Chapter 19

Process Resource Manager (PRM)

HP-UX Handbook
Revision 13.00

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Introduction

Process Resource Manager (PRM) is a resource management tool used to control the amount of resources that processes use during peak system load (at 100% CPU resource or 100% memory resource). PRM can guarantee a minimum allocation of system resources available to a group of processes through the use of PRM groups.

A PRM group is a collection of users and applications that are joined together and assigned certain amounts of CPU and memory resource. The two types of PRM groups are *FSS PRM groups* and *PSET PRM groups*. An FSS PRM group is the traditional PRM group, whose CPU entitlement is specified in shares. This group uses the Fair Share Scheduler (FSS) in the HP-UX kernel within the system’s default processor set (PSET). A PSET PRM group is a PRM group whose CPU entitlement is specified by assigning it a subset of the system’s cores (PSET). (A core is the actual data-processing engine within a processor. A single processor might have multiple cores. A core might support multiple execution threads.) Processes in a PSET have equal access to CPU cycles on their assigned cores through the HP-UX standard scheduler.

PRM’s Resource Managers

PRM has four resource managers:

CPU (CPU percentage)

Ensures that each PRM group is granted at least its allocation of CPU resources. Optionally for FSS PRM groups, this resource manager ensures no more than its capped amount of CPU resources. For PSET PRM groups, processes are capped on CPU resource usage by the number of cores assigned to the group.

MEM (memory)

Can manage both private memory and shared memory.

- For private memory:
  Ensures that each PRM group is granted at least its share, but (optionally) no more than its capped amount of memory. You can also specify memory shares be isolated so that a group’s assigned memory shares cannot be loaned out to, or borrowed from, other groups.
- For shared memory:
  Ensures a PRM group is allocated a minimum number of megabytes for use as shared memory.

DISK (disk bandwidth)

Ensures that each FSS PRM group is granted at least its share of disk bandwidth. PRM disk bandwidth management can only control disks that are mounted and under the control of HP's Logical Manager (LVM) or VERITAS Volume Manager(TM) (VxVM(R)).

PSET PRM groups are treated as part of PRM_SYS (PRMID 0) for disk bandwidth purposes.

APPL (application)
Ensures that specified applications and their child processes run in the appropriate PRM groups.

The following **daemons** belong to the PRM subsystem:

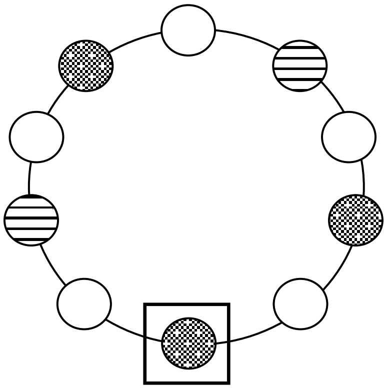
prm1d	Provides application management.
prm2d	Provides in-kernel memory management of both private memory and shared memory.

CPU and DISK resource management is done in the kernel.

How the FSS scheduler works

Consider the PRM CPU scheduler as the carousel below. The circles represent FSS PRM groups. There are 3 groups. The number of circles a group has in the carousel is determined by its CPU entitlement.

Group1 having 50% CPU entitlement, hence owning 5 of 10 circles.
Group2 having 30% CPU entitlement, hence owning 3 of 10 circles.
Group3 having 20% CPU entitlement, hence owning 2 of 10 circles.



Capping CPU resource use

PRM gives you two options for capping CPU resource use by FSS PRM groups:

- On a per-group basis
  (Available for HP-UX 11i v3 and later.) For per-group capping, use the MAX field in the FSS PRM group record for only those groups you want to cap.

- For all FSS PRM groups in the configuration
  The CPUCAPON mode, enabled through the prmconfig -M option discussed below, treats the FSS PRM group's minimum allocation as its maximum allocation. When CPUCAPON mode is enabled, CPU capping is in effect for all user-configured FSS PRM groups on a system - regardless of CPU load. Each FSS PRM group takes its entire CPU allocation. Thus, no group can obtain more CPU resources.

