create a startup file in the home directory. The easiest way to do this is:

```
$ cp /usr/contrib/Q4/lib/q4lib/sample.q4rc.pl ~/.q4rc.pl
```

Read the comments in the file for customization hints and rules.

Running Scripts

Installation of KWDB includes many scripts designed to help analyze what happened and is happening on the system. To take advantage of these scripts, include and run the scripts. This section includes information to help debug the scripts if that becomes necessary.

Invoking KWDB

There are two KWDB commands, `include` and `run`, associated with PERL programming. If starting KWDB without the `-p` option and invoke either of the two commands, KWDB will start the PERL session and prompt to continue with the commands.

Another way to use the PERL programming features of KWDB is to add the `-p` flag when invoking it. For example:

For crash dumps:

```
$ kwdb -q4 -p crash_dump_directory
```

For live systems:

```
$ kwdb -q4 -p /stand/vmunix /dev/[k]mem
```

For remote targets:

```
$ kwdb -p vmunix
```

KWDB will run PERL and make the necessary connections as shown in *Figure 7-2, "Invoking KWDB With PERL Option -p."*

Once everything has been initialized. get the usual prompt at which time use KWDB just like normal.

Including Program Files

To run programs, first load them and use the `include` command.

For example, load the programs that know how to manipulate processes:

```
$ kwdb -q4 -p crash_directory_path
...
q4> include processes.pl
loading ./q4lib/processes.pl ...
loading ./q4lib/misc.pl ...
loading ./q4lib/commands.pl ...
loading ./q4lib/credentials.pl ...
loading ./q4lib/user.pl ...
loading ./q4lib/vm.pl ...
q4>
```

PERL prints the name of each file as it loads it. Other files were loaded as well because `processes.pl` included them. It probably did this because one or more of the functions it defines rely on functions defined in these other files. (The `include` command knows what it's already seen so multiple includes of the same file will only read it once.)

If there are files to include every time, consider adding some `include` commands to the `.q4rc.pl` file.

NOTE KWDB can not tell if the scripts included in the previous script were successfully included. The script must be written so that the last line of the file, outside the scope of any function, is a print statement that indicates the file was successfully loaded. For example: `print "loaded MyScriptName.pl\n";`

Invoking Scripts

Once loaded the necessary files are ready to run programs. Use the `run` command to do this.

For example, emulate an analyze UAP:

```
$ kwdb -q4 -p crash_directory_path
...
q4> include analyze.pl
...
q4> run Analyze options
```

Function arguments are optional (depending on the individual function's requirements).

If multiple arguments are specified they are concatenated together (with white space separators) and passed to the function as a single PERL string argument. The function may use any of PERL's built in mechanisms for splitting it up if it chooses.

For example,

```
q4> run Analyze UAP
```

turns into

```
&Analyze("UAP")
```

inside PERL scripts.

```
q4> run Analyze U A P
```

would turn into

```
&Analyze("U A P")
```

Redirecting Script Output

Output generated by PERL programs can be redirected in one of two ways. The program can choose (for its own reasons) to write its output anywhere it wants or redirect the default output of the command (using the standard notation).

For example, run the program `PrintMessageBuffer` and pipe its output to `more`:

```
q4> run PrintMessageBuffer | more
```

Tracing Dialog Between PERL and KWDB

Trace the dialog between the PERL process and the KWDB process. There is a global variable, `$traceDialog`, which can be set to the filename for logging the dialog. The name of this file can be set by entering the following line in the startup script file `~/.q4rc.pl`.

```
$traceDialog =Filename;
```

If `$traceDialog` is defined, every message sent and received by the PERL process will also be written to that file. There are functions `TraceOn` and `TraceOff` defined in `.q4rc.pl` which can help control tracing.

```
q4> run TraceOn dialog file
q4> run script of interest
q4> run TraceOff
```

Interactively turn tracing on as shown in the previous example and then from another session tail the dialog file while KWDB is processing the script. See the last exchange, it may have to recreate the problem interactively to understand what is failing. The `TraceOn` and `TraceOff` functions can also be called within a script to trace a certain section of a script.

Debugging PERL Scripts

It is possible to debug PERL scripts by starting PERL in debug mode. This can be done by invoking KWDB with `-P` option as shown in example below. The system administrator must have installed a version of PERL that supports the debugging functionality

```
$kwdb -q4 -P /var/adm/crash/crash.0 -quiet

Using debug mode for PERL script

Loading DB routines from PERL5db.pl version 1.01
Emacs support available.

Enter h or `h h' for help.

main::(/home/mmuthira/.q4rc.pl:7):
7:              local($PROGRAM_NAME);
  DB<1> n
main::(/home/mmuthira/.q4rc.pl:8):
8:              local($EXECUTABLE_NAME);
```

The Two Scripts Most Often Run

The two scripts most often run are `WhatHappened` and `Analyze`. Include `whathappened.pl` and `analyze.pl` to run them. `WhatHappened` is also known as `WH`.

What Happened

The `WhatHappened` is a tool for diagnosing apparent system hangs. Use the word apparent because there are a number of things that can make a system seem like it's hung when it really isn't. When this happens it's fairly common for someone to get impatient and force a reboot (and a dump). `WhatHappened` is designed to look over the dump and determine if one of the common problems have occurred. If so, the problem is explained. If not, it says so and further work is needed.

Here are some of the things `WhatHappened` checks:

- What brought the system down? If it was a panic or HPMC (high priority machine check) then it wasn't a system hang.
- Were there real-time processes soaking up lots of CPU time? If there were enough of these to cover every processor (and they look like that's what they were doing) might have the cause right there. The offending processes may have exited before the dump started.

- Were there a lot of zombie processes lying around? If so, they may have been holding a lot of valuable resources. It's also suggestive of an application that was not cleaning up after itself.
- Was the process table full? If so, it may have been difficult or impossible to launch new processes.
- Were any specific users out of processes? The system imposes a limit on the number of processes each user may have in existence at any one time. If anyone was at this limit they would not be able to launch any new processes.
- Is memory scarce? There are many things the system cannot do (or do well) when memory is in short supply. When processes try to do these things they often sleep and are sometimes uninterruptible.
- Are *cblocks* scarce? If so, it could account for the difficulty users may have been having trying to type or get console echo.

To run `WhatHappened` do this:

```
$ kwdb -q4 -p crash_directory_path
...
q4> include whathappened.pl
...
q4> run WhatHappened
or
q4> run WH
```

The output is printed to `stdout` and there may be more than a screen's worth, to redirect it to a file or to a program like *more* (1).

Analyze

The `Analyze` tool is used primarily to analyze crash dumps. It can also be run on live systems.

Run it like this:

```
$ kwdb -q4 -p crash_directory_path
...
q4> include analyze.pl
...
q4> run Analyze
```

The output is printed to `stdout` and there will almost certainly be more than a screen's worth, redirect it to a file or to a program like *more* (1).

When run as shown above (without options) get the following information:

- Brief system description (`uname -a`)
- System uptime
- System load averages (1, 5, and 15 minutes)
- Console message buffer
- VM tables
- VM values
- VM stats
- Processes (including the text of the command, most process structure fields, and a stack trace)

The command syntax is `run Analyze` [*options*] where options is any combination of A, M, P, or U. Adding options adds information:

Option A

- Many kernel global variable addresses
- The crash processor table
- The crash event table
- The registers from the processor that crashed
- Stack trace of the processor that crashed
- Per-processor information

Option M

- The mounted filesystems
- The file table

Option P

- Process vas'
- Process pregions
- Process regions

Option U

- Various per-process user area fields
- The per-process user credentials

The options can be combined as in the following equivalent examples:

```
q4> run Analyze UAP
...
q4> run Analyze U A P
...
```

Analyzing with UAP options is very time consuming, and the output generated is very large.

Perl Shell Interface for KWDB

Starting from kwdb-3.1.5, a Perl Shell Interface has been added to kwdb. This provides a shell-based interface wherein the user can execute shell commands as well as kwdb commands from a single user interface prompt. Perl Shell is basically free software available from the internet. It provides an extensible shell-based interface. The kwdb commands have been added to this interface, and this enables the kwdb commands to be run directly from within this shell-based interface.

The Perl Shell interface can be started using:

```
# kwdb -P crash-dump-directory>
[..]

q4>ls

/dump1/dumps/ia/crash.1

q4>load proc_t from proc_list next p_factp max 10

loaded 10 struct procs as a linked list stopped by max count

q4>
```

As can be seen from the above, the shell command `ls` and the kwdb command `load` are both executed from the kwdb q4 prompt which in fact represents the perl shell prompt. The perl constructs can be used at the q4 prompt as shown below.

```
q4>sub myload {

‘load kthread_t from kthread_list next kt_factp max 10‘

‘print -tx kt_tid‘

}

q4>myload

loaded 10 struct kthreads as a linked list stopped by max count

<thread id’s of 10 kthreads starting from kthread_list and with the next pointer as
kt_factp>
q4>
```

As can be seen from the above, the keyword `sub` is a perl construct used to define a procedure. So `myload` is a perl procedure defined at the perl shell prompt. This procedure uses the kwdb `load` and kwdb `print` commands. Once the procedure is defined it can be invoked from within the perl shell just by mentionng the name of the procedure (in the same way any perl procedure is called).

Existing perl scripts can be included using the include command as before

```
#kwdb -P <dump-directory-name>
[..]

q4>include analyze.pl
loaded analyze.pl
q4>Analyze
[ output of analyze function ]
q4>
```

As can be seen in the `-p` mode, to run a perl procedure the run command needs to be executed followed by the procedure name. In the Perl shell mode, there is no need to give the run command. The procedure can be invoked directly by referring to the name of the procedure.

Writing Scripts

Stealing from existing PERL scripts programs is probably the best way to learn to write new ones. Still, there are things that need to be known that may not be well documented in the scripts. Some of these things are covered here including a style guide.

Basic Program Operation

PERL programs do their work by conversing with KWDB just as the interactive user does. The program sends KWDB commands, receives the response and acts on what happens. It returns control to the user when it's done it's job.

This back and forth communication is fairly primitive so the program must at all times make sure it reads KWDB's response completely. If it doesn't PERL and KWDB will get out of sync. This usually results in confusing behavior. Fortunately it's easy to avoid this. There is a whole library of supplied routines to make PERL/KWDB communications easy and painless. Most of these routines are in a file called `q4.pl` present in every version of the scripts. These routines will be loaded during PERL start up.

The functions are grouped into:

- "Communicating With KWDB"
- "Scripts That Implement Q4 Commands"
- "Output Formatting"
- "Interruption Handling"
- "Fields, Values and Expressions"
- "Miscellaneous"
- "Style Guide"

Communicating With KWDB

These routines manage the communications link between PERL and KWDB. They help send commands and receive the response.

- Send

  `Send` transmits a line of text to KWDB as if the user typed the command.

  For example, these two are equivalent:

  ```
  q4> load -r struct proc from proc max nproc
  ```

  and

  ```
  &Send("load -r struct proc from proc max nproc");
  ```

  To keep PERL and KWDB in sync with each other every `Send` should be followed by one call to either `TossResponse` or `PrintResponse` or the proper number of calls to `Receive`. If wrong, the program will not work.

  `Send` is defined in `q4.pl`.

- Receive

  `Receive` gets one line of response from KWDB.

The newline at the end of the line is automatically removed. `Receive` returns `undef` if there is no more text to read from the current response.

For example,

```
&Send("load struct proc from proc_list");
$result = &Receive();
$more = &Receive();
```

might set the PERL variable `$result` to "loaded 1 struct proc as an array (stopped by max count)".

The PERL variable `$more` would be set to `undef` because the `load` command only returns one line of output.

Always continue to call `Receive` until it returns `undef`. Each line of response text that KWDB returns must be answered with a call to `Receive`. If it isn't, PERL and KWDB will get out of sync. Think of KWDB's output stream as containing a marker indicating where each response ends. This is how `Receive` knows when to tell that there is no more text in the response. These virtual markers must have a corresponding `Receive` or there will be trouble.

`Receive` is defined in `q4.pl`.

- `TossResponse`

  `TossResponse` reads an entire response from KWDB and throws it away.

  This is most useful when issuing a command and are not interested in what KWDB has to say about it.

  For example,

  ```
  &Send("q4PrintOctal = 0"); # don't want octal output
  &TossResponse();
  ```

  `TossResponse` is defined in q4.pl.

- `PrintResponse`

  `PrintResponse` reads an entire response from KWDB and prints it.

  This is most useful when the program is not interested in a command's output but the user is.

