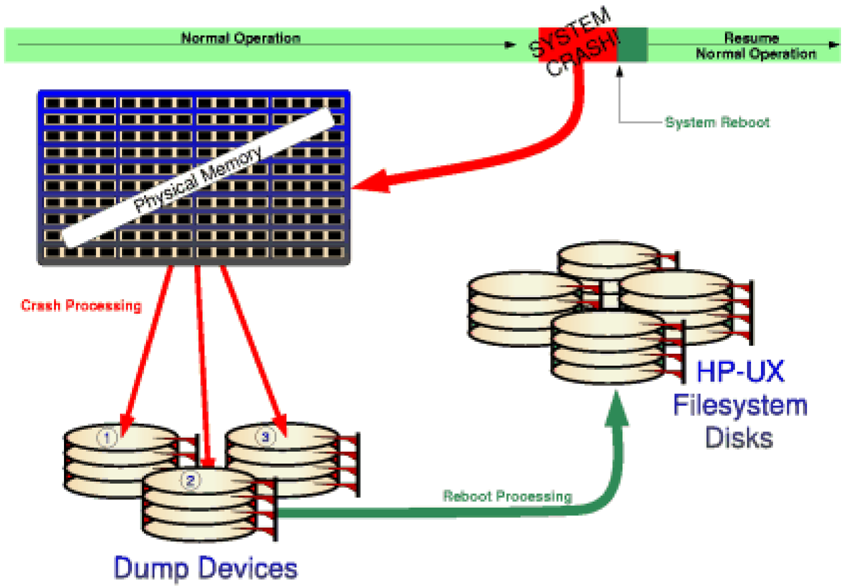
Crash Dumps

INDEX

Did you ever experience a sytem that was hung or crashed unexpectedly? This chapter explains how to configure a system for crash dump, how to install dump analysis tools and how to use them in order to quickly isolate the cause of the problem.

A little bit of theory

When the system crashes, HP-UX tries to save the image of physical memory (*core*), or certain portions of it, to predefined locations called *dump devices*. Then, during the following reboot, a special utility (*savecrash*) is invoked from a rc-script that copies the memory image together with the current kernel from the dump devices to the file system. Once there, you can analyze the memory image with a debugger. The following picture shows the action flow:



Crash events

An abnormal system reboot is called a *crash*. There are many reasons that can cause a system to crash; hardware malfunctions, software panics or even power failures. On a properly configured system, these will typically result in a crash dump being saved. The operating system logs a crash event for each reason that triggers a crash. There is usually one crash event per-processor. Although it is not uncommon to see two or more crash events associated with the same processor.

There are three different types of crash events: **PANIC**, **TOC** and **HPMC**:

PANIC

The crash even type *panic* refers to crashes initiated by the HP-UX operating system (software crash event). We differentiate between *direct* and *indirect* panics.

A *direct panic* refers to a subsystem calling directly the panic() kernel routine upon detection of an unrecoverable inconsistency, for example:

- panic ("wait_for_lock: Already own this lock!");
- panic ("m_free: freeing free mbuf");
- panic ("virtual_fault: on DBD_NONE page");
- panic ("kalloc: out of kernel virtual space");

An *indirect panic* refers to a crash event as a result of trap interruption which could not be handled by the operating system. For example when the kernel accesses a non-valid address, a Data page fault (trap type 15) would result. The trap handler will save some state information and then call the panic() routine to bring the box down in an orderly manner. This is indirect since panic() is called at a point slightly later than the trap condition that caused the failure. Some examples

- trap type 15, Data page fault
- trap type 18, Data memory protection fault
- trap type 6, Instruction page fault

TOC

The crash event type *TOC* refers to crashes initiated by a *Transfer-Of-Control* sequence. There are three different ways of getting a TOC event for a CPU:

- Operator initiated TOC (eg, manually pushing a TOC button, or cycling the power button 3 times on some systems, or using the TC command in console mode).
- MC/ServiceGuard initiated TOC (eg, when it is unable to maintain contact with the cluster daemon).
- Crash path initiated TOC. On multi-processors systems, the processor taking the initial crash event (eg, a panic) will cause the other processors to perform TOC automatically.

A manual TOC is usually done when a system is hung or unresponsive. This way the crash dump can be analysed to determine root cause.

HPMC

The HPMC crash event type refers to High Priority Machine Check crashes initiated by the hardware due to hardware inconsistencies or malfunctions such as a Data Cache parity error. Getting an HPMC does not always mean that the hardware is at fault. The HPMC tombstone needs to be analyzed to determine if the hardware was really at fault. Software defects can result in HPMC crash events, but are typically very rare in production quality software.

NOTE: on Itanium systems the naming is sligthly different:
HPMC = MCA (Machine Check Abort)
TOC = INIT

What happens when a system crashes?

Now that you understand the different types of crash events (panic, toc and hpmc), let’s see what the system does to process these events. Processing these events usually requires an interaction between the hardware and operating system software. There are well defined architected interfaces between hardware and software. For example, PDC entry points (processor firmware) on the processors and Interruption Vector Table (IVA) in the kernel. These interfaces allows the hardware to trigger software entry points to initiate logging, analysis and error recovery to be performed after a hardware fault or vice versa.

Some of the information presented here may be quite indepth on first reading. You may skim through them initially. It is important to grasp the concept presented here since any investigative dump analysis work begins with the crash events. It is worthwhile understanding what the system does in response to crash events and what crucial pieces of information are saved and where they are stored.

We categorise the crash events into two classes; hardware crash events and software crash events. Here is a description of what the system does to process these.

Hardware crash events

A hardware crash event can be *High Priority Machine Check (HPMC)*, *Low Priority Machine Check (LPMC)* or *Transfer of Control (TOC)*. The machine checks are typically caused by hardware malfunctions or certain classes of bus errors. TOC on the other hand is usually initiated by the operator in response to system software being stuck in an error state.
When a hardware crash event occurs, the processor immediately branch to PDC entry point; PDCE_CHECK for HPMC and LPMC faults, and PDCE_TOC for TOC. The implementation details of these PDC entry points are processor dependant. Fundamentally they save the processor’s state (general, control, space and interruption registers) into *Processor Internal Memory (PIM)*. The processor then vectors back into the operating system entry points; HPMC_Vector or TOC_Vector. These entry points are defined in the *IVA (Interruption Vector Table)* and MEM_TOC in Page Zero respectively.

On entry into the kernel, a crash event entry is created. The operating system makes a pdc call (PDC_PIM) to read the processor’s state information from PIM into a *Restart Parameter Block (RPB)*. As such the RPB structure contains information pertinent to the understanding of the crash. For example, the *Program Counter (PC)* in the RPB would indicate what routine was executing at the time of HPMC/TOC event. Once the state has been saved, the operating system continues to dump physical memory to the dump device.

Software crash events

A software crash event occurs when *panic()* routine is called. This can either be a direct or indirect panics. For a software crash event, the PDC and PIM are not involved at all. As such, the first thing that panic() routine does is to save the processor state into the RPB structure. The panicking processor will also initiate a TOC to other processors, causing them to stop what they are doing closer to the point where the problem is detected. This is important to allow the cause of the panic to be identified.

panic() actually calls a leaf routine panic_save_register_state() to save the processor registers state. So the return pointer (rp) in the RPB structure actually points to the panic() routine. The instruction address (pcoq) is zeroed out in the RPB to prevent unwinding beyond panic since this is the point of interest. Since panic_save_register_state() is a leaf routine, the stack pointer (sp) in the RPB will be the same as that of panic().

For a *direct panic*, the RPB contains the processor's registers state of the routine which called panic(). In other words, the RPB contains information closest to the point of failure and in the same context as the routine was called. Thus dump analysis begins with the RPB for direct panics.

For an *indirect panic*, the RPB contains the context of a trap handler and it does not reflect the value of the registers at the time of the fault. Please see the following diagram. An indirect panic is usually the result of a trap condition which cannot be resolved by the operating system. The trap handler needs to save the processor state information before bringing down the system gracefully with a panic call. The trap handler stores these registers state into a save_state structure. So for an indirect panic, the save_state structure contains information closest to the point of failure which triggered the trap condition. Thus dump analysis begins with the save_state for indirect panics.

After panic() has saved the state, it proceeds to dump physical memory to dump device.

PIM Tombstone

The Process Internal Memory or PIM is a storage area in a processor that is set at the time of an HPMC, LPMC, Soft Boot, or TOC, and is composed of the architected state save error parameters, and HVERSION-dependent (ie, processor dependent) regions. The internal structure of PIM is processor dependant. The PDC_PIM procedure is used to access PIM data.