For PSET PRM groups, capping is a result of the number of cores assigned to the group.

Installation

Current PRM Version and Patches

Install the full PRM product, B3835DA, on systems where you want PRM to control resource allocations.
HP PRM is included with HP-UX 11i v3 and can be purchased for use with HP-UX 11i v1 and HP-UX 11i v2. A 90-day trial version can be downloaded from the HP Software Depot.

HP Process Resource Manager (PRM) Version C.03.05 supports:

- HP-UX 11i v1 (B.11.11) operating system on HP 9000 servers
- HP-UX 11i v 2 (B.11.23) operating system running on either HP 9000 servers or HP Integrity servers
- HP-UX 11i v3 (B.11.31) operating system running on either HP 9000 servers or HP Integrity servers

HP Process Resource Manager (PRM) Version C.03.05.01 supports:

- HP-UX 11i v 2 (B.11.23) operating system running on either HP 9000 servers or HP Integrity servers
- HP-UX 11i v3 (B.11.31) operating system running on either HP 9000 servers or HP Integrity servers

The current versions are available on the application DVDs:

B3835DA	C.03.05.01	HP Process Resource Manager
B3835DA	C.03.05	HP Process Resource Manager

The PRM software includes 4 products:

PRM-Sw-Gui	C.03.05.01	Process Resource Manager PRM-Sw-Gui product
PRM-Sw-Krn	C.01.05	Process Resource Manager PRM-Sw-Krn product
PRM-Sw-Lib	C.03.05.01	Process Resource Manager PRM-Sw-Lib product
PRM-Sw-Sim	C.03.05.01	Process Resource Manager PRM-Sw-Sim product

NOTE: If the PRM-Sw-Krn.PRM-KRN fileset is not installed or it is installed but its revision is older than the current revision, the current revision will be installed, causing a reboot.

PRM Release History

	11.11	**11.23**	**11.22**	**11.31**	**End of Support**
C.02.00.04			✓		Sep 05
C.03.00	✓	✓			Jul 09
C.03.01	✓	✓			Jun 10
C.03.02	✓	✓			Mar 11
C.03.02.02				✓	Feb 11
C.03.03.01	✓	✓		✓	Mar 12
C.03.04	✓	✓		✓	*
C.03.05	✓	✓		✓	*
C.03.05.01		✓		✓	*

For a list of recommended patches consult the Release Notes and http://www.hp.com/go/prm (select the "Patches and Support" link at the bottom of the web site).

Pre-Installation Steps

Consult the Release Notes for detailed installation instructions. Before installing the PRM product:

1. Shut down any versions of PRM, WLM, and GlancePlus that are already installed. Having these products running can prevent the proper update of files that are in use. Be sure to shut down WLM (wlmd -k), its configuration wizard, wlmgui, PRM (prmconfig -r), xprm, and GlancePlus - if any of them are running.

2. Evaluate whether to upgrade any WLM version that is installed (see release notes for details).

3. Shut down MeasureWare if it is running:
   ```
   # /sbin/init.d/mwa stop
   ```

4. Shut down HP Integrity Virtual Machines if it is running:
   ```
   # /sbin/init.d/hpvm stop
   ```
   PRM cannot run on a host used as a VM Host. However, you can use PRM inside virtual machines.

Post Installation Steps

- **PRM module:**
  Check if the prm module is in the kernel.

  ```
  # kcmodule prm
  Module  State   Cause
  prm     static  best
  ```

- **Restart WLM / MeasureWare**

  Restart WLM if it was running before the PRM upgrade/installation:
  ```
  # /opt/wlm/bin/wlmd -A
  ```
  Restart MeasureWare if it was running before the PRM upgrade/installation:
  ```
  # /sbin/init.d/mwa start
  ```

Preparation

Your PRM configuration should reflect some aspect of your business priorities. You may choose to configure your system based on how much each user group funds the system (budget model). Alternatively, you may configure the system to reflect the priorities of the applications that run on it (application priority model). Perhaps, you will devise another configuration model.