  For example,

  ```
  &Send("trace event 0");  # trace the first crash event
  &PrintResponse();
  ```

  If `PrintResponse` is passed a string argument that string is prepended to every line of output in the current response. This is most often used to make the output a little more readable.

  For example,

  ```
  print(STDOUT 'Stack Trace:\n'); # print the title
  &Send("trace event 0");  # trace the first crash event
  &PrintResponse('  ');  # indent a little for readability
  ```

  `PrintResponse` is defined in q4.pl.

- `PushPrintFlag` and `PopPrintFlag`

  Output from `PrintResponse` can be turned on and off at will with `PushPrintFlag` and `PopPrintFlag`. `&PushPrintFlag(1)` turns printing on and `&PushPrintFlag(0)` turns it off. `&PopPrintFlag()` restores it to the setting in use before the previous call to `PushPrintFlag`.

  Mostly used to temporarily disable printing in some routines that don't implement controls of their own. `PushPrintFlag` and `PopPrintFlag` are defined in `q4.pl`.

Scripts That Implement Q4 Commands

There are many routines which implement Q4 commands and are convenient wrappers for common operations. All these routines are applicable in KWDB as well.

- Evaluate

  `Evaluate` sends an expression to KWDB for evaluation. The answer is always returned in decimal regardless of the settings of any KWDB control variables (depending on the expression, the answer may still be a 64 bit number, however).

  For example,

  ```
  $bytes = &Evaluate("sizeof(struct proc)"); # size of a process structure
  ```

  `Evaluate` is defined in `misc.pl`.

- Examine

  `Examine` sends an `examine` command to KWDB for evaluation.

  The first argument is an expression that evaluates to the starting address. The second is an examine format string.

  The first line of the response is separated at the whitespace and the parts are returned as an array. Any lines in the response after the first are discarded.

  For example,

  ```
  @loadAverage = &Examine('&avenrun', '3F'); # get the load averages
  ```

  `Examine` is defined in `misc.pl`.

- Forget

  `Forget` sends a `forget` command to KWDB.

  The argument is a pile history reference.

  The response from KWDB is discarded.

  `Forget` is most useful in utility routines that disturb the history list in some strange way. Routines that only add piles they are going to remove before they return can use `PushHistory` and `PopHistory`. For those routines that need to leave one or more piles in the history and clean up the rest `Forget` is the best choice.

  For example,

  ```
  &Forget(-1); # forget the previous pile
  ```

  `Forget` is defined in `misc.pl`.

- Keep

  `Keep` sends a `keep` command to KWDB.

  The argument is a boolean expression.

  `Keep` returns the number of items kept or `-1` if the command fails for some reason.

  For example,

  ```
  &LoadAllProcesses();
  $n = &Keep('p_stat!=0 && p_pid==10'); # find some process
  if ($n==-1) {
     # something went wrong
     ...
  ```

```
}
else if ($n==0) {
   # no matches
   ...
}
else if ($n==1) {
   # got it
   ...
}
else {
   # got several
   ...
}
```

`Keep` is defined in `misc.pl`.

- Load

  `Load` sends a `load` command to KWDB.

  The argument is a `load` command. `Load` returns the number of items loaded or `-1` if the command fails for some reason.

  For example, load the process table:

```
if ((&Load('struct proc from proc_list next p_factp max nproc')) == -1) {
   # load failed
   ...
}
```

  For example, load the process table entry at the location indicated by the PERL variable `$procp`:

```
if ((&Load("struct proc from $procp max 1")) == -1){
   # load failed
   ...
}
```

  In this example note the switch from single quotes to double quotes. The double quotes allow for PERL variable substitution within the string, the single quotes don't.

  `Load` is defined in `misc.pl`.

- `NameIt`

  `NameIt` sends a `name it` command to KWDB.

  The argument is the nickname to assign to the current pile.

  `NameIt` returns 1 if it succeeds, 0 otherwise.

  For example,

```
&LoadAllProcesses();
if (!&NameIt('AllProcesses')) {
   # it didn't work
   ...
}
```

  `NameIt` is defined in `misc.pl`.

- `PushHistory` and `PopHistory`

  `PushHistory` and `PopHistory` send `pushhistory` and `pophistory` commands to KWDB, respectively.

  Neither function takes an argument.

Neither function returns a value.

They are most often used to bracket the code in utility routines that create new piles that will need cleaning up before the routine returns. se Forget, but more often than not it's possible (and easier) to throw it all away with a single sweeping gesture.

For example,

```
&PushHistory();

 # do some things that may leave unwanted piles on the history list
&PopHistory();
```

`PushHistory` and `PopHistory` are defined in `misc.pl`.

- `RecallByName`

  `RecallByName` sends a `recall` command to KWDB.

  The argument is a pile history reference.

  `RecallByName` returns 1 if the pile was recalled, 0 if something went wrong.

  For example,

```
 if (&RecallByName('AllProcesses')) {
   # got it
   ...
 }
```

  `RecallByName` is defined in `misc.pl`.

Output Formatting

These routines help format output in a number of useful ways.

- Adjust

  Call it just like calling `printf`, but it produces output like *adjust* (1).

  Each line of output is broken into pieces at the whitespace. Each piece is added to the current output line until that line would be too long. At that point the current line is flushed and a new line is begun. This makes it easy for a program to print paragraphs of prose that contain items of variable length (like numbers and string extracted from the dump) without having to do a lot of gymnastics to keep the output readable.

  For example,

```
&Adjust("The statdaemon hadn't run in over %s
       (1 second is   normal).",
   &Elapsed(($ticks_since_boot-$p_lastrun_time)
            /$hz, '%.2f'));

if ($nRTProcesses) {
   &Adjust("At least %d real-time process%s ran".
      " since the last time the statdaemon ran.",
      $nRTProcesses,
      &Plural($nRTProcesses, '', 'es'));
}
else {
   &Adjust("No real-time processes can be *proven*".
      " to have been running during this time.");
}
```

```
&Adjust("They are probably monopolizing all of the".
   "processors since at least".
   " one of them has run recently on every processor.".
   " This may account for what looked like a hang.\n\n");
```

might produce

```
The statdaemon hadn't run in over 1.02 minutes (1 second is normal). At least 2 real-time
processes ran since the last time the statdaemon ran. They are probably monopolizing all of
the processors since at least one of them has run recently on every processor. This may
account for what looked like a hang.
```

`Adjust` is defined in `adjust.pl`.

- `OpenTable`, `AddToTable`, `CloseTable` and `PrintTable`

  The routines `OpenTable`, `AddToTable`, `CloseTable` and `PrintTable` provide a simple mechanism for printing primitive tables.

  In the context of these routines a table is defined as a two dimensional array of items printed on the page.

  The sequence of operations is as follows:

  1. Call `OpenTable` to start a new table. The first argument will be a `printf` format string used to print each table cell. The second argument will be a separator to print between each cell on a line. The third argument will be the number of columns to print on each line. (The last line of the table is allowed to have fewer cells.)
  2. Call `AddToTable` for each cell wanted in the table. The entries will be added left to right, starting with the first row and proceeding down. The first argument is the label for the cell. The second argument is the value for the cell.
  3. Call `CloseTable` once everything added in the table. It will flush the current line and clean up.

NOTE Only have one table open at a time.

  Use `OpenTable`, `AddToTable` and `CloseTable` make sure the table isn't too wide for the page. It will work even if wrong, but the lines may wrap or be truncated. For fully automatic table printing, use `PrintTable`.

  `PrintTable` takes two arguments; a list of cell labels and a list of cell values. It scans them all choosing a format string and number of columns that will accommodate a typical screen. Then it prints the entire table (the cell values are printed in hex).

  `OpenTable`, `AddToTable`, `CloseTable` and `PrintTable` are defined in `tables.pl`.

- `PrintFields`

  `PrintFields` takes a list of field names referring to the structure(s) in the current pile and prints a table of the specified fields (names and value in hex).

NOTE Only the first structure in the current pile is printed.

  `PrintFields` is defined in `tables.pl`.

- `PrintExprs`

  `PrintExprs` takes a list of expressions and prints a table of the expressions and their values (in hex)

  `PrintExprs` is defined in `tables.pl`.

Interruption Handling

Interrupting PERL programs via keyboard generated signals (`SIGINT`) is supported as long as care is taken to keep KWDB and PERL in sync with each other. Here's how it works.

- Interrupted

  When sending a keyboard interrupt, it is received by both KWDB and PERL. KWDB stops what it's doing and sends a message to PERL saying it's done with the current request. PERL notes the signal and resumes it's work. As soon as `Receive` sees this end marker it raises an exception that will abort the current operation and return control to the main loop.

  If doing something time consuming in PERL and don't expect to call `Receive` anytime soon consider calling `Interrupted` periodically to check for interrupts.

  `Interrupted` takes no arguments. It returns 1 if there is a keyboard interrupt pending, 0 otherwise.

  Keyboard interrupts are cleared automatically when execution returns to the main loop for another user command.

  For example, suppose the code is doing something from a loop that could take a while but it's all right to abort if interrupted. Put something like this in the loop:

  ```
  die 'interrupted' if &Interrupted();
  ```

  `Interrupted` is defined in `q4.pl`.

Fields, Values and Expressions

These routines help get structure fields and evaluate expressions.

- `GetFieldsDec`/`GetFieldsHex`

  `GetFieldsDec` gets the value of one or more specific fields from the current pile. The arguments are the names of any fields in the structure underlying the current pile. The `GetFieldsDec` routine gets the values in decimal (`%#lld`) format. The `GetFieldsHex` routine behaves similarly to `GetFieldsDec` except that the values are in hex (`%#llx`) format.

  If `GetFieldsDec` or `GetFieldsHex` is called with more than one argument, the return value is an array of values, one for each field requested from the first structure in the current pile. They are returned in the same order they appear in the argument list.

  For example, get the process ID, parent process ID, process group ID and session ID of the process just fetched:

  ```
  ($pid, $ppid, $pgrp, $sid) = &GetFieldsDec('p_pid', 'p_ppid', 'p_pgrp', 'p_sid');
  ```

  or

  ```
  ($pid, $ppid, $pgrp, $sid) = &GetFieldsDec('p_pid p_ppid p_pgrp p_sid');
  ```

  `If GetFieldsDec` or `GetFieldsHex` is called with one argument the return value is an array of values, one for every structure in the current pile. They are returned in the same order they appear in the pile.

  For example, print all of the process ID's in use:

  ```
  &LoadAllProcesses();
  @pids = &GetFieldsDec('p_pid');
  for $pid (@pids) {
  print(STDOUT $pid, "\n");
  }
  ```

  `GetFieldsDec` and `GetFieldsHex` are defined in `misc.pl`.

- `GetAllFieldNames`

  `GetAllFieldNames` returns an array naming every field in the structure underlying the current pile.

  It takes no arguments. The field names are returned in the order they are defined in the structure. The list of field names includes the synthetic fields defined by KWDB.

  For example, print all of the fields in the current structure:

  ```
  @fields = &GetAllFieldNames();
  for $field (@fields) {
     print(STDOUT $field, "\n");
  }
  ```

  `GetAllFieldNames` is defined in `misc.pl`.

- `GetAllFieldValues`

  `GetAllFieldValues` returns an array of every value in the structure underlying the current pile.

  It takes no arguments. The field names are returned in the order they are defined in the structure. The list of field values includes the synthetic fields defined by KWDB. The values match the field names returned by `GetAllFieldNames` one-for-one.

  `GetAllFieldValues` only supports piles containing a single structure. Its behavior on piles containing several structures is not defined.

  For example, print all of the fields in the current structure:

  ```
  @values = &GetAllFieldValues();
  for $value (@values) {
     print(STDOUT $value, "\n");
  }
  ```

  `GetAllFieldValues` is defined in `misc.pl`.

- `GetSymbolicField`

  `GetSymbolicField` gets the symbolic value of one specific field from the first structure in the current pile.

  The argument is the name of the field in the structure underlying the current pile. The return value is the symbolic value of the field requested. This is most useful for enumerated types. (The value returned for nonenumerated types will be numeric.)

  For example, get the process state of the process just fetched:

  ```
  $state = &GetSymbolicField('p_stat');
  ```

  If `p_stat==3`, this would return SRUN.

  `GetSymbolicField` is defined in `misc.pl`.

- `GetValues`

  `GetValues` evaluates one or more expressions and returns their values.

  The arguments are one or more expressions. The return value is an array of the values of each of the expressions (returned in the same order as the expressions appear in the argument list).

  For example, find out how many processors the system had and what the per-user process limit was:

  ```
  ($numCPUs, $perUserLimit) = &GetValues('runningprocs', 'maxuprc+1');
  ```

  `GetValues` is defined in `misc.pl`.