Different systems have different methods of accessing PIM information. On some systems, there is a pdcinfo program that allows online retrieval of this PIM data. This can be helpful to retrieve HPMC tombstone data for analysis. The script in /sbin/init.d/pdcinfo automatically runs pdcinfo command when HP-UX is booted and saves any tombstones in a file in the directory /var/tombstones. Up to 100 files can be saved. The file "ts99" is the most current, "ts98" is the next most current...."ts0" would be the oldest.

From a dump analysis point of view (especially HPMC/TOC), the RPB structure should be a reflection of the registers state in PIM since the information was copied from it. There are rare times when rpb values may not seem 'right'. If this is the case then it is better to use the register values in the PIM data as starting point for analysis. Some interesting registers are:

gr02	Return Pointer (rp)
gr30	Stack Pointer (sp)
cr17	Interruption Instruction Address Space Queue (pcsq)
cr18	Interruption Instruction Address Offset Queue (pcoq)
cr19	Interruption Instruction Register (iir)
cr20	Interruption Space Register (isr)
cr21	Interruption Offset Register (ior)
cr22	Interruption Processor Status Word (ipsw)
cr23	External Interrupt Request Register (eirr)
cr15	External Interrupt Enable Mask (eirr)

Save state structure

The save_state structure is used by the interrupt (ihandler) and trap (thandler) handlers to temporarily store away processor state (general, control, space and interruption registers) so that these handlers can safely reuse the registers. It will also allow the handlers to return to the point of interruption by restoring these register values from the save_state. The save_state structure (together with a frame marker) is typically allocated on the Interrupt Control Stack (ICS) or kernel stack.

Most of the processor registers are saved. However, some registers are not saved because they are irrelevant when returning to the point of interruption. Since these interrupt and trap handlers are executed frequently, it is crucial for performance reasons to save only what is necessary.

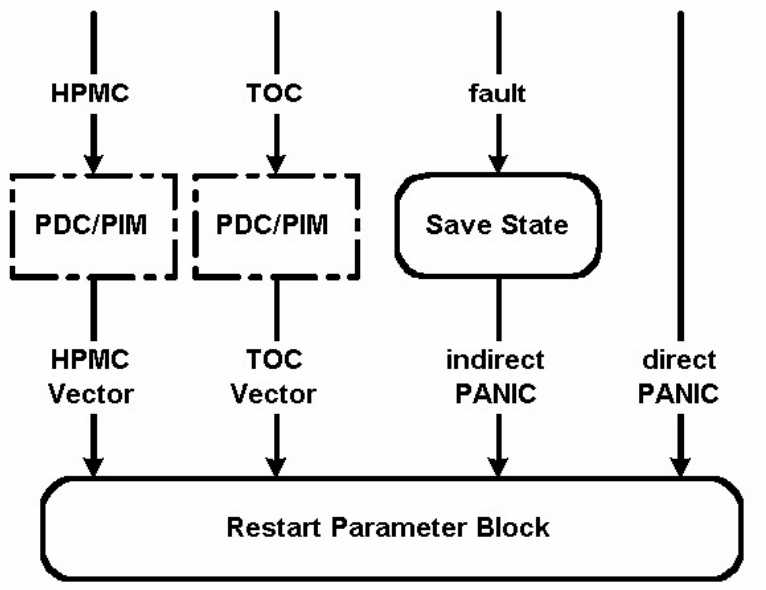
RPB structure

Every crash event will create a corresponding RPB structure to contain the processor state at the time of HPMC, TOC or panic. This register state allows us to understand what is happening at that point in time as well as provides a starting point for the stack unwind. The rpb structures are stored in a pre-allocated area in kernel static data area.

Unlike the save_state structure, the rpb structure will contain a more complete save of all the processor registers. For example, the cr16 interval timer is saved in the rpb but not in the save_state structure. We can afford to save more registers in rpb since it is created during the crash path which is not a performance sensitive code path.

Crash event flowchart

Here is a diagram summarizing the above:



How to configure dump devices

In order to understand the following text you should be familiar with the basic concept of the Logical Volume Manager LVM. I make use of the these abbreviations:

VG = Volume Group
LV = Logical Volume
PV = Physical Volume

Choosing dump devices

Dump devices are volumes on the disk that are used to hold the entire memory image when the system crashes. The cumulative size of all specified dump devices has to be some MB larger than the amount of memory in order to hold the entire core. To determine the current size of physical memory:

```
# dmesg | grep Physical
Physical:524288 KB ,lockable:386672 KB ,available:454144 KB
```

As of UX 11.00 you can use `crashconf(1M)`:

```
# crashconf | grep Total
Total pages on system:          131072
Total pages included in dump:    30832
```

(A page is always 4KB)

NOTE: Increasing the amount of dumpspace is an important thing to do when adding more physical memory to the system.

Formerly the maximum size of a dump device was 2GB or more precise: the dump LV had to be placed within the first 2GB of the PV whereas newer systems support dump devices up to 4GB or since UX 11.00 even greater than 4GB.
It's important to mention that it's the Interface Card, not the disk, that defines whether the disk can be used for more than 4GB of dump. Cards in the systems like L-, N-, V-Class and newer all support this. Details can be found in KMINE document S3100004913.

A swap device can also be used as dump device in order to save disk space but there are two disadvantages:

1) Is the **primary** swap device (usually /dev/vg00/lvol2) also configured as dump device, it takes more time for the system to bootup after a systemcrash.
   Reason: When a dump is found on the dump device during startup it will be written to the local filesystem (by the rc command savecrash). In the case that the dump device is also the primary swap, savecrash cannot run in the background because the swap area may be used during further startup.

2) Were there any problems with savecrash (lack of space in the crash directory) you still

have the possibility to run it again after the system boot completed (-r Option for resave dump). In case of a swap device there is a risk that parts of the dump are overwritten by "swapping" activities and therefor unusable.

You can influence the interaction of savecrash/core and swapon in the config file of savecrash/core. (see manpage of savecrash/core -w option)

Configuration steps

Creating the logical volumes that should be used for dump

You can specify up to 32 different dump devices. Each dump logical volume has to be ***contiguous***, i.e. all physical extents are placed one after another and reside on a single PV. Such a LV can be created with the option `-C y` of `lvcreate` command. ***Bad block relocation*** must be disabled (`–r n`):

```
# lvcreate -L <size in MB> -n lvdump -C y –r n /dev/vg00
```

You can check the LV parameters with lvdisplay:

```
# lvdisplay /dev/vg00/lvdump | grep Allocation
Allocation                  strict/contiguous

# lvdisplay /dev/vg00/lvdump | grep Bad
Bad block                      off
```

The dump LVs must not contain a filesystem of course.

Activating these logical volumes, i.e. tell the system to use them for dump

A *traditional dump LV* has to be located in the root VG (vg00) and the `lvlnboot` command is used to tell the system to uses these LVs for dump. A reboot is neccessary in order to activate them. Here’s how to configure such a dump device:

Display the current settings:

```
# lvlnboot -v
Boot Definitions for Volume Group /dev/vg00:
Physical Volumes belonging in Root Volume Group:
 /dev/dsk/c0t6d0 (10/0.6.0) -- Boot Disk
 /dev/dsk/c0t5d0 (10/0.5.0)
Root: lvol1  on:   /dev/dsk/c0t6d0
Swap: lvol2  on:   /dev/dsk/c0t6d0
No Dump Logical Volume configured
```

Option `-d` sets the dump device:

```
# lvlnboot -d lvol2 /dev/vg00
# lvlnboot -d lvdump /dev/vg00
```

Check it:

```
# lvlnboot -v | grep dump
Dump: lvol2     on:     /dev/dsk/c0t6d0, 0
```

```
Dump: lvdump    on:     /dev/dsk/c0t6d0, 1
```

If the dump devices are configured according your needs you have to reboot in order to make the changes take effect. The message buffer displays all valid dumpdevices during reboot:

```
# dmesg | grep DUMP
Logical volume 64, 0x2 configured as DUMP
Logical volume 64, 0x9 configured as DUMP
```

If you like to use a dump device for other purposes you have to deconfigure it using `lvrmboot`. Only the last dump device can be deconfigured:

```
# lvrmboot -d lvdump /dev/vg00
```

NOTE: An entry in the kernel (`/stand/vmunix`) is necessary if you like to have more than one (traditional) dump device with LVM. This entry is set by default:

```
# strings /stand/vmunix | grep "dump lvol"
dump lvol
```

As of UX 11.00 you have the possiblility to configure additional dump devices online, i.e. without the need of a reboot. These dump LVs must not be configured using `lvlnboot –d` but with `crashconf(1M)`. You are no longer restricted to choose a dump LV from the root VG only. The configuration of such dump devices is similar to the configuration of secondary swap devices. Here's how to configure a dump device online:

Add a line for each dump device to `/etc/fstab`, e.g.:

```
/dev/vg01/lvdump  /  dump  defaults  0 0
```

Then run `crashconf -a` to activate it and `crashconf` to verify that it is enabled. Configuring non-root dump devices is similar to configuring secondary swap devices.