Miscellaneous

These routines provide miscellaneous, but frequently used services.

- Include

  `Include` is used to bring in additional PERL code from another file. It takes the name of the file as its argument.

  `Include` mimics the PERL built-in `require` in two ways:

  — If the filename is not rooted the directories named in the array @INC are searched to find the file.

  — The file is not read a second time if it has already been `Included`.

  `Include` differs from `require` if the file has been modified since it was last `Included`. In that case it will be read again. This means staying inside KWDB while making changes to a script in another window.

  For example, include the process handling library:

  ```
  &Include('processes.pl');
  ```

  `Include` is defined in `q4.pl`. Don't include anything to use it.

  If there is a syntax error in the file, will not get any diagnostic, but if a print command is added at the end of the script, outside the scope of all the functions defined, PERL will execute that statement when the script is included successfully.

  ```
  print "loaded YourNameHere.pl\n";
  ```

- Elapsed

  Format an amount of time in an easy to read format.

  The first argument is the amount of time (in seconds). The second argument is a `printf` format string for the numeric part of the result.

  Examples:

  ```
  &Elapsed(5, '%d') produces 5 seconds

  &Elapsed(60, '%d') produces 1 minute

  &Elapsed(70, '%d') produces 1 minute

  &Elapsed(70, '%.2f') produces 1.17 minutes

  &Elapsed(86400, '%.2f') produces 1 day
  ```

  `Elapsed` is defined in `misc.pl`.

- Plural

  `Plural` takes a value and two strings (a singular form and a plural). If the value is equal to 1, `Plural` returns the singular string, otherwise the plural one.

  For example, print some number of processes:

  ```
  printf(STDOUT "There %s %d %s.\n",
     &Plural($processes, 'is', 'are'),
     $processes,
     &Plural(ticks, 'process', 'processes'));
  ```

  The output might look like this:

  There is 1 process.

  or

```
There are 3 processes.
```

`Plural` is defined in `misc.pl`.

- Unique

  `Unique` takes an array of values and returns a sorted array of the those same values in which each of the values appears exactly once (it's similar to `sort -u`).

  The arguments are one or more arrays of values. The return value is an array of the values sorted in ascending order with all duplicates removed.

  For example, make a list of the process ID's of processes that have children:

```
&LoadAllProcesses();
@parents = &Get1Field('p_ppid'); # make a list of every parent pid
@parents = &Unique(@parents);  # lose the dup's
```

  The `Unique` step is required in this example because some parent processes may have more than one child.

  `Unique` is defined in `misc.pl`.

Style Guide

Here are some hints to help write scripts that are more robust, usable and portable.

General Hints

- Remember that every `Send` must be matched by the right number of calls to `Receive`. Either the script takes care of it or some routine being called does, but it must be done or PERL and KWDB will get out of sync and things get very confusing when that happens.
- Remember that in addition to matching every line of the response with a `Receive`, the end-of-response marker must be `Received` as well. In fact, looking for the end marker is usually the best way to know when the whole response has been seen.
- Remember that while KWDB is fairly kernel independent, some scripts may not be.
  - — As a script *user*, try to use the scripts that match the kernel that dumped.
  - — As a script *writer*, try to make the scripts written handle any version of the kernel (more on this under the *Making Kernel Differences Transparent* section).
- There are two ways to ask KWDB to evaluate expressions. One works better in scripts than the other. To evaluate expression 1+2, do this:

```
&Send('1+2');
$answer = &Receive();
&TossResponse(); # toss to end of response marker
```

  or this:

```
$answer = &Evaluate('1+2');
```

The second is preferred partly because it is easier to do but more importantly because the first example depends on the settings of the variables `q4PrintDecimal`, `q4PrintHex`, and `q4PrintOctal`. (The example assumes that `q4PrintDecimal` is on and `q4PrintHex` and `q4PrintOctal` are off.) The user has probably set them according to his preference which may not be what the script expects and tampering with them in the script means restoring them after they are done or leaving them in a state the user didn't expect. It's far safer and easier to use `Evaluate` instead.

Making Kernel Differences Transparent

KWDB solves the reconstruction problem, but leaves the navigation problem to the scripts. This makes KWDB (mostly) independent of changes to all but a tiny few data structures and algorithms. (See the *Kernel Developer's Guide* for details.) Therefore, one version of KWDB suffices for any kernel.

This means the burden of handling most kernel revision specific changes falls to the scripts. This is an improvement over the old situation because the scripts are written in a higher level (that is, more power for less effort) language (PERL vs. C) that doesn't require recompilation when changes are made. Therefore, as the kernel changes over time, the user should remember to use the scripts that were delivered with the version of the kernel that dumped.

But suppose some users forget or mistakenly grab the wrong set of scripts. For most kernel changes it should be possible to write the scripts so they can handle each of the different cases automatically. Here is an example.

In older versions of HP-UX, processes were kept in a table which is allocated at boot. Once created it is fixed. It will never grow (to allow for more processes) or shrink (to save space).

A PERL script fragment to load every process might look like this:

```
# get the whole process table
&Send('load struct proc from proc max nproc');
&TossResponse(); # real routines should check for errors

# keep only the valid entries
&Keep('p_stat != 0');

# the "keep" created a new pile, clean up the previous one
&Forget(-1);
```

If the process table is turned into a linked list, as done in later kernels, process structures could be created and destroyed at will saving memory when the load was light but still providing for heavy loads.

A PERL script fragment to handle the linked list might look like this:

```
# get the process list
# (the 1000000 is an upper bound we don't expect to hit)
&Send('load struct proc from proc_list next p_factp max 1000000');
&TossResponse(); # real routines should check for errors

# no need for a "Keep" since the list only contains real processes

# no need for a "Forget" because we only created the pile we want
```

Now both of these examples are pretty simple, but if a change like this were made in the kernel the user would have to know which kernel produced the dump to know which script to use. This is a real nuisance and is error prone besides.

It would be far better if the script was prepared for either kernel. This can be very easy to do if just a little care is taken making the kernel changes. One such example is introduction of a kernel variable, *dpta_supported*, with the introduction of dynamic process table allocation. By looking at the value of *dpta_supported*, can tell whether the kernel supports dynamic process table allocation or not.

Here is a replacement for the previous examples that can handle either data structure automatically.

```
# does this kernel support dynamic process allocation?

local($res) = &Evaluate("dpta_supported");
local($dpta);
if ($res =~ /no/) {
```

```
      $dpta = 0;
   } else {
      $dpta = 1;
   }

   # the kernel global, dpta_supported, was added so only the
   # linked list version of the kernel has this variable and we
   # can use it to differentiate between the two types of kernel
   # at debug-time.

   if ($dpta == 0 ) {
      $aplr = &Load('struct proc from proc max nproc');
      if($aplr <= 0) {
         printf( "Fatal error, no processes to load!\n");
         die;
      } else {
      # keep only the used ones
         $aplr = &Keep('p_stat != 0');
         &Forget(-1);
      }
   } else { # This is DPTA
      $aplr = &Load('struct proc from proc_list max nproc next
      p_global_proc');

      if($aplr <= 0) {
         printf( "Fatal error, no processes to load!\n");
         die;
      } else {
         # keep only the used ones
         $aplr = &Keep('p_stat != 0');
         &Forget(-1);
      }
   } # end DPTA case
```

By isolating this knowledge of the data structure in a single routine make the rest of the library of debugging routines independent of the navigation required to get the data structures. This will pay off down the road when the data structures change again and have less debugging code to change when the schedule can least afford it.

8 Command Quick Reference

The most commonly used KWDB commands for kernel debugging are listed here. For a complete list of commands and details of each command with examples, may use the help command from within KWDB. KWDB allows partial commands to be entered as long as there is no ambiguity. All address arguments are virtual addresses unless specified otherwise.

Commands

The command groups in this chapter are described in the most probable order of use:

Starting KWDB

kwdb [*options*] *kernel_file*

Start KWDB on a copy of the target kernel executable file on the host system. Options for all the Starting KWDB commands are:

-m	Process loaded DLKM modules for debugging
-p	Start KWDB to run PERL scripts
-q4	Start KWDB in Q4 mode
-write	Allow writing into kernel files or memory
-s=SYMFILE	Source symbols from file specified by SYMFILE

kwdb [*options*] [*kernel_file*] *crash_dump_directory*

Start KWDB for crash dump analysis

kwdb [*options*] *kernel_file remote_system:port*

Start KWDB for remote crash dump analysis

kwdb [*options*] *kernel_file* `/dev/[k]mem`

Start KWDB for live memory analysis

Further control how KWDB starts by using GDB command line options.

Stopping KWDB

INTERRUPT	**Ctrl-c** terminate current command, or interrupt target kernel
quit	Exit KWDB; also **q** or **EOF** (**Ctrl-d**)

Getting Help

help	list classes of commands
help *command*	describe command

Attaching and Debugging Targets

attach 0 [*target_id*]

Attach to target:	**target_id is:**
Console target	Not used
Halfdome SUB/SINC	Partition name
IPF LAN	Ethernet MAC address of target LAN
IPF RS-232	Not used

Lantron serial	Not used
NDDB 11.0 or earlier	Ethernet MAC address of target LAN
S700/S800 RS-232	Not used
S700/S800/V-Class LAN	Ethernet MAC address of target LAN
UDP connection	Not used

detach release target from KWDB control and allow it to continue

kill release target from KWDB control and reboot

target console *lantron_name:20nn*

Debug using the on-console debugger and KWDB via the remote console. *nn* is the port number for the remote console

target crash *crash dump*

Specify that the target is a crash dump. The **attach** command is not used with this target.

target devmem

KWDB runs on the target system and debugs live memory using `/dev/mem` or `/dev/kmem`. The `attach` command is not used with this target.

target ia64_kern *comm_server*[:47001]

Set up LAN-based debugging via KWDB server on *comm_server* for IPF architecture.

target serial *devicefile*

Set up RS-232-based debugging via specified serial device file.

target lantron_serial *lantron_name:30nn*

Set up Lantron serial debugging. *nn* is the serial port on the target system.

target nddb -h *comm_server* **-t** *ethernet_address*

Debug an 11.0 or earlier kernel using nddb compatibility mode.

target pa_kern *comm_server*[:47001]

Set up LAN-based debugging via `kwdbd` server on *comm_server* for PA-RISC architecture.

target sub *name_of_sub*:[:47001]

Set up Superdome/Matterhorn/Keystone/Orca debugging via SUB/SINC.

target udp *ip-address*

Set up udp-based debugging. *ip-address* is the IP address of the target.

Breakpoints

b[**reak**] [*file*:] *line*

Set breakpoint at *line* number [in *file*]

break [*file*:] *func*

Set breakpoint at function *func* [in *file*]

break **addr*

Set breakpoint at address *addr*

break

Set breakpoint at next instruction

break [location]if *expr*

Break conditionally on nonzero *expr* at next instruction (or location specified as line or address or function)

break [location]thread *thread_id*

Break conditionally on thread number specified by *thread_id* at the location specified as line or address or function

hbreak [*file*:] *line*

Set hardware breakpoint at `line` number [in *file*]

hbreak [*file*:] *func*

Set hardware breakpoint at function `func` [in *file*]

hbreak **addr*

Set hardware breakpoint at address *addr*

hbreak

Set hardware breakpoint at next instruction

hbreak [location]if *expr*

Break (hardware breakpoint) conditionally on nonzero *expr* at next instruction (or location specified as line or address or function)

hbreak [location]thread *thread_id*

Break (hardware breakpoint) conditionally on nonzero *expr* at next instruction (or location specified as line or address or function)

clear

Delete breakpoints at next instruction

clear [*file*:] *func*

Delete breakpoints at entry to *func()*

clear [*file*:] *line*

Delete breakpoints on source line

commands *n* [**silent**] *command-list* **end**

Execute *command-list* every time breakpoint *n* is reached

cond *n* [*expr*]

New conditional expression on breakpoint *n*; make unconditional if *expr* is omitted

delete [*n*]

Delete breakpoints [or breakpoint *n*]

disable [*n*]

Disable breakpoints [or breakpoint *n*]

enable [*n*]

Enable breakpoints [or breakpoint *n*]

ignore *n count*

Ignore breakpoint *n, count* times

info break

Show breakpoints and watchpoints

info module *addr*

Show the module to which a given address belongs. The address may belong to the text or data segment of the module

info func *func-name*

Show all the inlined instances of the function *func-name* along with the places where this function is inlined along with the line numbers in the caller where this function is inlined.

info target

Gives detailed information about the target to which kwdb is attached.

tbreak … [args]

Like break command except the breakpoint is temporary; disabled when reached. It accepts args as in break command.

watch **addr*

Set watchpoint at address *addr* - by default; four bytes will be watched

watch *name*

Set watchpoint at global symbol specified by *name*

watch *name* **length** *length*

Set watchpoint starting from address corresponding to the symbol indicated by the *name* to address + length

watch_target *addr*

This command takes *addr* as a pointer and puts a watchpoint on the target of that address.