Refer to the `crashconf(1m)` and `fstab` manual pages for details.

NOTE: Whenever you have dump devices that are not also used for swap activity, make sure that they are configured last. This will cause them to be used first (dump goes from the end backward), which will minimize the chance of writing into an area shared by swap. Writing into swap space is undesirable because it will slow down your reboot processing (see section above).

NOTE: There are often questions like: "Why is the dump LV not mirrored like root, boot and swap LVs are?"

```
# lvlnboot -v
Boot Definitions for Volume Group /dev/vg00:
Physical Volumes belonging in Root Volume Group:
        /dev/dsk/c0t6d0 (10/0.6.0) -- Boot Disk
        /dev/dsk/c0t5d0 (10/0.5.0) -- Boot Disk
Root: lvol1     on:     /dev/dsk/c0t6d0
                        /dev/dsk/c0t5d0
Swap: lvol2     on:     /dev/dsk/c0t6d0
```

```
                        /dev/dsk/c0t5d0
Dump: lvol2     on:     /dev/dsk/c0t6d0, 0
Dump: lvdump    on:     /dev/dsk/c0t6d0, 1
```

The answer: the system dumps onto a previously configured area of the disk. The dump process is a low level routine that bypasses the LVM layer, hence the data is not going to be mirrored. The OS simply stored the hardware path of the disk and the starting and ending offset on this disk at the time you activated it. This information is given by the dump LV. This is the reason why dump LVs must be contiguous.

The dump/savecrash process

Writing the memory image to the dump devices

The kernel routine responsible for dumping is dumpsys().

Dump formats

There are four known dump formats. Which format you deal with can be found in the INDEX file (`grep version INDEX`):

COREFILE (Version 0)
This format, used up through HP-UX 10.01, consists of a single file containing the physical memory image, with a 1-to-1 correspondence between file offset and memory address. Normally there is an associated file containing the kernel image. Sources or destinations of this type must be specified as two pathnames to plain files, separated by whitespace; the first is the core image file and the second is the kernel image file.

COREDIR (Version 1)
This format, used in HP-UX 10.10, 10.20, and 10.30, consists of a `core.n` directory containing an INDEX file, the kernel (vmunix) file, and numerous `core.n.m` files, which contain portions of the physical memory image.

CRASHDIR (Version 2)
This format, used in HP-UX 11.00, consists of a crash.n directory containing an `INDEX` file, the kernel and all dynamically loaded kernel module files, and numerous `image.X.Y` files, each of which contain portions of the physical memory image and metadata describing which memory pages were dumped and which were not.

PARDIR (Version 5)
This format is used in UX 11.11 and later. It is very similar in structure to the CRASHDIR format in that it consists of a `crash.n` directory containing an `INDEX` file, the kernel and all dynamically loaded kernel module files, and numerous `image.X.Y` files, each of which contain portions of the physical memory image and metadata describing which memory pages were dumped and which were not. In addition to the primary `INDEX` file, there are auxiliary index files (`indexX.Y`), that contain metadata describing the image files containing the memory pages. This format will be used when the dump is compressed. See crashconf(1M).

Other formats, for example tape archival formats, may be added in the future.

Selective dumps

The most significant change compared to UX 10.X is the possibility of configuring **selective dumps**. Dumps no longer contain the entire contents of physical memory. With memory sizes growing in leaps and bounds, it become critical that HP-UX dump only those parts of physical memory which are considered useful in debugging a problem. By default you get a core of approx. 5-40% of physical memory, variing with the state of the system at dumptime. Configuration can be checked and modified with the crashconf utility:

```
# crashconf

CLASS           PAGES  INCLUDED IN DUMP  DESCRIPTION
--------   ----------  ----------------  ----------------------------
UNUSED          14253  no,  by default   unused pages
USERPG          23876  no,  by default   user process pages
BCACHE         129981  no,  by default   buffer cache pages
KCODE            2044  no,  by default   kernel code pages
USTACK            451  yes, by default   user process stacks
FSDATA            753  yes, by default   file system metadata
KDDATA          72447  yes, by default   kernel dynamic data
KSDATA          17699  yes, by default   kernel static data

Total pages on system:             261504
Total pages included in dump:       91350

DEVICE        OFFSET(kB)   SIZE (kB)  LOGICAL VOL.  NAME
------------  ----------  ----------  ------------  -----------------
 31:0x006000       72544      524288   64:0x000002  /dev/vg00/lvol2
                          ----------
                              524288
```

Compressed dumps

Even with selective dump feature a Superdome equipped with 256GB RAM would take hours to write the dump to the dump devices. The bottleneck of copying system moemory to disk is the I/O path. This could be alleviated by dumping to multiple disks in parallel but the system firmware (IODC) isn’t designed to permit multiple simultaneous I/O requests. Thus the only approach is to limit the amount of I/O that has to be done.

There is a new feature called *compressed dumps* available as of HP-UX Itanium release UX 11i v2 (i.e. UX 11.23) and additionally for UX 11i v1 (i.e. UX 11.11). The data is compressed (using LZO algorithm) before being written out to the dump device. When the system crashes, the dump subsystem assigns one processor to perform the writes to the dump device(s). It assigns another four processors to perform compression.

The dump compression features is targeted for large memory systems. Following requirements must be met:

Systems:	Superdome, Keystone, Matterhorn and Prelude	
OS:	PA-RISC:	UX 11i v1 (11.11) + patch
	Itanium:	UX 11i v2 (11.23)
Configuration:	at least 2GB RAM,	
	at least 5 processors	

The compression option is turned ON by default. But it just a hint to the kernel. At the time of a system crash, the dump subsystem examines the state of the system and its resources to determine whether it is possible to use compression. Depending on the resources available, the system decides dynamically whether to dump compressed or not.

Other situations can cause the dump subsystem to decide not to dump compressed: recursive panic, memory allocation failure - all logged on system console at crash dump and flagged in the kernel.

HP can't guarantee a specific compression factor. All compression tends to be dependent on the type of data being compressed, in particular how random it is. The dump should speedup by at least a factor of 3 with default selective dump configuration. More typically, customers will experience a factor of 7.

The crashconf(1M) command was enhanced to be able to configure dump compression:

```
# crashconf -c on

# crashconf -v
CLASS          PAGES  INCLUDED IN DUMP  DESCRIPTION
--------  ----------  ----------------  ------------------------------
UNUSED       3645411  no, by default    unused pages
USERPG          7113  no, by default    user process pages
BCACHE        210990  no, by default    buffer cache pages
KCODE           2670  no, by default    kernel code pages
USTACK           264  yes, by default   user process stacks
FSDATA           116  yes, by default   file system metadata
KDDATA         68736  yes, by default   kernel dynamic data
KSDATA        259004  yes, by default   kernel static data

Total pages on system: 4194304
Total pages included in dump: 328120

Dump compressed: ON

DEVICE        OFFSET(kB)   SIZE (kB)  LOGICAL VOL.  NAME
------------  ----------  ----------  ------------  -----------------
 31:0x03a000      310112     4194304   64:0x000002  /dev/vg00/lvol2
                          ----------
                             4194304
```

If you like to make the configuration changes either for selective dump or for compressed dumps resistant across reboots you need to modify the rc-script `/etc/rc.config.d/crashconf`. Usually there should be no need to change the defaults.

The compressed dump feature uses a new crash dump format, PARDIR, for saving the dumps. You recognise a compressed dump with this evidences:

- In the INDEX file you will find a version 5.
- In the dump directory you will find `indexX.Y` files along with the usual `image.X.Y` files.

The dumpreading tools (p4, crashinfo, kmeminfo, etc...) are aware of this new format.

Since the dump is compressed you have little gain to compress it again with gzip, yet since the compression is done with a 'compress(1)' compatible algorithm and small chunks, gzip'ing the dump still reduce it a bit sometime.