Kernel Stack

backtrace [*n*], **bt** [*n*]	Trace all frames in stack; or of *n* frames – innermost if *n*<0, outermost if *n*>0
down *n*	Select frame *n* frames down
frame [*n*]	Select frame *n* or frame at address *n*; if no *n*, display current frame
info all-reg	Display all registers including floating point registers (not supported in PA-RISC architecture)
info args	Arguments of selected frame
info frame [*addr*]	Describe selected frame, or frame at *addr*
info locals	Locals of selected frame
info reg [*rn*]	Register values [for reg *rn*] in selected frame

up *n*	Select frame *n* frames up

Execution Control

call *function(arg1, arg2,...arg8)*	Call function with up to eight 64-bit sized arguments
continue [*count*]	Continue running; if *count* specified, ignore this breakpoint *count* times
finish	Run until current function returns
jump **address*	Resume execution at specified *address*
jump *line*	Resume execution at specified *line* number
next [*count*]	Like `step` command but do not step into functions
nexti [*count*] **ni** [*count*]	Like `stepi` command but do not step into functions
return [*expr*]	Pop selected stack frame without executing [setting return value]
set var = *expr*	Evaluate *expr* without displaying it; use for altering kernel variables
step [*count*] **s** [*count*]	Execute until another source line is reached; repeat *count* times if specified
stepi [*count*], **si** [*count*]	Step by machine instructions rather than source lines
until [*location*]	Run until next instruction (or *location* specified as line or address or function)

Display

disassem [*addr*]	Display memory as machine instructions for the function at addr
disassem [*func*]	Display memory as machine instructions starting at function *func*
disassem filename:[*func*]	Display memory as machine instructions starting at function *func* present in the file filename.
print [*/f*] [*expr*]	Show value of *expr* [or last value $] according to format *f*:
	a address, absolute and relative
	c character
	d signed decimal
	f floating point
	o octal
	t binary
	u unsigned decimal
	x hexadecimal
x [*Nuf*] *expr*	Examine memory at address *expr*; optional format specs are:
	N count of how many units to display
	u unit size; one of
	b — individual bytes
	g — giant words (eight bytes)

	h — half words (four bytes)
	w — words (four bytes)
f	printing format. Any **print** format, or
	i — machine instructions
	s — null-terminated string

Automatic Display

disable disp *n*	Disable display for all expression(s) or one or more expressions specified by list number.
display [/f] *expr*	Show value of *expr* each time kernel stops [according to format *f* listed with x command]
display	Display all enabled expressions on the list created with display command.
enable disp *n*	Enable display for all expression(s) or one or more expressions specified by list number.
info display	Numbered list of display expression(s)
undisplay *n*	Remove all or one or more expressions specified by list number from list of automatically-displayed expressions

Expressions

expr	An expression in C or any language supported by the WDB code base, or:	
	addr@len	an array of *len* elements beginning at *addr*
	file::nm	a variable or function *nm* defined in *file*
	(type)addr	read memory at *addr* as specified *type*
$	Most recent displayed value	
$_	last address examined with **x**	
$__	Value at address **$_**	
$*n*	*n*th displayed value	
$var	Convenience variable; assign any value	
$$	Displayed value previous to **$**	
$$*n*	*n*th displayed value back from **$**	

Symbol Table

info var [*regex*]	Show names, types of global variables (all, or matching *regex*)
info address *s*	Show where symbol *s* is stored
info func[*regex*]	Show names, types of defined functions (all, or matching *regex*)
ptype [*expr*] **ptype** *type*	Describe type, struct, union, or enum
whatis [*expr*]	Show data type of *expr* (or **$**) without evaluating

Source Files

dir *names*	Add directory *names* to front of source path
dir	Clear source path
forw *regex*	Search following source lines for *regex*
info line *num*	Show starting, ending addresses of code for source line *num*
info source	Show name of current source file
info sources	List all source files in use
list	Show next ten lines of source list
list -	Show previous ten lines
list *f,l*	From line *f* to line *l*
list *lines*	Display source surrounding *lines*, specified as:
	**addr* line containing *addr*
	[*file*:]*num* line number [in named file]
	[*file*:]*func* beginning of function [in named file]
	+off *off* lines after last printed
	-off *off* previous to last printed
rev *regex*	search preceding source lines for *regex*
show dir	show current source path

DLKM Commands

catch load [*modname*]	Stop on loads of module *modname*. If modname omitted, catch all loads.
catch unload [*modname*]	Stop on unloads of module *modname*. If modname omitted, catch all unloads.
info sharedlibrary	Display information about loaded modules
path *directory*	Add *directory* to search path for kernel modules
tcatch load [*modname*]	Like catch but temporary — deleted when hit. If modname omitted, catch all loads.
tcatch unload [*modname*]	Like catch but temporary — deleted when hit. If modname omitted, catch all unloads.
uncatch load [*modname*]	Do not catch load for *modname*. If modname omitted, do not catch any loads.
uncatch unload [*modname*]	Do not catch unload for *modname*. If modname omitted, do not catch any unloads.

Special Kernel Debugging Commands

cpu select *n,* **cs** *n,* **set cpu** *n*

Select CPU #*n* as the viewed CPU.

set crash event *n*

Set crash event *n* as current context, *n* is the index of event in crash event table.

set kwdb cache [on | off]

Turn memory caching on or off.

set kwdb controlregs [on | off]

Enable/disable display of IPF control registers.

set kwdb floatregs [on | off]

Enable/disable display of IPF floating point registers.

set kwdb log [on | off]

Set logging of KWDB output to file `kwdb-log`.

set kwdb logfile *name*

Change name of log file from `kwdb-log` to *name*.

set kwdb memory_cache *number*

Set number of pages for caching memory read from crash dump. Default is 10007 pages.

set kwdb ntimeout *number*

Set number of retries for remote network I/O.

set kwdb performanceregs [on | off]

Enable/disable display of IPF performance registers.

set kwdb remotelog [on | off]

Log data packet communications to and from the target to file `kwdb-remote-log` for support purposes.

set kwdb q4 [on | off]

Set KWDB to q4 mode or turn q4 mode off.

set kwdb spaceid *sid*

Set virtual space ID for memory access.

set kwdb timeout *number*

Set timeout for remote network I/O in tenths of seconds.

set kwdb pile-cache-dir *directory*

Set the directory for storing the pile objects in kwdb.

set kwdb pile-cache-limit *number*

Set the limit on the number of structures in the piles, exceeding which the pile object will be written to the file.

set kwdb recursive-backtrace [on/off]

Enables printing of stacktraces of recursive (inlined or non-inlined) functions.

set kwdb pile-memory-limit <*number*>

Set the maximum limit for in-memory storage of piles (in bytes)

set kwdb ttyoutput [on | off]

Set terminal output on/off.

set print strings [on | off]

Control printing of strings referenced by character pointers.

set thread *addr*

Set thread with given address *addr* as current context. To find out what threads are running on the target system, use the `info threads` command.

Q4 Commands

Some of the q4 commands are prefixed with q4 because the same commands exist in KWDB with different behavior. If KWDB is run in q4 mode, this prefix is not required.

adddebug *file*

Add type information from an object file *file*.

addmodule *modname*

Process the DLKM module *modname* for debugging.

catalog [**-h**] *regex*

Print cataloged types matching *regex*.

-h option to print header even if output is redirected.

code [-o] [*name*|*addr*], **disassemble** [*name*|*addr*]

Prints the assembly code for function *name* or function surrounding the address *addr*.

-o — read from local copy of the kernel file, not from crash dump or remote target.

constant

Print enumerants in symbol table with values.

discard [*cond_expr*]

Discards structures satisfying a condition *cond_expr*.

disassemble [*name*|*addr*]

Prints the assembly code for function *name* or function surrounding the address *addr*.

evaluate *expr*

Evaluate expression *expr*, it may contain:

ltor (*vaddr*)	Get physical address corresponding to the virtual address *vaddr*; *vaddr* can be an expression.
tooffset (*long_addr*)	Get space of *long_addr*.
tospace (*long_addr*)	Move offset of *long_addr* to space.
var_name = *value*	Create a variable *var_name* with value *value*.

examine [*flags*] [*addr*] [**for** *lines*] [**using** [*n*] *fmt*]

Print contents of memory from address *addr* using the format specified.

-o	Flag to read the data from the kernel file and not from the crash dump or to read from the local copy while doing remote debugging.
-r	Flag to read the memory from given address without translation.

addr	Start reading memory from the value of *addr*, *addr* can be an expression. If not given, use its value from previous run.
for *lines*	To specify how many lines to read; lines can be an expression. If not given, use value from previous run. Default value is 1.
using [*n*] *fmt*	Print n items per line as per format specified by *fmt*, which can be any of the following characters:

^ Decrement address by the current increment (that is, back up over the previous value retrieved), nothing is printed.

\+ Increment address by one, nothing is printed.

- Decrement address by one, nothing is printed.

a Print the value of dot as a symbolic kernel address, address is not incremented.

A Print the value of dot as a decimal number, address is not incremented.

b Print a byte in hex, increment address by one.

B Print a byte in octal, increment address by one.

c Print a character, increment address by one.

C Print a character with backslash escapes to make it readable, increment address by one.

d Print a half-word in decimal, increment address by two.

D Print a word in decimal, increment address by four.

f Print an IEEE float, increment address by four.

F Print an IEEE double, increment address by eight.

i Print an instruction, address is incremented by size of instruction.

I Print a bundle of instructions, address is incremented by size of a bundle.

L Print 64 bit in hex, address is incremented by eight.

o Print a half-word in octal, increment address by two.

O Print a word in octal, increment address by four.

P Print the word dot points to as a symbolic kernel address, increment address by four.

s Print a string, increment address by the length of the string (*including* the trailing null character).

S Print a string with enough backslash escapes to make it readable, increment address by the length of the string.

u Print a half-word in unsigned decimal, increment address by two.

U Print a word in unsigned decimal, increment address by four.

x Print a half-word in hex, increment address by two.

X Print a word in hex, increment address by four.

Y Print a word as a date and time string, increment address by four (see *ctime* (3C).

expr

Evaluate expression *expr* (in KWDB q4 mode only)

fields [*flags*] [struct|union] *type*

Listing fields in *type* in format specified by following *flags*:

-c	Option to print fields in C style.
-h	Option to print header even if output is redirected.
-v	Print fields with offset and size in C style.
-x	Option to expand any embedded structures in C style.

find [**-r**|**-o**] *value* [**from** *addr*|**until** *addr*|**max** *num*|**mask** *pattern*]

search a *value* in kernel file. Options **-o** and **-r** have the same meanings as in the **examine** command.

forget [*num* | *-num*| *name*]

delete current pile or a pile specified by:

num	*num* as the pile number
-num	*num* piles before the current pile
name	the pile name

getasm [*args*]

Prints assembly code using external disassembler.

help q4

Prints list of q4 commands.

help q4 *cmd*

Prints help message for q4 command *cmd*.

history

Print the history of loaded data structures.

include *file*

Load PERL script from *file*.

keep [*cond_expr*]

Selects structures satisfying a condition *cond_expr*.

load [**-r**] [*type*] **from** *addr* [**max** *expr* | **skip** *expr*] **next** *next_field* | **until** *addr*]

Reads a collection of structures:

-r	Option to read the structures without address translation.
type	Type of the data structure to read; if the *type* is not given, will use type of *addr* if available.
from *addr*	Start reading structures from the value of *addr*; *addr* can be an expression.
max *expr*	Read at most *expr* number of structures.
skip *expr*	Skip *expr* number of structures before starting to read.

next *next_field*
: Name of the field in the structure which points to the next structure in a linked list.

until *addr*
: Read structures until *addr* is reached; *addr* can be an expression.

merge [*num* | *-num* | *name*]

Merge data from a pile, specified by argument as in forget command, to current pile.

modules

Prints details of currently loaded DLKM modules.

name it [*num* | *-num*| *name*], **call it** [*num* | *-num*| *name*]

Name the current pile or the pile specified with *name*.

pileon [*type*] **from** field

Read structures of type from values of field from current pile.

pophistory

Pop piles marked by last **pushhistory**.

pushhistory

Save state of current pile history for future popping.

q4 print [*options*] *field1* [*%fmt*],*field2* [*%fmt*], ...]

Print fields in current pile. The options are:

%fmt
: Prints numerical value of the field using format *%fmt*; format characters for `printf` can be used in *fmt*.

-d
: Prints integer fields in decimal format.

-h
: Turns on column headings even if the output is redirected.

-H
: Turns off column headings even if the output is not redirected.

-o
: Prints integer fields in octal format.

-t
: Prints fields one per line than in multiple columns.

-x
: Prints integer fields in hexadecimal format.

q4 print [*options*] [*type*] **from** *addr*

Print a structure from the value of *addr*; *addr* can be an expression:

options
: All the options available for the first form of q4 print command shown above are valid.

type
: Type of the data structure to print; if the *type* is not given, use type of *addr* if available.

from *addr*
: Start printing structures from the value of *addr*; *addr* can be an expression.

q4 run *func* [*args*]

Run a PERL script function *func* [with *args*].

q4 symbols *regexp*

Print kernel symbols matching *regexp*.

q4 unset *var_name*

Remove a user defined variable *var_name*.

recall [*num*| *-num* | *name*]

Make a pile, specified by argument as in forget command above, current pile.

system *cmd*

Execute shell command *cmd*.

q4 trace [*options*] **event** *num*

Display stack trace for crash event *# num* (for crash target only). The options for all the `trace` commands are:

-f Print input, local and output registers for each frame.

-u Print arguments for each level and registers for first level.

-v verbose

Output of the `trace` commands can be controlled by setting following q4 variables:

q4PrintArgs Print arguments for each level and registers for first level.

q4UnwLevel Start unwinding stack from the level set by `q4UnwLevel`.

q4MaxStackDepth Maximum number of levels displayed during stack trace. The default is 250.

q4 trace [*options*] *pc sp*

Display stack trace with *pc* & *sp* (PA only).

q4 trace [*options*] **pile**

Display stack trace for structures from current pile for process, processor, thread and crash event structures.

q4 trace [*options*] **process** at *addr*

Display stack trace for process at *addr*.

q4 trace [*options*] **processor** *num*

Display stack trace for processor # num.

q4 trace [*options*] **savestate** at *addr*.

Display stack trace for `savestat` at *addr*.

q4 trace [*options*] **thread** at

addr

Display stack trace for thread at *addr*.

Options are:

q4 translate *addr*

Display page table entry or translation registers used for translating *addr*.

variables

Display all user defined q4 variables and values.

write [-o | -r] *data* at *addr* {using *fmt*}

Write the *data* into the kernel file or memory at address *addr* using the format specified by the format character *"fmt"*. Flags -o or -r have the same meaning as in the examine command. The *fmt* characters can be:

b	write a byte
w	write a half-word (2 bytes)
W	write a word (4 bytes)
L	write a long word (8 bytes)
c	write a character
s	write a string

Other Commands and Features

Other HP WDB commands supported by KWDB but not listed in the quick reference include:

- **cd** *dir*
- **define** *cmd*
- **document** *cmd*
- **file** [*file*]
- **pwd**
- **set** *param value* (see exceptions)
- **shell** *cmd*
- **show** *param*
- **source** *script*

HP WDB commands not supported by KWDB include:

- **core** [*file*]
- **exec** [*file*]
- **gdb** *program core*
- **handle** *signal*
- **run**
- **set args**
- **set env**
- **signal**
- **throw** | **exec** | **fork** | **vfork**]
- **tty**

HP WDB features also supported by KWDB that are not discussed in detail here are:

- The `csh` like history substitution.
- The `Emacs` style and `vi` style inline editing of commands.
- Storage and recall of command history across debugging sessions.
- User defined commands, command hooks, and command files.

9 Troubleshooting

This chapter contains information to help recognize and resolve some common problems encountered when debugging remote targets and when running KWDB with PERL. At the end of this chapter, there is a list of error messages and the corresponding corrective actions recommended for each error message.

Problems While Debugging Remote Targets

- Networking services fail to start at system startup on a target being debugged via LAN communications.

  The most common cause of this problem is that the LAN interface used for KWDB communication is also configured for HP-UX networking. See *Chapter 2, "Setting Up KWDB for Remote Debugging,"* for more information.

- KWDB cannot connect to the target. Check all of the following:

  — On the target, verify the correct boot flags were used to boot the kernel.

  Verify that target waits for a KWDB connection at boot time (if booted with boot-and-wait flags appropriately). The target should print `waiting for kwdb to attach`, or for older kernels it will hang after the `size and start address line` is printed and not proceed until you resume execution after connecting with KWDB.

  If the target boots up without waiting for a KWDB connection, it may mean that the hpux `-f` flag value is incorrect for PA or that the flag value is incorrect for IPF. It may also mean that no LAN or RS-232 device was found that may be used for KWDB communications. See *Chapter 2, "Setting Up KWDB for Remote Debugging,"* for information on what devices are needed.

  — Verify the correct communications link information is specified to the host debugger.

  For RS-232 communications, verify the proper serial device on the host is selected. The default serial device used on the host is `/dev/tty1p0`; if you have connected the RS-232 cable to a different serial port you must specify the correct device file.

  For LAN communications, verify that the correct hostname, where the `kwdbd` communications server executes, has been entered, and that the correct Ethernet station address has been entered.

  — Verify the communications link is correct.

  For RS-232, verify the correct cables are connected to the correct ports. See *Chapter 2, "Setting Up KWDB for Remote Debugging,"* for more information.

  For LAN, verify the `kwdbd` communications server is executing (receive a `connection refused` error if not), that the `kwdbd` system has a LAN interface that is connected to the same subnet as the target system, and that `kwdbd` is configured to manage connections over that LAN interface using the `-f` runstring option (normally set in file `/etc/rc.config.d/kwdbd`). See *Chapter 2, "Setting Up KWDB for Remote Debugging,"* for additional information.

- Debug information is not present in the kernel file or DLKM module.

  Ensure that the modules to generate debug information are actually compiled with the symbolic debug turned on (`-g`). For IPF the *`+noobjdebug`* flag must also be specified.

  If debugging `vmunix` or a DLKM module, ensure the module in which you are interested is actually loaded into the kernel. Check whether the kernel or DLKM module you are debugging has been stripped of debug info using different utilities depending on whether you are debugging a PA or IPF system. On PA, use `odump -spaces` or `odump64 -h` on your file. On IPF use `elfdump -h`. A file with source level debugging info will contain a `$DEBUG$` space (32-bit SOM) or `.debug_gntt` section (64-bit ELF) on PA and on IPF will contain a section called `.debug`. The presence of debug info indicates that the kernel contains some debug information, but does not necessarily indicate that the debug information includes the routines and data types in which you are interested. All "debug" flavor kernel builds originally contain some debug information for use by crash dump analyzer, and so the presence of debug information does not necessarily indicate that it has successfully compiled the debug info of interest into the kernel.

- The kernel boots without pausing for a KWDB connection.

  Check that the kernel is booted with the appropriate boot flag. Refer to *Chapter 3, "Getting Started with Remote Debugging."*

  This may also mean that no LAN or RS-232 device was found that may be used for KWDB communications. See *Chapter 3, "Getting Started with Remote Debugging,"* for information on what devices are needed.

- KWDB can not set breakpoints at functions or read variables, complaining that the address cannot be read. The address looks like an invalid value.

  This often means the file has been compiled with incorrect options, such as options that specify optimization that is incompatible with source level debugging.

- Attach to a kernel booted to stop and wait for a client connection does not say the kernel is stopped at `kgdb_break` (PA) or `kwdb_kern_break` (IPF) but reports some other symbol instead.

  This often means the versions of the kernel executable files on the host and target systems do not match. Make sure the kernel file on the host system is for the same build as the kernel file booted on the target.

- **Ctrl-c** does not interrupt KWDB.

  The `stty` setting might not be correct. Make sure that interrupt is defined as **Ctrl-c**.

Problems While Running KWDB with PERL

- Customization Issues

  Because the PERL extensions to KWDB can be configured in many flexible ways, be aware of the ways that the system may be custom configured. Here is how to customize KWDB to run PERL scripts.

  — Move the Q4 subdirectory out of `/usr/contrib/` to the directory of choice. Study the `$Q4_ROOT/bin/set_env` script. There the KWDB/Q4 installation can be moved from the default `/usr/contrib/Q4` subdirectory to any directory and change the `Q4_ROOT` and your `PATH` *`env`* parameters.

  — Install an alternative version of PERL. Set your `Q4_PERL_PATH` *`env`* variable to use the version.

  — Use an alternative startup script. Set your `Q4_STARTUP_SCRIPT` *`env`* variable to indicate your desired startup script.

  — Modify the startup script. Change the `@INC PERL` array. This array should include desired load path which controls the resolution of `use`, and `require` functions in interactive use and in the PERL scripts and modules. Modify the startup script so the choice of scripts are included and executed as part of startup.

- KWDB does not use the best PERL available on the system.

  Verify your `Q4_PERL_PATH` *`env`* variable points to the new PERL installation. If no `Q4_PERL_PATH` *`env`* variable, KWDB will look first for `$Q4_ROOT/bin/perl` and if there is no executable at `$Q4_ROOT/bin/perl`, KWDB will test for an executable in your path.

- KWDB can not find the `q4.pl` script

  Verify that the startup script exists. This file can be specified by the `Q4STARTUP_SCRIPT` *`env`* variable. If this variable does not exist check the `$HOME/.q4rc.pl` script. If no `$HOME/.q4rc.pl` script, check the `/.q4rc.pl` script.

  An informative message should be received about which subdirectory was searched when KWDB was trying to access the `q4.pl` file.

- Included script does not work

  Check to make sure the script can be processed by PERL with no compile error by running PERL with the `-w` option like so: `perl -w myscript.pl`.

- Scripts hang

  Here's how to debug a hanging script.

  Trace the dialog between the PERL process and the KWDB process. There is a global variable, *`$traceDialog`*, which can be set to the value of file path. If *`$traceDialog`* is defined then every message sent and received by the PERL process will also be written to that file. There are functions `TraceOn` and `TraceOff` defined in sample `.q4rc.pl` which can help control tracing. Interactively turn tracing on and then from another session tail the dialog file while KWDB is processing the script. See the last exchange. The problem may have to be recreated interactively to understand what is failing. The `TraceOn` and `TraceOff` functions can also be called within a script to build the trace under program control.

  It is possible to debug PERL scripts by starting PERL in debug mode. This can be done by invoking KWDB with the `-P` option, but install a version of PERL that supports the debugging functionality.

Error Messages

These are some of the common KWDB specific warning and error messages. This section is not an extended list of all gdb error messages.

- `Bad File Number`

  This message might occur after issuing the `target` command when attempting to connect the KWDB remote client to the target. Usually it means that the KWDB communications server is not running.

  Corrective Action: Make sure that the `kwdbd` program is running on the system selected as the communications server host.

- `Can't Attach to Task`

  This message might occur after issuing the `attach` command when attempting to connect the KWDB remote client to the target.

  Corrective Action: For PA-RISC systems it might mean that a kernel is older than 11.0 and need to use `kwdb` in nddb compatibility mode.

- `Can't Complete Breakpoint Transfer, You're in Big Trouble Now`

  This message indicates an internal error in KWDB.

  Corrective Action: Contact the HP support representative with a complete description of the target machine, target kernel and exactly what events occurred prior to getting this message.

- `Can't Do That Without a Running Program; Try "break main" "run" First`

  This message occurs when trying to set a data watchpoint before attaching the program.

  Corrective Action: Issue the `attach` command before setting a data watchpoint.

- `Couldn't Construct Load Module Descriptor for Unwinding`

  This message could occur when first attaching KWDB or when interrupting a running kernel. This message is sometimes harmless and KWDB will continue to function normally.

  Corrective Action: If this message is repeated with each command entered or if the target appears to hang, contact the HP support representative with a complete description of the target machine, target kernel and exactly what events occurred prior to getting this message.

- `Error 14 While Unwinding`

  This message could have a number of causes and needs to be analyzed on a case by case basis. These are a few reasons for this message:

  — The host and target versions of the kernel or DLKM module don't match.

  Corrective Action: Verify the host and target kernel and DLKM modules match.

  — The DLKM module has multiple unwind sections on an IPF system. This could happen if using C++ in a DLKM module.

  Corrective Action: Use the `elfdump -h` command on the DLKM module and look for the IA64 unwind section. If there is more than one, that is the cause of the problem. This problem will be fixed in 11.23 and a patch is available for 11.22. Contact the HP support representative to obtain the patch.