A consequence of the compressed dump is indeed a faster "time to dump" and a somewhat faster "time to reboot" but the dumpreading tools suffer a serious performance penalty, making the "time to diagnose" or "time to fix" significantly longer.

NOTE: To enable compressed dump feature at UX 11.11 you need to install the CDUMP11i product from http://www.software.hp.com/ER_products_list.html. This product contains a set of enabling patches. At UX 11.23 the compressed dump feature is enabled in core, hence no product or patches are needed.

Documentation about the compressed dump feature can be found at in the "Managing Systems and Workgroups" paper at
http://www.docs.hp.com/hpux/os/11i/index.html#System%20Administration

Saving the dump to the filesystem

After the system has finished to write the whole or only parts of the dump to the dump devices, the system reboots and automatically starts up again. When booting up, the system starts a rc script to copy the dump into the file system.

As of UX 11.00 the rc script itself is `/sbin/init.d/savecrash`. The configuration file is stored at `/etc/rc.config.d/savecrash`. The default location is `/var/adm/crash` with sub directories named `crash.n` for every saved crash. The `crash.n` directory contains an ASCII file named `INDEX` that contains some metadata of the dump, a copy of the current kernel `vmunix` and files for every saved contiguous chunk of memory named `image.m.n`. If the kernel contains loadable modules, those are copied to the dump directory too.

You can configure crash directory, compression mode, etc. in the appropriate configuration file `/etc/rc.config.d/savecrash`:

Here are the most important options:

`SAVECRASH`	`1` = save a crashdump (default) `0` = do not save a crashdump
`SAVECRASH_DIR`	directory for the crashfiles. Default is `/var/adm/crash`
`COMPRESS`	`0` = never compress `1` = always compress `2` = compress in case of insufficient space in crasdirectory (default)

Further options (`MINFREE`, `SWAP_LEVEL`, `CHUNK_SIZE`, `SAVE_PART`, `FOREGRD`, `LOG_ONLY`) are explained in the comments of the config file.

Saving the dump manually

If the dump was not saved completely due to lack of space in the crash directory you have the possibility to save the dump again. The `-r` option (resave) need to be included when this is not the first time that savecrash runs.

```
# savecrash -v [-r] <crash directory>
```

There is also the possibility to save the dump directly to a DDS tape:

```
# savecrash -v [-r] -t /dev/rmt/0m
```

Analysis of the dump

A complete analysis of a crashdump requires deep internal knowledge and much experience. That would certainly go beyond this document. Here I'd like to explain how to use the utility *crashinfo* in order to narrow down the cause of the crash.

If you like to examine the dump by yourself, please refer to the excellent online webcourse offered by the Expert Center. This course should be considered as starting point for any dump analysis. Whenever you deal with a crashdump i recommend you to visit this site. In most cases you should be able to find a solution. Links to all available dump reading tools are included.

http://wtec.cup.hp.com/~hpux/crash/FirstPassWeb/ (HP internal)

About the crashinfo utility

crashinfo is an executable that is based on libp4, the library of the P4 kernel debugger. It replaces the old whathappened perl script that was based on the Q4 kernel debugger. P4 and crashinfo are much more powerful and advanced than Q4/whathappened. The P4 debugger is based on the korn shell (ksh88) which makes it comfortable to use and the libp4 library.

p4 and crashinfo can be performed on a dump (by executing it from within a crash directory) as well as on a live system (by executing it not within a crash directoy). The latter can be useful to examine kernel structures when the system is e.g. not completely hung.

crashinfo is smart, depending on the type of the crash (PANIC, TOC, SG TOC or HPMC) it prints out the appropriate structures. It also reacts to certain conditions e.g. system low on free memory, spinlock panics, etc. and prints out the necessary data.

How to obtain and install and execute crashinfo

Use the standalone version to perform a quick check

Obtain the *static (standalone) version* of the crashinfo binary from the Ktools server (refer to the Additional information section below). From there the tool can be sent to the customer by email or pushed to an external ftp server. Size is about 800K.
Store the static crashinfo binary e.g. at `/usr/contrib/bin/` on the affected system.
This version should be used to perform a first quick check of the dump.
To get a fingerprint of the dump simply run the standalone crashinfo without options from within the crash directory:

```
# cd /var/adm/crash/crash.0
# /usr/contrib/bin/crashinfo >ci.out
```

NOTE: Should the chunkfiles (image.n.m for a UX 11.X crashdump) be compressed (the suffix .gz indicates that) they get decompressed automatically during the execution of crashinfo. This can take a while. Be sure to have enough space left in the crash directory.

With the help of the webcourse mentioned above it should be possible to solve most of the problems.

Anyway in some cases you might need information that is beyond the standard output of crashinfo. In this case you can use one of crashinfo's options or use the *P4 debugging environment* to perform a deeper analysis.

At this point you have to decide wether to ship the debugging tools to the customer and provide a remote connection for a HP RCE or to ship the dump to the Response Center, either via ftp upload or on a DDS tape or CD-ROM by mail. Which of the above possibilities (remote login, ftp upload, ship by mail) is appropiate depends on availability of remote login, the size of the dump and the severity of the problem.

If remote login is not possible, ship the dump to the Response Center

If you choose to analyze the dump on the customers system, obtain the tools either from the Ktools server (refer to the Additional information section below). Select *p4*, then *shared*, then *internet* or via anonymous ftp from
ftp://tahoe.grc.hp.com/dumpreading/dump_analyse.tar.gz (HP internal)
Size is about 7MB.
Unpack the files e.g. below /usr/contrib/dumpreading on the system, where the dump is located.
Before starting you need to set some path variables:

```
export P4_ROOT=/usr/contrib/dumpreading
export PATH=$P4_ROOT/bin:$P4_ROOT/p4:$PATH
export SHLIB_PATH=$P4_ROOT/bin:$P4_ROOT/p4
```

Either put the above lines in /etc/profile or simply source the included set_env file in order to set these variables:

```
# cd /usr/contrib/dumpreading
# . ./set_env
```

If remote login is not possible, ship the dump to the Response Center

If you choose to ship the dump to the Response Center additional information from the customers system depending on the type of the crash is needed.

Examine crashinfo output to determine which of the crash event types this is:

PANIC	the system ran into an unhandable condition and paniced
TOC	the system was hung and you TOCed it
SG TOC	the TOC was initiated by MC/ServiceGuard
HPMC	High Priority Machine Check. The crash was caused by a HW failure

Example:

```
# cat ci.out | grep "Note: Crash"
Note: Crash event 0 was a PANIC !
```

Provide the following:

`swlist -l product >swlist.out`	(currently installed software & patches)
`/var/adm/syslog/OLDsyslog.log`	(the syslog from the previous boot)

Additionally in case of a *TOC*, i.e system hang answer these questions:

”Did you try a telnet connection to the system? How exactly did it fail?”
”Did you try a rlogin connection to the system? How exactly did it fail?”
”Did you try a console connection to the system? How exactly did it fail?”
”Did the system respond to ping?”
“What was the value shown on the hex display?”

Additionally in case of a *ServiceGuard TOC*:

`/var/adm/syslog/[OLD]syslog.log` (appropriate syslogs of **all** nodes in the cluster)

Additionally in case of a *HPMC*:

`/var/tombstones/ts99` (tombstone file containing chassis logs and PIM data)
system’s serial number (obtained from MP/GSP)

Answering the following questions is very important, too:

“Did the system hang or panic more than once recently?”
“Did anything change recently?” (e.g. kernel patches installed, 3rd party software installed, configuration changes or simply a reboot.

NOTE: A system that panics/hangs multiple times altough no changes have been performed is likely to suffer from a hardware problem. Whereas hardware failures can happen all of a sudden, software failures are usually caused by configuration changes.

Please log a **hardware case** when your system crashed due to HPMC,
else log a **software case**.