  — If the message occurs after issuing a `step` or `next` command, see if the line or instruction was a function call. If so, the unwind information in the function might be faulty or missing.

Corrective Action: Set a breakpoint immediately after the function call and do a `continue` rather than a `next` or `step` command.

- `Kernel module <name> not found. Try adding the directory in which it lives to your path environment variable.`

  This message occurs when a load of a DLKM module occurs and the remote KWDB client cannot find a local copy of the DLKM module.

  Corrective Action: Copy the DLKM module from the target to the host system and use the `path` command if necessary to specify the directory in which it is located.

- `KWDB: kdebug_kern_ttrace() kdebug_errno:<number>`

  This message is sometimes displayed by KWDB when a command was not able to complete properly. The <number> is usually the standard UNIX *errno* value. This message can occur when setting a breakpoint or watchpoint, or accessing registers or memory. The problem is often intermittent and caused by communication problems between the host and target systems.

  Corrective Action: If it persists or if the message is repeated for every command issued, contact the HP support representative with specific details regarding the target system, target kernel, and exactly what sequence of commands caused the problem. A KWDB “screenshot” would be helpful.

- `No Debugging Symbols Found`

  This message indicates that KWDB did not find any symbolic debugging information in the kernel.

  Corrective Action: See Debug information is not present in kernel file or DLKM module in the *Problems While Debugging Remote Targets* section.

- `No Debugging Symbols Found in DLKM Module`

  This message indicates that KWDB did not find any symbolic debugging information in the DLKM module.

  Corrective Action: See Debug information is not present in kernel file or DLKM module in the *Problems While Debugging Remote Targets* section.

- `Pxdb Internal Warning: Unimplemented gntt kind 256`

  This message can occur when debugging a DLKM module from a 32 bit PA-RISC system. It is usually accompanied by many more like it.

  Corrective Action: Install patch `PHCO_22899` on the target 32 bit system.

- `Unsupported Feature Number From Remote Stub: <number>`

  This message means that the version of KWDB that is embedded in the `vmunix` kernel is newer than the remote KWDB client.

  Corrective Action: Upgrade to the latest version of KWDB to make use of all the features that the `vmunix` kernel provides.

- `Warning: pxdb not found at standard location: /opt/langtools/bin kwdb will not be able to debug <filename>. Please install pxdb at the above location and then restart kwdb. Warning: File <filename> not processed by pxdb. No symbolic debugging will be possible - assembly level debugging only!`

  This message is issued when KWDB needs to run `pxdb` utility on a file and is not able to find `pxdb` in standard location. The `pxdb` utility processes PA-RISC symbolic debug information into a form that KWDB can understand. Without it, only assembly level debugging is possible. This message can occur in two separate circumstances:

1. When KWDB catches a load or unload of a DLKM module. In this case, the <filename> refers to a temporary version of the DLKM module stored in /var/tmp.
2. When first invoking KWDB on a vmunix kernel file. In this case, the <filename> refers to the vmunix file.

Corrective Action: As the message suggests, install pxdb at standard location: /opt/langtools/bin. If the pxdb is in another directory, assign the full pathname of the pxdb executable to the exported shell variable PXDB (all caps). KWDB will then invoke the version of pxdb defined by the PXDB shell variable. If this message is issued for the vmunix file, also run pxdb on that kernel manually and restart KWDB (this will not work for DLKM modules). For DLKM modules, use a version of pxdb that processes 64-bit ELF files. This message is specific to PA-RISC systems and will not occur when the target system is IPF.

10 Guide to Writing KWDB Compatible Code

This chapter describes how to add KWDB support to the kernel and DLKM modules for new data structures and how to make changes to the kernel without disturbing the existing support for debugging remote systems and analyzing crash dumps and live systems.

How to Write KWDB Compatible Kernel Code

This section presents guidelines on how to write code that can be debugged using KWDB, and how to make changes to the HP-UX kernel that are compatible with KWDB.

If modifying code in the HP-UX kernel, and the existing code contains sections that are `#ifdef`'d with symbol `KGDB_ON`, or references to variables or functions that begin with identifier `kdebug_`, `kgdb_`, `kwdb_`, or `rdb_`, then the code in question interacts with KWDB. Discuss any proposed changes to the code with the KWDB team first to ensure that KWDB continues to function on the target kernel after the changes.

Kernel locations that currently contain KWDB "hooks" include the following:

- `$locore`, `$ihandler`, and `$thandler`
- Level 1 (real mode) I/O configuration
- `io_scan` operation for various CDIOs
- Clock interrupt code
- `realmain` callouts

KWDB depends on the following functionality:

- Reading and writing kernel memory.
- Intercepting interrupts and traps such as `I_BRK_INST` and `I_EXT_INTP`. Note that KWDB services interrupts even during real mode.
- Interrupting execution of a running kernel, either by polling the communication device during a clock tick interrupt or through the normal PA EIR mechanism, depending on the device. KWDB's interrupt is enabled for all `SPL` levels except `SPL7`.
- Communicating over its communications device at all times. If intervening hardware such as bus adapters are configured, reconfigured, have coherent I/O turned on, and so forth, KWDB may need to reconfigure its own communications over the device. Note that KWDB begins communicating during real mode, even before level 2 I/O configuration during virtual mode.
- Accessing the `save_state_t` data structure. If a particular machine register is not saved in the kernel's `save_state` then KWDB reads and writes the register directly, rather than modifying `save_state` fields. If the set of registers saved in `save_state` changes, KWDB may also need to change.
- Freezing execution of the system for long periods of time without panicking or causing other serious disturbance to system operation. See *Chapter 4, "Command Reference,"* for more information.

Adding New Data Structures

KWDB can manipulate and print any kernel data structure — which appears in the kernel's symbolic debug information. This means add support for favorite data structures without having to change KWDB.

What's Needed

Access to these data structures during debugging is usually through global variables or local variables if at breakpoint.

In addition to `struct`'s and `union`'s KWDB can also handle `enum`'s. KWDB prints the values of fields declared as enumerated types symbolically, therefore debugging is easier if fields are declared using enumerated types rather than `int`'s and `#define`'s.

Adding a New Data Structure

Here is the simple recipe for adding a new data structure:

1. Create a source file for your subsystem or driver's KWDB debug information. It should be a real source file (`foo.c`), not a header (`foo.h`). If such a file is already created for other data structures, reuse it here.
2. Define the data structure in the file. The most common way to do this is to `#include` in this file whatever header file actually defines the data structure.
3. Arrange for this file to be compiled with symbolic debug turned on (`-g` and `+noobjdebug`) and the optimizer turned off (no `-O`).
4. Arrange for the object file produced from this source (`foo.o`) to be linked into the kernel whenever the subsystem or driver is linked in. This may mean:
   - — explicitly pulling it out of a library and linking it in, or
   - — including in it a symbol definition that is referenced in your subsystem or driver's code.

There are several caveats worth mentioning:

- This file should not be used for anything but KWDB definitions. Since symbolic debug will be turned on for the entire file any code appearing in it will not be optimized (or optimized poorly). Also, symbolic debug info will be generated for this code which will make the `vmunix` file bigger but which KWDB will not use.
- If a data structure already appears in the symbolic debug info try not to include it again. Doing so doesn't break anything, but it does make the `vmunix` file bigger.

Testing New Entry

After adding a definition for the new data structure, test it before shipping. The obvious way to do this is to use KWDB.

The approach is:

1. Build two kernels, one with the subsystem or driver included, one without.
2. Verify that the data structure appears in the first kernel and is correct.
3. Verify that the data structure does not appear in the second kernel and that this kernel is smaller (size of the `vmunix` file) than the first. (The data structure may appear anyway and the `vmunix` files may be the same size if another subsystem or driver included in the kernel has defined it. Don't worry about this case unless the data structure was not defined.)

To find out if the data structure has been included in the kernel run KWDB on the kernel (don't need a dump for this) and use the `catalog` command to look for it.

For example, suppose the data structure is called a `struct timeval`. It might look like this:

```
$ kwdb vmunix
(kwdb) catalog timeval
BYTES FIELDS SHAPE   NAME
    8      2  struct ki_timeval
    8      2  struct lvm_timeval
   16      2  struct timeval
    8      2  struct timeval_new
   32      3  struct timeval_record
(kwdb)
```

In this case, look for in the third line of output below the heading. It is possible to limit the output by modifying the command as:

```
(kwdb) catalog   ^timeval$
BYTES FIELDS SHAPE   NAME
   16      2  struct timeval
(kwdb)
```

Now that the definition is there, make sure it's right. Use the `fields` command for that. Continuing the previous example:

```
(kwdb) fields -c struct  timeval
struct timeval {
   u_int tv_sec;
   long tv_usec;
}
(kwdb)
```

If this is the correct definition we're done.

Adding New Constants

Since KWDB can manipulate fields symbolically that were declared to be of an enumerated type, use this mechanism rather than `int`'s and `#define`'s.

For example,

```
enum flags (
        FOO = 1,
        BAR = 2,
        BAZ = 4
);

struct sample (
        ...
        enum flags s_flags;
        ...
);
```

is better than

```
#define FOO    1
#define BAR    2
#define BAZ    4

struct sample (
         ...
        int s_flags
         ...
);
```

If print an `s_flags` field with the second set of definitions (might see 6). With the first set see `BAZ|BAR` which is usually more useful.

Even though KWDB uses the symbolic enumerants by default (when the definitions are present) always override it and use the numeric form. Without the definitions, however, don't go back the other way because the information just isn't there.

To add KWDB support for existing data structures, if these structures have already been seen by customers it may not be free to change `#define`'d constants to enumerants. Work around it as in this example:

Imagine a field `signo` declared as an `int` with the following possible values:

```
#define SIGHUP  1
#define SIGINT  2
#define SIGQUIT 3
```

Create a new enumerated type like this:

```
enum signals {
       sighup  = SIGHUP,
       sigint  = SIGINT,
       sigquit = SIGQUIT
};
```

and change the declaration of `signo` to an `enum` signals.

KWDB can now manipulate and print the field symbolically without requiring any customer code be rewritten, recompiled or relinked. Because the enumerants are defined in terms of the original constants, the chance of mis-typing or an other error setting the wrong value, is reduced.

It may be that a case like the one above, except the field is declared as a `char` or `short`. Knowing that enumerated types are the same size as `int`'s.

The HP-UX C compilers permit the constructs `char enum` and `short enum` (which do the obvious thing).

If compiling in ANSI mode, consider switching to extended ANSI mode (`-Ae` to the C compiler) which permits use of these constructs in an otherwise ANSI C environment.

Testing New Constants

Testing enumerated types is done the same way as structures and unions.

When printing an enumerated type, it will be something like this:

```
(kwdb) fields -c enum proc_state
enum proc_state {
  SUNUSED = 0,
  SWAIT = 1,
  SIDL = 2,
  SZOMB = 3,
  SSTOP = 4,
  SINUSE = 5
  }
(kwdb)
```

How to Avoid Breaking KWDB

For most accesses into the crash dump KWDB is able to use the symbolic debug information compiled into the kernel to figure out what's in a structure and how it's organized.

There are a few things in the dump, however, that KWDB has to know more about. These are things like the address translation and stack tracing algorithms where knowing the layout of the data structures is not enough.

For these subsystems KWDB is actually hard coded with its own version of the algorithm the kernel uses. If the workings of any of these subsystems is changed KWDB must be changed with it. Therefore, it is strongly suggested these things not be changed or, if one of them must be changed for some reason, please:

1. Notify the KWDB project of the changes far enough in advance that can have an updated KWDB ready for use when the changed subsystem is checked in.
2. Make sure there is some way to tell from the `vmunix` and image files alone which version of the code was used. One such example is introduction of dynamic process table allocation. A kernel variable, `dpta_supported`, was added with the introduction of dynamic process table allocation. By looking at the value of `dpta_supported`, we can tell that whether the kernel supports dynamic process table allocation or not. This is explained in more detail in *Chapter 7, "KWDB PERL Programming Reference."*

Kernel Symbols Used

KWDB uses the following kernel global variables:

```
utsname
HPUX_Support_String
_release_version

crash_processor_table
crash_event_table
crash_event_ptr
ct_normal
ct_panic
ct_toc
ct_hpmc
panic_save_state
panic_second_save_state


tr_desc
vhpt
vhpt_size
em_as_limits
htbl
htbl2_0
nhtbl2_0
pdirhash_type
inverted_space_hash_mask
mid_variable_page_power
```

```
mpproc_info
nmpinfo
spu_info

modhead

proc
proc_list
```

Address Translation

To be able to find things in a crash dump or in `/dev/[k]mem` on a live system, KWDB has to know how to translate virtual addresses into physical address. Any change in the address translation algorithm has to be taken care of in KWDB as well.

In addition to knowing the address translation algorithm and associated kernel variables, KWDB uses the following fields in the following data structure. Though using only the listed fields for the time being, it may be possible to use other fields as well in future. It will be good if any change in these structures is communicated.

- `struct hpde`

  ```
  pde_next
  pde_vpage
  pde_phys
  pde_space
  pde_valid
  ```

- `struct hpde2_0`

  ```
  pde_invalid
  pde_next
  pde_phys
  pde_vpage
  ```

- `struct tr_entry_t`

  ```
  tr_state
  tr_tpa
  tr_itir
  tr_tva
  tr_rr
  ```

- `union rr`

  ```
  bits.rid
  bits.ps
  ```

- `union itir`

  ```
  bits.ps
  ```

- `union tpa`

  ```
  bits.ppn
  bits.p
  ```

- `struct pte`

  ```
  tpa.bits.p
  tpa.bits.ppn
  itir.bits.ps
  pte.tag
  ```

Stack Traces

In addition to knowing the algorithm for stack tracing, KWDB uses following fields in the following data structures. Though using only the listed fields for the time being, it may be possible to use other fields as well in future. Therefore, it will be good if any change in these structures is communicated.

- `crash_event_t`

  ```
  cet_event
  cet_hpa
  cet_savestate
  cet_handle
  ```

- `frame_marker_t`
- `kthread_t`

  ```
  kt_nextp
  kt_procp
  kt_tid
  kt_upreg
  ```

- `union mpinfou`

  ```
  pdkptr
  pikptr
  ```

- `mpinfo_t`

  ```
  ibase
  prochpa
  procp (used only with nonthreads kernels)
  threadp (used only with threads kernels)
  ```

- `preg_t`

  ```
  p_space
  p_vaddr
  ```

- `proc_t`

  ```
  p_firstthreadp
  p_lastthreadp
  p_pid
  p_comm
  ```

- `rpb_t`

  ```
  // most of the fields
  ```

- `save_state_t`

  // most of the fields

- `stubDesc_t`

  ```
  addr
  length
  type
  ```

- `unwindDesc_t`

  ```
  args_stored
  end_ofs
  frame_size
  hpux_int
  millicode
  save_mrp_in_frame
  save_rp
  save_sp
  start_ofs
  ```

- `user_t`

  ```
  u_pcb.jb.lb_cmn.rp.val
  u_pcb.jb.lb_cmn.sp.val
  u_pcb.jb.lb_cmn.ar_bsp.val
  u_pcb.jb.lb_cmn.ar_pfs.val
  u_pcb.ar_rnat
  u_procp
  ```

- `struct pcb`

  ```
  pcb_r2
  pcb_r30
  pcb_sr5
  ```

DLKM

KWDB uses following fields from the data structures listed below for handling DLKM modules.

- `struct modobj`

  ```
  md_mcl
  md_path
  md_bss
  md_space
  ```

- `struct modctl`

  ```
  mc_id
  mc_version
  mc_name
  mc_modp
  mc_next
  ```

- `struct modctl_list`

  ```
  mcl_mcp
  mcl_next
  ```

- `struct module`

  ```
  mod_obj.md_path
  mod_obj.md_space
  mod_obj.md_bss
  mod_obj.md_mcl
  ```

Endianism

KWDB assumes all the code be Big Endian at the very lowest levels. KWDB may become flexible about this in the future, but it isn't at present.

Object File Format

KWDB expects HP-UX kernels to be stored in the form of **Spectrum Object Modules** (SOMs) or in the form of **Executable and Link Format** (ELF) objects. KWDB will require modification if this ever changes.

Symbolic Debug Format

On PA targets KWDB expects the kernel's symbolic debug information to be stored in the SOM or ELF object that the kernel was loaded from and the format to be defined by the `symtab.h` or `symtab64.h` file provided by the compiler delivery lab. On IPF targets KWDB supports ELF64 objects and the DWARF2 debug format. KWDB will require modification if this ever changes.

Glossary

A

32-Bit Program A program compiled to run in 32-bit mode. For example. programs compiled for the PA RISC 1.X processors.

64-Bit Program A program compiled to run in 64-bit mode. For example, programs compiled for the PA-RISC 2.0 processor in wide mode.

100BT 100BASE-T is the technical term for the Fast Ethernet or IEEE802.3u standard. See also, Fast Ethernet.

Adapter Card Physical hardware, under software control, which is typically attached either directly to an I/O bus or to an auxiliary bus (e.g., SCSI) attached to a directly connected adapter. A device typically combines a hardware controller with the mechanism (e.g., disk controller with disk).

ANSI American National Standards Institute.

Area Allocator The memory attribute based allocated in HP-UX kernel which replace the old `MALLOC()/FREE()` interface. The advanced features include object caching, improved fault isolation, reduced memory fragmentation and better scaling.

ARP Address Resolution Protocol.

Attach Chain A linked list of driver attach routines (`<drv>_attach`). As a hardware module is being configured, this list is walked to allow each driver in the system a chance to recognize and claim the hardware module.

Autoload
A capability made possible via the DLKM feature. It occurs when the kernel detects a particular loadable module is required to accomplish some task, but the module is not currently loaded. The kernel automatically loads the module. During an autoload, the kernel also loads any modules that the module being loaded depends upon, just as it does during a demand load.

B

BAR Base Address Register. On a PCI card, one of the registers in PCI configuration space that contains the size and alignment requirements needed to map the card's registers. Each BAR also contains information (encoded in the low-order bits of the register) indicating whether they are base registers for PCI memory space or for PCI I/O space. The system reads and decodes this information and writes a PCI address back into these registers when it initially maps them in. BARs contain PCI addresses when properly set up.

BDR Boot Data Record.

Beta Semaphores Mutually-exclusive, blocking semaphores. When a thread acquires a beta semaphore, it is released. The owning thread may subsequently block (i.e., sleep) and still keep ownership. Threads waiting to acquire an owned beta semaphore are blocked.

Big Endian A format for storage or transmission of binary data in which the most significant bit or byte comes first. See also, Little Endian.

bit mask A patter of binary values, typically used in bitwise operations.

Bit An atomic unit of data representing either a 0 or a 1.

Bitwise Operation A bitwise operation treats its operands as a vector of bits rather than a single number.

BN-CDIO Bus Nexus CDIO, low-level kernel software that manages platform-dependent bus connection hardware.

Broadcast Address A well-known multicast address signifying the set of all stations.

Bundle A collection of filesets, possibly from several different products, "encapsulated" for a specific purpose. Bundles can consist of groups of filesets or products.

Bus Mastering The act of taking over a bus and generating cycles on it. A bus master is any piece of hardware that creates read or write cycles on the PCI bus. Typical cards become bus masters only when they perform DMA operations, although any card-initiated cycle (for example, a peer-to-peer transaction) is an example of bus mastering.

Bus Nexus Connection between two buses.

C

Cache Coherence Consistency of data in host memory as viewed by processor caches and I/O devices.

Cacheline The smallest unit of memory that can be transferred between the main memory and the cache. Typically, Cacheline is hardware dependent.

Canonical format Synonymous with Little Endian format.

ccNUMA Cache-Coherent Non-Uniform Memory Architecture. See also, NUMA.

CDB Command Descriptor Block.

CDIO Context Dependent I/O module. A module in GIO framework which contains all bus specific and/or driver environment specific functionality.

Central Bus CDIO (CB-CDIO) The BN-CDIO which is responsible for discovering and initializing CEC components.

CKO Checksum Offload.

Class A logical grouping of device or hardware modules by type. For instance the class “tape” would include all tape devices regardless of bus interface.

Coherent I/O Accesses to data in host memory by I/O devices are consistent with accesses by CPU caches. Hardware in the platform maintains the consistent view of data in host memory as DMA transactions flow through the hardware.

Continuous DMA A type of DMA that makes a host memory buffer continuously available to an I/O device. This type of DMA is mainly used for control structures and circular queues that are shared between the device driver and the hardware device.

Core Electronics Complex (CEC) The chipset which interfaces directly to the processor in the processor-memory interconnect. In simple systems, this usually includes memory controllers and I/O adapters. On more complex systems, it might include high-speed interconnects and coherency controllers.

CPU Central Processing Unit

CSMA/CD Carrier Sense, Multiple Access with Collision Detection.

D

Data Link layer The second layer of the seven-layer OSI model, responsible for frame delivery across a single link.

Datagrams (1) A frame or packet transferred using connectionless communications. (2) A frame or packet sent using best-effort service. (3) An IP packet.

Decapsulation The process of removing protocol headers and trailers to extract higher-layer protocol information carried in the data payload. See also, Encapsulation.

Depot A repository of software products managed by SD/UX. A depot consists of a directory or physical media such as tapes, CD-ROMS, or DVDs.

Device Driver The software used to provide an abstraction of the hardware details of a network or peripheral device interface. Device drivers allow higher-layer entities to use the capabilities of a device without having to know or deal with the specific implementation of the underlying hardware.

Device Driver Environment (DDE) A defined set of services and entry points which allow a driver to function.

DLKM Dynamically Loadable Kernel Module. A feature available in HP-UX 11.0 that supports dynamic loading and unloading of kernel modules, to avoid wasting kernel memory by keeping modules in core when they are not in use.

DLPI Data Link Provider Interface.

DLSAP Data Link Service Access Point.

DMA Direct Memory Access. I/O transactions for which the device interacts directly with memory without processor intervention.

Driver Software module which controls a device, interface card or bus-nexus. See also, Device Driver

DSAP Destination Service Access Point.

E

Encapsulation The process of taking data provided by a higher-layer entity as the payload for a lower-layer entity and applying a header an trailer as appropriate for the protocol in question. See also, Decapsulation.

ENET HP-UX sample Native STREAMS DLPI network interface driver.

Ethernet The popular name for a family of LAN technologies standardized by IEEE 802.3.

F

Fast Ethernet An Ethernet system operating at 100 Mb/s.

Filesets Include all the files and scripts that make up a product. They can only be part of a single product. They are the lowest level object managed by SD.

Fragmentation A technique whereby a packet is subdivided into small packets so that they can be sent through a network with a smaller MTU. See also, Reassembly.

Frame The Data Link layer encapsulation of transmitted or received information

Frame Check Sequence A block check code used to detect errors in a frame. Most LANs use a CRC-32 polynominal as their FCS.

Full Duplex A mode of communication whereby a device can simultaneously transmit and receive data across a communications channel. See also, Half-duplex.

G

Gigabit Ethernet An Ethernet system operating at 1000 Mb/s.

GIO General I/O System.

Group Address Synonymous with multicast address.

H

Half duplex A mode of communication in which a device can either transmit or receive data across a communications channel, but not both simultaneously. See also, Full duplex.

HBA Host Bus Adapter.

Header A protocol-specific field or fields that precede the encapsulated higher-layer data payload (e.g., the MAC addresses in a Data Link frame). See also, Trailer.

High Availability (HA) Used to describe a computer system that has been designed to allow users to continue with specific applications even though there has been a hardware or software failure.

HP-DLPI's HP's own implementation of the DLPI layer.

I

ICMP Internet Control Message Protocol.

IELAN HP-UX sample non-native HP-DLPI based network interface driver.

IHV Independent Hardware Vendor.

ILP32 C language data model where int, long and pointer data types are 32 bits in size.

Init Function This is an attribute in driver modules modmeta file. An "initfunc" statement specified an initialization function, provided y the module, that the system should call during driver initialization.

Init List A linked list of device driver `init` routines (`<drv>_init`) which is built as the drivers configure themselves and run as the I/O system configuration is completed to perform any device driver-specific initialization.

Installed Product Database (IPD) SD uses the Installed Product Database (IPD) to keep track of what software is installed on a system. The IPD is a series of files and subdirectories that contain information about all the products that are installed under the root directory (/). For depots, this

information is maintained in catalog files beneath the depot directory. The SD commands automatically add to, change and delete IPD and catalog information as the commands are executed.

Interface Select Code (ISC) Each instance of an adapter card has an ISC entry that the system maintains in an internal table. Each ISC entry is used by WSIO to maintain interface device driver information.

Interface Service Routine (ISR) A function that handles interrupts that are received for a specific device driver. A pointer to this routine is linked to a system vector table. When an interrupt occurs, it is routed to the ISR that is placed in the section of the Interrupt Vector Table that corresponds to the received interrupt.

Interrupt Service Routine A function that handles interrupts that are received for a specific device driver. A pointer to this routine is linked to a system vector table. When an interrupt occurs, it is routed to the ISR that is placed in the section of the Interrupt Vector Table that corresponds to the received interrupt.