About the stack trace

Before we come to panic() we execute a few other functions that are always the same. Searching for one of these functions will too turn up lots of hits. How does this typical part of the stack trace look like?

for UX 10.x and 11.x (PA-RISC):

```
panic+0x14
report_trap_or_int_and_panic+0x80
trap+0x6dc
thandler+0xd20
```

for Serviceguard TOCs:

```
Send_Monarch_TOC+0x58
safety_time_check+0x188
per_spu_hardclock+0x318
clock_int+0x60
mp_ext_interrupt+0x130
ihandler+0x904
```

the other CPUs are usually spinning on the safety timer lock and have this stack trace:

```
preArbitration+0x2ec
```

```
wait_for_lock+0x120
sl_retry+0x1c
safety_time_check+0xfc
per_spu_hardclock+0x4f8
clock_int+0x10c
mp_ext_interrupt+0x180
ihandler+0x90c
```

for "kalloc" panics:

```
panic+0x10
kalloc+0x174
kmalloc+0x1a8
```

or

```
panic+0x10
kalloc+0x174
kalloc_from_superpage+0xc8
kmalloc+0x358
kmem_alloc+0x11
```

for "spinlock deadlock" panics (an example):

stack trace for event **0** crash event was a **panic** **panic+0x14** **too_much_time+0x2e0** **wait_for_lock+0x14c** **sl_retry+0x1c** unselect+0x1c invoke_callouts_for_self+0xc0 sw_service+0xb0 mp_ext_interrupt+0x144 ivti_patch_to_nop3+0x0 idle+0x4dc swidle_exit+0x0	stack trace for event **1** crash event was a **TOC** **wait_for_lock+0x198** **sl_retry+0x1c** unselect+0x1c invoke_callouts_for_self+0xc0 sw_service+0xb0 mp_ext_interrupt+0x144 ivti_patch_to_nop3+0x0 idle+0x4e0 swidle_exit+0x0
stack trace for event **2** crash event was a **TOC** PCM_wait_for_TOC+0x0 printf+0x6c **too_much_time+0x2e0** **wait_for_lock+0x14c** **sl_retry+0x1c** unselect+0x1c invoke_callouts_for_self+0xc0 sw_service+0xb0 mp_ext_interrupt+0x144 ivti_patch_to_nop3+0x0 idle+0x6a8 swidle_exit+0x0	stack trace for event **3** crash event was a **TOC** preArbitration+0x280 **wait_for_lock+0x110** **sl_retry+0x1c** issig+0x64 _sleep_one+0x678 semop+0x304 syscall+0x200 $syscallrtn+0x0

Analysis beyond standard crashinfo output

crashinfo's options

crashinfo has some options that might be useful:

```
$ crashinfo -h
crashinfo (3.19)
Usage:   crashinfo [options ...] [coredir | kernel core]
Default: coredir="." if "INDEX" file present else
         kernel="/stand/vmunix" core="/dev/kmem"
Options:
        -h | -help [flag,flag...]
                 flags: detail
        -u | -update
        -v | -verbose
        -c | -continue
        -H | -Html
        -e | -email <mail_addr>[,flag,flag...]
                 flags: file=<file>
                        from=<from>
                        callid=<callid>
        -t | -trace [flag,flag...]
                 flags: args
                        regs    (PA Only)
                        Rregs   (PA Only)
                        locals  (IA64 Only)
                        frame   (IA64 Only)
                        mems    (IA64 Only)
                        bsp     (IA64 Only)
                        ss      (IA64 Only)
        -s | -syscall
        -f | -full_comm
        -l | -listonly
        -n | -nolist
        -S | -Sleep
        -i | -ioscan
             -ofiles [pid]
             -signals [pid]
             -vmtrace [flag,flag...]
                 flags: bucket=<bucket>
                        arena=<arena>
                        count=<num>
                        leak
                        cor
                        log
                        parse
             -kmeminfo
```

Refer to the crashinfo homepage in order to get more information on the usage.

Working with the P4 debugger

From within the dump directory execute p4:

```
$ p4
Send bugs, remarks, ideas to  --> ktools@wtec.cup.hp.com

Web based p4 at http://ktools.france.hp.com/~ktools/wp4

$ man                    # For online help on p4 functions
$ man -l                 # For a listing of p4 functions
$ ref -n                 # Lookup p4 reference manual on the web -
                           http://ktools.france.hp.com/~ktools/p4-4/
```

```
$ p4 -u              # Get the latest version of p4

P4 revision: 7.103

Loading symbols from lab07/vmunix
Kernel TEXT pages not requested in crashconf
Will use an artificial mapping from lab07/vmunix TEXT pages

Using a.out from lab07/vmunix and mem from crash.0/INDEX ...
Open crash.0/vmunix and crash.0/INDEX OK

HP-UX trefftz1 B.11.00 U 9000/800 648359312
This is a WIDE mode kernel (LP64)
$
```

To obtain a stacktrace:

```
$ trc event 0
Event #0  : proc[29] pid=1498 tid=1555  cmd="/usr/sbin/nfsd 4"
==============  EVENT  ============================
= Event #0 is PANIC on CPU #3
= p crash_event_t 0x22000
= p rpb_t 0x975608
= Using pc from pim.wide.rp_rp_hi = 0x3a1174
==============  EVENT  ============================
panic+0x14
report_trap_or_int_and_panic+0x84
trap+0xe14
thandler+0xd24
+-------------  TRAP  ----------------------------
|  Trap type 6 in KERNEL mode at 0 (0x00000000_00000000)
|  p struct save_state 0xa8da000.0x400003ffffff2850
+-------------  TRAP  ----------------------------
suspicious trap addr, try to resync with ss_rp=0x277a48
sendfile_rele+0x318
...
...
```

P4 includes a pool of useful commands:

```
$ man -l
p4_btype_def      - Define a new base type for p4
p4_ls_type        - List all the p4 data types
p4_kernel_symbols - Access kernel global variables as ksh variables
p4_ls_su          - List all struct/union data types
p4_ls_td          - List all typedefs
p4_ls_enum        - List all enum types or members of an enum type
p4_add_enum       - Define an enum type or enumerant
p4_struct_init    - Dynamically load additional debug infos
p4_print          - General print utility
p4_print_next     - General print utility, print next element
p4_print_prev     - General print utility, print previous element
p4_print_redo     - Redo p4_print command
p4_printf         - Print formatted output similar to printf(3S)
...
...
```

Each command has a man page.

Some P4 commands are intended to provide the same functionality as existing HP-UX commands. The usually begin with a capital letter:

$ Bdf
```
Filesystem          kbytes    used   avail %used Mounted on
/dev/root           204800   75635  121232   38% /
/dev/vg00/lvol1     299157   46240  223001   17% /stand
/dev/vg00/lvol8    4706304 1018611 3459291   23% /var
/dev/vg00/lvol7    1343488  590072  706389   46% /usr
/dev/vg00/lvol4     204800  146089   55072   73% /tmp
/dev/vg00/lvol6    1024000  966638   53817   95% /opt
/dev/vgdata/lvdata 102400000 78978488 23238632   77% /mnta2
/dev/vgabin/lvbin  102400000 29787064 72059592   29% /mnta1
/dev/vgprog/vgprog 102400000 100095664 2227558   98% /interconnect
/dev/vg00/lvol5      20480   14763    5396   73% /home
/dev/vg03/ldata2   102400000 38024176 63930960   37% /mnta3
/opt/bmpa/tmp/.MTP_interface_pipe.15840
                         0       0       0    0%
```

$ Swapinfo -tm
```
             Mb      Mb      Mb   PCT  START/      Mb
TYPE      AVAIL    USED    FREE  USED   LIMIT RESERVE  PRI  NAME
dev        4096     498    3598   12%       0       -    1  /dev/vg00/lvol2
reserve       -    1003   -1003
memory     1580     598     982   38%
total      5676    2099    3577   37%       -       0    -
```

$ BootString
```
disc(10/4/12.0.0;0)/stand/vmunix
```

$ Boottime
```
0x3d27fc5f  :  Sun Jul  7 10:31:27 2002
```

$ Time
```
0x3d2d41de  :  Thu Jul 11 10:29:18 2002
```

$ Crashconf -v
```
CLASS          PAGES  INCLUDED IN DUMP  DESCRIPTION
--------  ----------  ----------------  -------------------------------------
UNUSED         24611  no,  by default   unused pages
USERPG         95002  no,  by default   user process pages
BCACHE        162582  no,  by default   buffer cache pages
KCODE           1908  no,  by default   kernel code pages
USTACK          1440  yes, by default   user process stacks
FSDATA          1258  yes, by default   file system metadata
KDDATA         25286  yes, by default   kernel dynamic data
KSDATA         15593  yes, by default   kernel static data

Total pages on system:            327680  ( 1310720 Kb )
Total pages included in dump:      43577  (  174308 Kb )

DEVICE        OFFSET(Kb)   SIZE (Kb)  LOGICAL VOL.  NAME
------------  ----------  ----------  ------------  -------------------------
 28:0x030000      101216     1024000   64:0x000002  /dev/vg00/lvol2
                          ----------
                             1024000

Total avail dump space:      1024000  (  256000 pages )
Space for dump headers:     -     60  (      15 pages )
                          ==========
Total useable dump area:     1023940  (  255985 pages )
```

$ CpuUsage
```
   pid      tid pri spu kt_cpu  recent      user       sys     intr    kt_start
p_comm
     0        0 128   3      0       0         0      4695      162  0x3d27fc5f
swapper
     1        1 168   0      0       0       265      5052        0  0x3d27fc68 init
     2        2 128   0      0       0         0      1104        0  0x3d27fc5f
vhand
```

```
     3       3 128   2     1        0         0     93680     1865  0x3d27fc5f
statdaemon
...
```

```
$ Dmesg
o
10/0 c720
10/0.6 tgt
10/0.6.0 sdisk
10/0.7 tgt
10/0.7.0 sctl
...
```

```
$ Fstyp /var
hfs
f_bsize: 8192             /* preferred file system block size */
f_frsize: 1024            /* fundamental file system block size */
f_blocks: 1443040         /* total blocks of fr_size on file system */
f_bfree: 532045           /* total number of free block in fs */
...
```

```
$ Ipcs -m
IPC status from /dumps/dumpread/labs/lab20 as of Thu Jul 11 10:29:18 2002

T       ID      KEY         MODE         OWNER     GROUP
Shared Memory:
m        0 0x411057d6  --rw-rw-rw-      root      root
m        1 0x4e100002  --rw-rw-rw-      root      root
m        2 0x41142787  --rw-rw-rw-      root      root
m        3 0x5011e167  --r--r--r--      root     other
m     9220 0x0c6629c9  --rw-r-----      root      root
...
```

```
$ Processes
Loaded 4116 proc_t entries in 'DefaultView'

$ keep p_stat               (UX 10.X and 11.00 only)
Kept     281 entries in DefaultView

$ vp p_pid p_ppid p_comm | grep getty
0x00000663 0x00000001 getty

$ Ps -p 16440
  Sleep PRI   TID   PID  PPID           PCOMM     SC_NAME     KSTAT CTXT_FLAGS
   1026 661 12314 16440 23369              rm      unlink   TSSLEEP 0x00000000
```

Additionally there are other useful commands:

Get the command line of a process:

```
$ pcmd -p 16440
       addr   pindx    pid : command
  0x6393d80     2225  16440 : rm 1_450.dbf 1_4500.dbf 1_45000.dbf 1_45001.dbf
1_45002.dbf
```

Get the stacktrace of a process:

```
$ trace -a -p 16440
proc[2225] pid=16440 tid=12314  cmd="rm 1_450.dbf 1_4500.dbf 1_45000.dbf 1_45"
Process   : p proc_t    0x6393d80
            proc[2225] pid=16440 rm
Kthread   : p kthread_t 0x67e89a8
Using PCB: p user_t 0x627f400.0x400003fffff0000
SR5=0x0627f400
```

```
                SP     SZ         RP Return Name
0x400003ffffff21a0 0x00c0 0x00128a8c _swtch+0xd4
         arg0: 0x00000000001cc988
0x400003ffffff20e0 0x0130 0x001286ac _sleep+0x154
         arg0: 0x0000000000957448
         arg1: 0x0000000000000295
0x400003ffffff1fb0 0x00d0 0x001cc988 getnewbuf_desperate+0x258
         arg0: 0x0000000000000001
         arg1: 0x0000000000002000
0x400003ffffff1ee0 0x0120 0x00168d2c getnewbuf+0x584
         arg0: 0x0000000000004850
         arg1: 0x0000000000002000
...
...

Or use
$ trace -w -p 16440
```

Print values and structures:

Print value at address 0x023ff070:

```
$ p i4 0x023ff070
0x023ff070
0x023ff070 : 0x023e95f0
```

I.e. the value referenced by the "pointer" 0x023ff070 is 0x023e95f0

If you know that you are referencing a certain structure you can print it:

```
$ p struct inode 0x023ff070
0x023ff070
0x023ff070 :
0x023ff070 struct inode {
0x023ff070   struct inode *i_chain[2];             0x023e95f0
0x023ff078   dev_t   i_dev;                        0x40000005
0x023ff07c   ino_t   i_number;                     0x00058a40
0x023ff080   u_int   i_flag;                       0x00000446
0x023ff084   ushort  i_lockword;                   0x0011
0x023ff088   tid_t   i_tid;                        0x00001b2f
0x023ff08c   struct vnode {
0x023ff08c     u_short v_flag;                     0x0000
...
```

P4 provides some nice commands to **calculate**:

convert to decimal:

```
$ d 0x100
256
```

or

```
$ dec 0x100
256
```

convert to hexadecimal:

```
$ x 256
0x100
```

or

```
$ hex 256
0x100
```

convert to any format:

```
$ Let -b 256
100000000

$ x 0x7fff64d8-0x30
```

Print kernel globals/tunables:

```
$ printf '%d\n' nproc
6420

$ d nproc
6420

$ d vxfs_ninode
128000
```

NOTE: `dec`, `hex` and `Let` are aliases for the `p4_let(1)` command.