Instance A number assigned to an I/O tree node. The number is unique within a driver class.

I/O Adapter Hardware to provide IOVA translation between an I/O bus and the processor/memory interconnect devices on the I/O bus issue bus transactions to IOVA memory targets and the I/O adapter translates IOVA memory targets to physical addresses. The I/O adapter also participates in the coherency protocol of the processor caches for platforms that are coherent or semicoherent.

I/O Bus Interconnect bus for I/O cards and devices. PCI is an example of an I/O bus.

I/O Node An element of an I/O tree which includes all relevant information needed for configuring a single hardware module.

I/O PDIR I/O Page Directory. Address translation table associated with an I/O adapter. The I/O PDIR is analogous to the PDIR used by CPUs for virtual-to-physical address translations. It is a table maintained by the kernel to provide mappings between IOVAs and physical addresses.

I/O Tree Data structure for recording the I/O subsystem configuration information.

IOVA I/O Virtual Address. Address used by I/O devices to access host memory. Platforms that are semicoherent or coherent, or where the processor/memory interconnect is greater than 32-bits wide, generally implement IOVAs.

IP Internet Protocol.

IPF Itanium Processor Family.

IRQ Interrupt Request.

ISC Interface Select Code. Usually used as a pointer to an element of a table of `isc_table_type` structures (one per interface card). Each ISC entry is used by WSIO to maintain interface device driver information.

ISCSI SCSI over IP.

ISR Interrupt Service Routine. A driver-specific routine which handles interrupts from the device.

ISV Independent Software Vendor

J

Jumbo Frame A frame longer than the maximum frame length allowed by a standard. Specifically used to describe the 9-Kbyte frames on Ethernet LANs.

K

Kcweb The HP-UX Kernel Configuration tool user interface uses as a web browser.

Kernel module A section of code responsible for supporting a specific capability or feature. Normally, such code is maintained in individual object files and/or archives, enabling modules to be conditionally included or excluded from the kernel, depending on whether or not the features they support are desired.

L

LAN Local Area Network. A network with a relatively small geographical extent.

LBI Line Based Interrupt.

Length Encapsulation The Ethernet frame format where the length/Type field contains the length of the encapsulated data rather than a protocol type identifier. Length Encapsulated frames typically use LLC to multiplex among multiple higher-layer protocol clients. See also, Type Encapsulation.

Little Endian A format for storage or transmission of binary data in which the least significant bit or byte comes first. See also, Big Endian.

LLC Line Based Interrupt.

Logical Address See Multicast Address.

LP64 C language data model where the `int` data type is 32 bits wide, but long and pointer data types are 64 bits wide.

LSB Least significant bit or least significant bit.

LUN Logical Unit Number.

LVM The Logical Volume Manager is a disk management subsystem that offers access to file systems as well as features such as disk mirroring, disk spanning, and dynamic partitioning.

M

MAC Medium Access Control.

MAC Address A bit string that uniquely identifies one or more devices or interfaces as the sources or destination of transmitted frames. IEEE 802 MAC addresses are 48 bits in length and may be either unicast (source or destination) or multicast (destination only).

MAC Algorithm The set of procedures used by the stations ion a LAN to arbitrate for access to the shared communication channel (e.g., CSMA/CD, Token Passing).

Map PCI Device/Function
The act of mapping a PCI device or function involves determining the size and alignment requirements for each memory or I/O range described by an implemented configuration-space base register. Using these requirements, PCI Services finds a suitable hole in the memory or I/O address space and updates the corresponding base register to point to this range. This is taken care of by the system (firmware and/or the kernel) at the time of the card's initialization.

Map PCI to Port Handle Mapping a PCI I/O space address to a port handle is the act which allows a driver to access the I/O space using `pci_read_port_uintNN_isc()` and `pci_write_port_uintNN_isc()`, passing in the port handle as a argument. The mapping is done through a call to `pci_get_port_handle_isc()`.

Map PCI to Virtual Address Mapping a PCI memory space address to a virtual address is the act that allows a driver to access PCI space using `READ_REG_UINTNN_ISC()` or `WRITE_REG_UINTNN_ISC()` with that virtual address. The mapping is done through a call to `map_mem_to_host()`.

mblk Message block. Data structure used in networking stack.

mbuf Message buffer. Data structure used in mass storage stack.

Metadata The metadata for a module are used by the kernel configuration tools when configuring a module, they are also used by various kernel services while the module is in use.

Memory Mapped I/O (MMIO) I/O that occurs by mapping the devices's I/O to system memory.

Module type A module type is distinguished by the mechanism used to maintain the modules of that type within the kernel. DLKM modules are classified according to a fixed number of supported module types.

MP Multi-Processor

MP Safe Describes a module which is protected in an MP environment through the use of various spinlocks and semaphores. Note that MP-safeness does not imply any performance considerations due to the granularity of the semaphores (e.g., use of a single I/O Empire semaphore or separate semaphores for each instance all imply MP-safeness).

MP Scalable Describes an MP module which may add components without causing more drain on other MP modules. An MP-scalable driver will provide a separate spinlock for each instance of the driver. Non MP-scalable drivers may still be MP-safe but perhaps only provide a single semaphore and spinlock for all instances of the driver. Adding more instances of a non MP-scalable driver will therefore cause additional taxing of those resources for each instance added to the system.

Modwrapper The additional code and data structures added to a DLKM module to make it dynamic.

MSB Most significant bit, or most significant byte.

MTU Maximum Transmission Unit.

MTU Discovery A process whereby a station can determine the largest frame or packet that can be transferred across a internetwork without requiring fragmentation.

Multicast Address A method of identifying a set of one or more stations as the destination for transmitted data. Also known as logical address or group address.

N

NFS Network File System.

NIC Network Interface Card or Network Interface Controller.

Noncoherent I/O Accesses to data in host memory by I/O devices are not made consistent with processor caches by hardware. Software must explicitly flush the processor caches prior to starting a DMA transaction by an I/O device; and, in the case of data read from an I/O device, purge the processor caches after the DMA transaction completes.

NUMA Non-Uniform Memory Architecture. A memory architecture, used in multiprocessors, where the access time depends on the memory location. A processor can access its own local memory faster than non-local memory (memory which is local to another processor or shared between processors). See also, ccNUMA.

O

On-Line Addition and Replacement (OLA/R)

The ability to insert adapter cards and replace such cards while a system is being used (Hot Plug).

On-Line Delete (OLD) The ability to delete adapter cards.

Operating System The low-level software responsible for managing the underlying hardware in a computer, scheduling tasks, allocating storage.

OSI Open Systems Interconnect.

P

PA Precision Architecture.

Package A collection of files that need to be distributed. It is created by a SD command.

Packet The Network layer encapsulation of transmitted or received information.

Packet DMA A type of DMA that maps a host memory buffer temporarily. This is used when pre-existing memory objects must be mapped for DMA, or when a mapping only needs to be temporary.

PCI Peripheral Component Interconnect. An industry standard bus used mainly by current generations of HP platforms as a means of providing expansion I/O.

PCI Address An address in the PCI memory or I/O space. This is the type of address found in a PCI memory or I/O base address register. It is NOT a virtual address or an I/O port handle, which a driver could use to access a card.

PCI Card A PCI bus can have up to 32 devices; each device can have up to eight functions. A PCI card can have single or multiple devices; each device can have single or multiple functions. For example, a four-port LAN card is a multi-device PCI card, but none of these devices is multi-functional. On the other hand, a dual-port SCSI card is a single device, but it has two functions.

PCI Configuration Space This always-accessible space allows a driver to configure and obtain status from PCI devices or functions.

PCI I/O Space The space that is addressed by an I/O cycle on the PCI bus. This is a less often used way to access card registers on cards who choose to respond to PCI I/O accesses. Most cards have registers that are in PCI memory space instead of I/O space (i.e., they respond to PCI memory cycles, not PCI I/O cycles).

PCI Memory Space
The space that is addressed by a memory cycle on the PCI bus. It is called memory space to indicate that it is memory-mapped input/output, as opposed to a special I/O style of input/output. The current PA Workstation I/O architecture allows the PA processor to directly access PCI memory space (i.e., a single instruction). Typical cards map their registers into PCI memory space, meaning they can only be accessed by PCI memory cycles.

Perl A procedural programming language created by Larry Wall. It's ancestors include `awk`, `sed` and `C`.

Physical Address Real address by which host memory or an I/O device register is accessed.

Physical Layer The lowest layer of the seven-layer OSI model, responsible for transmission and reception of signals across the communication medium.

Ping A utility program used to test for network connectivity by using the Echo Request and Echo Response mechanisms of ICMP.

Port Handle The kernel resource associated with a mapped range of PCI I/O space. This handle is used to access the I/O space addresses by calling `pci_read_port_uintNN_isc()` and `pci_write_port_uintNN_isc()`.

Port I/O (PIO) Communication with an I/O device using the device's ports.

PPA Physical Point of Attachment

Product Collections of filesets and (optionally) subproducts and control scripts.

Product Specification File (PSF) A master file where all bundle configuration information (attributes) exists.

Promiscuous Mode A mode of operation of a network interface in which it receives (or attempts to receive) all traffic regardless of Destination Address.

Protocol A set of behavioral algorithms, message formats, and message semantics used to support communications between entities across a network.

pSCSI Parallel SCSI. See also, SCSI.

Q

QLISP HP-UX sample parallel

Quiesce (networking) To render quiescent, i.e., temporarily inactive or disabled. For example to quiesce a device (such as a digital modem). It is also a system command in MAX TNT software which is used to "Temporarily disable a modem or DS0 channel".

R

Reassembly The process of reconstructing a packet from its fragments. See also, Fragmentation.

Root In SD, a system on which depot software is installed.

S

SAM System Administration Manager. A GUI based application for HP-UX system administration.

SAP Service Attach Point

SCSI Small Computer System Interface. An industry standard external I/O bus available on all HP9000 systems.

SDTR Synchronous Data Transfer Request.

Semicoherent I/O Similar to coherent I/O. However, for the case of data read from an I/O device, software must synchronize the data that have been read into host memory after the DMA transaction completes.

Series 700 HP9000/7XX family of PA-RISC workstations.

Series 800 HP9000/8XX family of PA-RISC business servers.

Server I/O (SIO) I/O environment for port-server drivers with origins in S/800 systems.

SGML Acronym meaning Standardized General Markup Language, this template contains macros that convert your document into SGML.

SIO Server I/O; I/O environment for port-server drivers with origins in S/800 systems.

SNAP Sub-Network Access Point

Software Distributor (SD) The software distributor tool for HP-UX operation system.

Software Objects Can be a bundle, product or filesets.

Spinlock Basic locking primitive used by the kernel for short-term locks. When a thread acquires a spinlock, the thread's current processor becomes the effective owner until the spinlock is released. Threads (processors) waiting to acquire an owned spinlock will spin while waiting; they do not block. For the duration that a processor owns a spinlock, external interrupts to the processor are disabled.

Stream A connection supported by the STREAMS facilities between a user process and a device driver. It is a structure made up of linked modules, each of which processes the transmitted information and passes it to the next module. Use STREAMS to connect to a wide variety of hardware and software configurations, using building blocks, or modules, that can be stacked together. STREAMS drivers and modules are similar in that they both must declare the same structures and provide the same interface. Only STREAMS drivers manage physical hardware and must therefore be responsible for handling interrupts if appropriate.

T

Target Either a host (the host's file system) or a depot that resides on a host.

TBI Transaction Based Interrupt.

TCP Transmission Control Protocol.

Token Ring A LAN whose MAC algorithm uses token passing among stations on a logical ring topology (i.e., IEEE 802.5).

Topology The physical or logical layout of a network.

Trailer A protocol-specific field or fields that follow the encapsulated higher-layer data payload (e.g., the FCS in a Data Link Frame). See also, Header.

Type Encapsulation The Ethernet frame format in which the Length/Type field identifies the protocol type of the encapsulated data rather than its length. See also, Length Encapsulation.

U

UDP User Datagram Protocol.

V

Virtual Address Address used by processors, when executing in virtual mode, to access host memory. Address translation hardware converts a virtual address to a physical address before host memory is accessed. Virtual addresses may also be used to map and access I/O device registers.

W

WDTR Wide Data Transfer Request.

WSIO Workstation and Server I/O. A CDIO, also the HP-UX Driver Development Environment (DDE).

X

XML Acronym meaning eXtensible Markup Language. A subset of SGML (Standardized General Markup Language), this template contains macros that convert your document into XML.

L

S

V

W

X