crashinfo output example

```
                      crashinfo (3.10) output

                        =====================
                        = Table Of Contents =
                        =====================

* General Information
* Crash Events
* Message Buffer
* Memory Globals
* Buffer Cache Globals
* Swap Information
* Global Error Counters / kmem_writes
* Network Interfaces
* IOVA Usage Check
* Crash Event / Processor Information
* Processor Clock Info
* Syswait Array
* Load Averages
* Thread Information
* Kernel Patches

                        =======================
                        = General Information =
                        =======================

Dump time Fri May  9 08:14:12 2003 UTC-2
System has been up 1 minute.

System Name      : HP-UX
Node Name        : banana
Model            : 9000/800/A500-7X
HP-UX version    : B.11.00 (64-bit Kernel)
Number of CPU's  : 2
Disabled CPU's   : 0
CPU type         : PCXW+ (750 Mhz)
CPU Architecture : PA-RISC 2.0
Load average     : 0.29  0.08  0.03

                        ================
                        = Crash Events =
                        ================

Note: Crash event 0 was a TOC !


Note: This seems to be a user initiated TOC !
It seems the monarch processor has not updated the system wide clock
for approx 4547 seconds. Concentrate on the stack trace for the monarch
processor (usually CPU 0) !
For more information go to:
"http://wtec.cup.hp.com/~hpux/crash/FirstPassWeb/PA/toc/crashinfo_clock.htm"

Stack Trace for crash event 0
=============================

==============  EVENT  ============================
= Event #0 is TOC on CPU #0
= p crash_event_t 0x22000
= p rpb_t 0x7bc358
= Using pc from pim.wide.rp_pcoq_head_hi = 0x126348
==============  EVENT  ============================
SR4=0x00000000
                SP          RP Return Name
0x000000000b7e22a0 0x00126348 idle+0x1000
0x000000000b7e2050 0x00128adc swidle+0x20


Stack Traces for other processors
=================================


Processor #1
```

```
==============  EVENT  ============================
= Event #1 is TOC on CPU #1
= p crash_event_t 0x22030
= p rpb_t 0xcac370
= Using pc from pim.wide.rp_pcoq_head_hi = 0x126388
==============  EVENT  ============================
SR4=0x00000000
                SP          RP Return Name
0x000000000b7e52a0 0x00126388 idle+0x1040
0x000000000b7e5050 0x00128adc swidle+0x20

                        ==================
                        = Message Buffer =
                        ==================

gate64: sysvec_vaddr = 0xc0002000 for 1 pages
NOTICE: autofs_link(): File system was registered at index 3.
NOTICE: nfs3_link(): File system was registered at index 5.
0 sba
0/0 lba
0/0/0/0 btlan3
0/0/1/0 c720
0/0/1/0.7 tgt
0/0/1/0.7.0 sctl
0/0/1/1 c720
0/0/1/1.7 tgt
0/0/1/1.7.0 sctl
0/0/1/1.15 tgt
0/0/1/1.15.0 sdisk
0/0/2/0 c720
0/0/2/0.7 tgt
0/0/2/0.7.0 sctl
0/0/2/1 c720
0/0/2/1.7 tgt
0/0/2/1.7.0 sctl
0/0/2/1.15 tgt
0/0/2/1.15.0 sdisk
0/0/4/1 asio0
0/2 lba
0/4 lba
0/6 lba
8 memory
160 processor
162 processor
btlan3: Initializing 10/100BASE-TX card at 0/0/0/0....

    System Console is on the Built-In Serial Interface
Entering cifs_init...
Initialization finished successfully... slot is 8
Logical volume 64, 0x3 configured as ROOT
Logical volume 64, 0x2 configured as SWAP
Logical volume 64, 0x2 configured as DUMP
    Swap device table:  (start & size given in 512-byte blocks)
        entry 0 - major is 64, minor is 0x2; start = 0, size = 8388608
    Dump device table:  (start & size given in 1-Kbyte blocks)
        entry 0 - major is 31, minor is 0x1f000; start = 310112, size = 4194304
Warning: file system time later than time-of-day register

Getting time from file system
Starting the STREAMS daemons-phase 1
Create STCP device files
Starting the STREAMS daemons-phase 2
    B2352B/9245XB HP-UX (B.11.00) #1: Wed Nov  5 22:38:19 PST 1997

Memory Information:
    physical page size = 4096 bytes, logical page size = 4096 bytes
    Physical: 3145728 Kbytes, lockable: 2374088 Kbytes, available: 2731304 Kbytes



                        ==================
                        = Memory Globals =
                        ==================

Physical Memory      = 786432 pages (3.00 GB)
Free Memory          = 676440 pages (2.58 GB)
Average Free Memory = 599788 pages (2.29 GB)
```

```
desfree              = 3072 pages (12.00 MB)
minfree              = 1280 pages (5.00 MB)

                        ========================
                        = Buffer Cache Globals =
                        ========================

dbc_max_pct            = 50 %
dbc_min_pct            = 5 %
dbc current pct        = 5.4 %
bufpages               = 42627 pages (166.51 MB)
Number of buf headers = 22596

fixed_size_cache = 0
dbc_parolemem    = 0
dbc_stealavg     = 0
dbc_ceiling      = 393216 pages (1.50 GB)
dbc_nbuf         = 19660
dbc_bufpages     = 39321 pages (153.60 MB)
dbc_vhandcredit  = 0
orignbuf         = 0
origbufpages     = 0 pages

                        ====================
                        = Swap Information =
                        ====================

swapinfo -mt emulation
======================

             Mb       Mb       Mb   PCT  START/       Mb
TYPE      AVAIL     USED     FREE  USED   LIMIT RESERVE  PRI  NAME
dev        4096        0     4096    0%       0       -    1  LVM vg00/lv2
reserve       -        3       -3
memory     2324       24     2300    1%
total      6420       27     6393    0%       -       0    -


                ========================================
                = Global Error Counters / kmem_writes =
                ========================================

default_disk_ir = 1

Note:  Immediate reporting for SCSI devices switched on per default !


                        ======================
                        = Network Interfaces =
                        ======================

Name   PPA   Driver      Interface          Mac       States      IP
              Name      Description       Address    Link IP     Address
--------------------------------------------------------------------------------
lan0    0    btlan3  100BT PCI Built-in 0x00306e26c1ac UP   n/c  n/c

n/c : means "Not Configured", ifconfig has not been done on this interface


If you want more information, you can use : "lanshow -f"

                        ====================
                        = IOVA Usage Check =
                        ====================

99% of IOVA still available/free.

                ========================================
                = Crash Event / Processor Information =
                ========================================

Number of processors = 2

        s
        t
        a       spin reg eiem/spl         eirr              ipsw
evt cpu t type  dpth src cr15             cr23              cr22
```

```
--- --- - ----- ---- --- ---------------- ---------------- ----------------
0   0   E TOC   2    rpb c600000000000000 0800000000000012 080efc1f WBCVRQPDI
                     mpi fffffff0ffffffff
1   1   E TOC   0    rpb fffffff0ffffffff 0000000100000000 0804fc1f WCRQPDI

Outstanding external interrupts
===============================

    eirr
cpu bit  SPL                Handler SPL        Handler
--- ---- --------           -----------        -------
0   4    SPL6/SPINLOCK_EIEM SPL6/SPINLOCK_EIEM clock_int
0   59   SPL6/SPINLOCK_EIEM SPL5/SPLIO         sapic_interrupt
0   62   SPL6/SPINLOCK_EIEM SPL5/SPLIO         sapic_interrupt
1   31   SPLNOPREEMPT       SPLNOPREEMPT       take_a_trap

SPL/EIEM values:

0xfffffffeffffffff = SPLPREEMPTOK - Default user mode SPL level.
0xfffffff0ffffffff = SPLNOPREEMPT - Disable kernel preemption (scheduling interrupt off).
0xffffff00ffffffff = SPL2 - Disable software interrupt (software triggers off).
0xef00080000000000 = SPL5 - Disable IO modules.
0xc700000000000000 = SPL6+CLOCK_RESYNC - Disable hardclock+enable clock-resync.
0xc600000000000000 = SPL6 - Disable hardclock.
0x0000000700000000 = SPL7/PSW_I=0 - Disable the world.


                        ========================
                        = Processor Clock Info =
                        ========================

hardclock_late = 796
itick_per_tick = 7500000
lbolt          = 10644 (0x2994)

    mpi                interval                          clk eiem eirr PSW
cpu timeinval          timer              delta (ticks) od  0,4  0,4  I
--- ------------------ ------------------ ------------- --- ---- ---- ---
0   0x2e22064a2f       0x3492b9cb4da      -455287       796 1 0  0 1  1
1   0x3494f94b457      0x3494f36f29a      0             0   1 1  0 0  1

WARNING: Processor 0 appears to have had clock interrupts held off for
approx 4547 seconds. Current SPL = 0xc600000000000000 (SPL6).


                        =================
                        = Syswait Array =
                        =================

cpu iowait
--- ------
1   1
Note: This shows the number of threads waiting on buffer I/O.
First figure out how long the I/O is outstanding. A good way to do
so is by searching in the threads list for processes that have a
waitchannel like biowait, ogetblk or swbuf. As a rule of thumb, only
consider I/O's outstanding longer than 30 seconds (your mileage may
vary).

For more information go to:
"http://wtec.cup.hp.com/~hpux/crash/FirstPassWeb/PA/toc/buffer_hang.htm"


                        =================
                        = Load Averages =
                        =================

avenrun
=======
0.29  0.08  0.03

real_run
========
0.144118  0.044052  0.015964

pwrun ("fast" io wait)
======================
```

```
0.429802  0.121551  0.043083

mp_avenrun
==========
cpu0 : 0.461995  0.135315  0.048295
cpu1 : 0.111926  0.030288  0.010752

                        ======================
                        = Thread Information =
                        ======================

9 Threads ran in the last second
46 Threads ran in the last 5 seconds
47 Threads ran in the last 10 seconds
52 Threads ran in the last minute
89 Threads ran in the last hour

statdaemon ran 84 ticks ago


Most Common Wait Channels
=========================
                                                          ticks since run:
Wait Channel                                       count  longest    shortest
------------                                       -----  ---------- ----------
vx_inactive_thread_sv                              25     6271       171
vx_inactive_thread_sv+0x8                          25     6271       171
lvmkd_q                                            6      225        225
streams_mp_sync                                    2      6307       6306
streams_blk_sync                                   2      6307       6306

Most Common Sleep Callers
=========================
                                                          ticks since run:
Sleep Caller                                       count  longest    shortest
------------                                       -----  ---------- ----------
vx_inactive_thread()                               50     6271       171
lvmkd_daemon()                                     6      225        225
wait1()                                            3      239        0
biowait()                                          2      0          0


Idle Globals
============

candidate_idle_spu = 0
migration_cycles = 0

Running Threads (TSRUNPROC) and idle Processors
===============================================


                    TICKS      TICKS                  I TICKS
                    SINCE      SINCE                  C SINCE      NREADY
TID     PID   PPID  RUN        IDLE       PRI SPU STATE S MIGR      FR LO AL COMMAND
------- ----- ----- ---------- ---------- --- --- ----- - --------- -- -- -- -------
                               0              0   IDLE  N 171       0  0  0
                               0              1   IDLE  N 203       0  0  0

Note:
FR: free to run on any processor (candidate for thread migration).
LO: locked (via processor affinity/mpctl) to this processor).
AL: Alpha semaphores misses (special scheduling when miss a sema).


Threads waiting on cpu (TSRUN) - sorted by cpu/pri/ticks-since-run
==================================================================

Note:  There is 1 thread in TSZOMB stat !


All Threads - sorted by ticks-since-run
=======================================

TID     PID   PPID  TICKS      PRI SPU STAT  SYSCALL        COMMAND        WCHAN
------- ----- ----- ---------- --- --- ----- -------------- -------------- -----
503     446   445   0          148 1   SLEEP execve         sh             biowait(0x42f8a6d8)
```

```
502      445   440   0          152 0   SLEEP execve       sh             proc[33]+0x1a8
497      440   430   0          158 0   SLEEP waitpid      nettl          proc[27]
35       33    0     69         138 1   SLEEP n/a          vxfsd          vx_ifree_thread_sv
33       33    0     71         138 0   SLEEP n/a          vxfsd
vx_event_wait(0x42b88aa0)
34       33    0     71         138 0   SLEEP n/a          vxfsd          vx_iflush_thread_sv
36       33    0     71         138 1   SLEEP n/a          vxfsd
vx_inactive_cache_thread_sv
4        4     0     84         128 0   SLEEP n/a          unhashdaemon   unhash
3        3     0     84         128 1   SLEEP n/a          statdaemon     ticks_since_boot
38       33    0     152        138 1   SLEEP n/a          vxfsd
vx_logflush_thread_sv
39       33    0     171        138 1   SLEEP n/a          vxfsd          vx_attr_thread_sv
75       33    0     171        138 1   SLEEP n/a          vxfsd
vx_inactive_thread_sv+0x8
54       33    0     171        138 0   SLEEP n/a          vxfsd
vx_inactive_thread_sv
37       33    0     171        138 0   SLEEP n/a          vxfsd
vx_delxwri_thread_sv
40       33    0     171        138 0   SLEEP n/a          vxfsd          vx_tuning_thread_sv
499      442   1     202        127 0   SLEEP read         nktl_daemon    netdiag_ques+0x44
498      441   440   203        178 0   ZOMB  exit         nettl
1        1     0     203        168 1   SLEEP sigsuspend   init           *uptr+0
483      426   1     204        154 0   SLEEP select       syslogd        selwait
23       23    0     225        147 1   SLEEP n/a          lvmkd          lvmkd_q
19       19    0     225        147 0   SLEEP n/a          lvmkd          lvmkd_q
22       22    0     225        147 0   SLEEP n/a          lvmkd          lvmkd_q
21       21    0     225        147 0   SLEEP n/a          lvmkd          lvmkd_q
20       20    0     225        147 0   SLEEP n/a          lvmkd          lvmkd_q
18       18    0     225        147 0   SLEEP n/a          lvmkd          lvmkd_q
487      430   100   226        158 1   SLEEP waitpid      nettl          proc[28]
486      429   1     237        155 0   SLEEP msgrcv       ptydaemon      msgque[0]+0x5c
157      100   1     239        158 0   SLEEP waitpid      rc             proc[23]
52       33    0     274        138 0   SLEEP n/a          vxfsd
vx_inactive_thread_sv
73       33    0     276        138 1   SLEEP n/a          vxfsd
vx_inactive_thread_sv+0x8
50       33    0     277        138 0   SLEEP n/a          vxfsd
vx_inactive_thread_sv
0        0     0     284        128 0   SLEEP n/a          swapper        runout
71       33    0     316        138 1   SLEEP n/a          vxfsd
vx_inactive_thread_sv+0x8
69       33    0     319        138 1   SLEEP n/a          vxfsd
vx_inactive_thread_sv+0x8
...
...
...
85       33    0     6271       138 1   SLEEP n/a          vxfsd
vx_inactive_thread_sv+0x8
12       12    0     6306       -32 0   SLEEP n/a          ttisr          ttirr
28       28    0     6306       100 0   SLEEP n/a          sblksched      streams_blk_sync
26       26    0     6306       100 0   SLEEP n/a          smpsched       streams_mp_sync
24       24    0     6306       148 0   SLEEP n/a          lvmschedd      lv_schedule_daemon
25       25    0     6307       100 1   SLEEP n/a          smpsched       streams_mp_sync
27       27    0     6307       100 1   SLEEP n/a          sblksched      streams_blk_sync
10       10    0     6384       100 0   SLEEP n/a          strweld        weldq_runq
8        8     0     6384       100 0   SLEEP n/a          supsched       streams_up_runq
9        9     0     6384       100 0   SLEEP n/a          strmem         __gp+0x4e8
11       11    0     6384       100 0   SLEEP n/a          strfreebd      str_freeb_idle

                        ==================
                        = Kernel Patches =
                        ==================

PHKL_12965      PHKL_13431      PHKL_13810      PHKL_14026      PHKL_14088
PHKL_14763      PHKL_14765      PHKL_15510      PHKL_15547      PHKL_15550
PHKL_15551      PHKL_15553      PHKL_15705      PHKL_15910      PHKL_16074
PHKL_16209      PHKL_16236      PHKL_16819      PHKL_17042      PHKL_17205
PHKL_17258      PHKL_17458      PHKL_17869      PHKL_17953      PHKL_18295
...
...
PHNE_15537      PHNE_16017      PHNE_16599      PHNE_17586      PHNE_18272
PHNE_18409      PHNE_19620      PHNE_19759      PHNE_20344      PHNE_20431
PHNE_21217      PHNE_21433      PHNE_21897      PHNE_22086      PHNE_22125
PHNE_22159      PHNE_22244      PHNE_22245      PHNE_22566      PHNE_22642
PHNE_22962      PHNE_23249      PHNE_23456      PHNE_23930      PHNE_24100
```

Patches related to crash dumps

There are several patches that fix problems related to crash dumps. Either a dump could not be properly or not at all taken or the unwinding of the stack trace was not possible. There have also been problems when saving the crash to the file system or with the crashconf(1M) command. The kernel patches usually patch the /usr/conf/lib/libshutdown-pdk.a library.

UX 11.00:
PHKL_20873 - 11.00 patch for kernel stack unwinding
PHKL_21121 - 11.00 patch for kernel stack unwinding
PHKL_21120 - 11.00 patch for kernel stack unwinding
PHKL_20900 - 11.00 Add missing crash dump debug information
PHKL_22926 - 11.00 Incomplete Selective Dump, TOC/Panic Failure
PHKL_20937 - 11.00 Fix for TOC vector overwriting
PHKL_20989 - 11.00 Cumulative dump device, dump size patch
PHKL_20173 - 11.00 Include zero page in dumps
PHKL_20915 - 11.00 trap-related panics/hangs
PHCO_26188 - 11.00 savecrash(1M) cumulative patch
PHCO_20196 - 11.00 savecrash startup files cumulative patch
PHCO_19726 - 11.00 crashconf(1M) cumulative patch

UX 11.11:
PHKL_27918 - 11.11 EPIC debug info
PHKL_32715 - 11.11 crash,vpars,timeout;SG TOC,nParCnfg,shutdown
PHKL_28237 - 11.11 vPar enablement, CDUMP enablement patch
PHKL_26705 - 11.11 syslog/console handling,printf panic fix
PHKL_34106 - 11.11 early dump, CDUMP, dump menu, EVA, zero page
PHCO_30361 - 11.11 savecrash cumulative, CDUMP enablement

UX 11.23:
PHCO_30312 - 11.23 q4 patch version B.11.23l
PHCO_31561 - 11.23 Cumulative savecrash(1M) patch
PHCO_31609 - 11.23 Improve the performance of libcrash
PHCO_31612 - 11.23 crashutil support to control libcrash cache
PHKL_31500 - 11.23 Sept04 base patch
PHKL_31503 - 11.23 IDE/ATAPI cumulative patch
PHKL_31507 - 11.23 Cumulative kernel SCSI patch
PHKL_34213 - 11.23 vPars CPU migr, cumulative shutdown patch
PHKL_34460 - 11.23 Cumulative Crash Dump Patch;EH;MCA Full,Comp

Additional information

Dump reading webcourse:
http://wtec.cup.hp.com/~hpux/crash/FirstPassWeb/ (HP internal)

Dump reading webcourse for Itanium systems:
http://wtec.cup.hp.com/~hpux/crash/ia64crash/ (HP internal)

Ktools server (p4ooshop)
http://ktools.france.hp.com/~ktools/cgi-bin/p4ooshop.cgi (HP internal)

P4 homepage:
http://ktools.france.hp.com/~ktools/p4-4/ (HP internal)

There is a nice web based P4:
http://ktools.france.hp.com/~ktools/wp4 (HP internal)

crashinfo homepage:
http://wwwukrc.uksr.hp.com/edt/crashinfo.html (HP internal)

System crash dump white paper:
http://docs.hp.com/cgi-bin/otsearch/getfile?id=/hpux/onlinedocs/os/syscrash.html

Refer to the vPars Chapter to learn how a *virtual partition* system dumps.

Related manual pages:
savecrash(1M), crashconf(1M), crashutil(1M), lvlnboot(1M)