In general, when planning a PRM configuration, you should determine:

1. Your total available memory, number of cores, number and throughput speed of disks.
2. Who the users are and what their needs are.

Whatever model you choose, it is important to identify the configuration model you want before you begin to identify resource use and assign PRM groups and resource allocations.

The following sections help you to answer the following questions:

- Which applications should run under control of PRM?
- Which processes belong to those applications?
- What should be the names of the PRM groups?
- Which of the system resources (CPU, MEMORY, DISK) should be controlled by PRM?
- Which entitlements should each PRM group have?

Dividing Processes into Groups

Consult the output of the process table during normal system load:

$ ps -ef

```
  UID    PID  PPID  C   STIME TTY      TIME COMMAND
 root     0     0  0  Jan 10  ?       1:09 swapper
 root     1     0  0  Jan 10  ?       1:34 init
 root     2     0  0  Jan 10  ?       8:24 vhand
 root     3     0  0  Jan 10  ?      79:28 statdaemon
  ...
  ...
kdoi22  5403     1  0  Jan 10  ?       0:42 ora_smon_bfl
kdoi22  5242     1  0  Jan 10  ?       1:18 /oracle/app/oracle/product/8.1.5/bin/tnslsnr LISTENER -inherit
kdoi22  5420     1  0  Jan 10  ?       0:12 ora_s000_bfl
kdoi22  5422     1  0  Jan 10  ?       0:13 ora_s001_bfl
kdoi22  5424     1  0  Jan 10  ?       0:12 ora_s002_bfl
kdoi22  5426     1  0  Jan 10  ?       0:11 ora_s003_bfl
kdoi22  5428     1  0  Jan 10  ?       0:12 ora_s004_bfl
  ...
  ...
```

The most important PRM concept is groups. A PRM group is a collection f processes that is assigned system resources. PRM allows the assignment of applications and users to PRM groups. PRM then manages each group's CPU, disk bandwidth, and memory resources according to the current configuration.

The PRM application manager checks that applications are running in the correct PRM groups every *interval* seconds. The default *interval* is 30 seconds; however, you can change it.
There are several possibilities to associate the application processes with PRM groups, for instance:

User record
Specifies a user or a collection of users (through a netgroup) and assigns the user or netgroup to an initial PRM group.
Optionally, it can specify alternate PRM groups.

Unix group record
Unix groups are collections of users given Unix permissions as a whole. PRM allows you to map Unix groups to PRM groups without having to specify each user in the Unix group. With a Unix group record, any process running as a specific Unix group can be assigned to a PRM group.

Application record
Application records assign applications to PRM groups. Each record specifies an application and he PRM group it and its child processes can run in. Application records are optional; if an application does not have a record, it runs in the PRM group of the user who invoked it.

Oracle example:
If you intend to put Oracle database instances into different PRM groups you need to consider that when you open an instance, the Oracle executable ($ORACLE_HOME/bin/oracle) renames itself regarding the environment variable

$ORACLE_SID. The Oracle processes are named:

ora_<process-name>_$ORACLE_SID

$ORACLE_HOME and $ORACLE_SID are standard environment variable names for Oracle's home directory (usually /oracle/app/oracle/product/<oracle-version>/) and the name of the Oracle database instance, respectively.

The Oracle Server Manager ($ORACLE_HOME/bin/svrmgrl) starts following instance processes:

/oracle/app/oracle/product/8.0.6	$ORACLE_SID = "ORA_ORM"
/oracle/app/oracle/product/8.1.5	$ORACLE_SID = "ORA_BFL"

The instances are listed in the file /etc/oratab:

```
bfl:/oracle/app/oracle/product/8.1.5:Y
ormt:/oracle/app/oracle/product/8.0.6:Y
ormq:/oracle/app/oracle/product/8.0.6:Y
...
```

These instances create the following sub-processes by doing fork & rename:

<table>
<tr><th colspan="2">Instance ORA_ORM</th><th colspan="2">Instance ORA_BFL</th></tr>
<tr><td colspan="2">$ ps -ef | grep orm</td><td colspan="2">$ ps -ef | grep bfl</td></tr>
<tr><td>ora_arch_orm7t</td><td>(server process)</td><td>ora_arc0_bfl</td><td>(server process)</td></tr>
<tr><td>ora_ckpt_orm7t</td><td>(server process)</td><td>ora_ckpt_bfl</td><td>(server process)</td></tr>
<tr><td>ora_dbw0_orm7t</td><td>(server process)</td><td>ora_d000_bfl</td><td>(server process)</td></tr>
<tr><td>ora_lgwr_orm7t</td><td>(server process)</td><td>ora_d001_bfl</td><td>(server process)</td></tr>
<tr><td>ora_pmon_orm7t</td><td>(server process)</td><td>ora_d002_bfl</td><td>(server process)</td></tr>
<tr><td>ora_reco_orm7t</td><td>(server process)</td><td>ora_dbw0_bfl</td><td>(server process)</td></tr>
<tr><td>ora_smon_orm7t</td><td>(server process)</td><td>ora_lgwr_bfl</td><td>(server process)</td></tr>
<tr><td>oracleorm7t</td><td>(shadow process)</td><td>ora_pmon_bfl</td><td>(server process)</td></tr>
<tr><td>oracleorm7t</td><td>(shadow process)</td><td>ora_reco_bfl</td><td>(server process)</td></tr>
<tr><td>...</td><td></td><td>ora_smon_bfl</td><td>(server process)</td></tr>
<tr><td></td><td></td><td>ora_snp0_bfl</td><td>(server process)</td></tr>
<tr><td>ora_arch_orm7q</td><td>(server process)</td><td>oraclebfl</td><td>(server process)</td></tr>
<tr><td>ora_ckpt_orm7q</td><td>(server process)</td><td>oraclebfl</td><td>(server process)</td></tr>
<tr><td>ora_dbw0_orm7q</td><td>(server process)</td><td>...</td><td></td></tr>
<tr><td>ora_lgwr_orm7q</td><td>(server process)</td><td></td><td></td></tr>
</table>

ora_pmon_orm7q (server process) ora_reco_orm7q (server process) ora_smon_orm7q (server process) oracleorm7q (shadow process) oracleorm7q (shadow process) ...	

NOTE: A shadow process is created for each user connecting to the database instance.

To put these two instances into different PRM groups you need to specify alternate names using wildcards:

ora*orm*	includes all processes (server & shadow) of the instance ORA_ORM
ora*bflt	includes all processes (server & shadow) of the instance ORA_BFL

NOTE: Pattern matching rules
Pattern matching follows the rules for Basic Regular Expressions and, with PRM C.03.02 and later, Extended Regular Expressions, as outlined in the regexp(5) manpage. Because pattern matching is intended to match a collection of alternate names to a fully qualified executable, PRM was engineered to ensure that other applications and processes matching the pattern were not inadvertently put in the wrong PRM group. PRM does this by comparing file system inode numbers. For a process matching the alternate name pattern to be placed in the configured PRM group, it must share the file system inode number of the parent process.

The Oracle database administrator does not have to worry about inode numbers because all processes launched from the same executable (for example, Oracle database instances) share the same file system inode number.

NOTE: Managing **listener** processes
Although listener processes can be associated with a particular database instance, they are actually started as part of the networking processes that run with Oracle. In ps output, they appear as fully qualified executables:

```
oracle  1769    1  0 09:35:02 ?     0:00 /oracle/app/oracle/product/9.0.0/bin/tnslsnr LISTENER_Sales
oracle  1779    1  0 09:35:23 ?     0:00 /oracle/app/oracle/product/9.0.0/bin/tnslsnr LISTENER_Mktg
oracle  1774    1  0 09:35:12 ?     0:00 /oracle/app/oracle/product/9.0.0/bin/tnslsnr LISTENER_Support
```

The three listeners have exactly the same executable name, but with different parameters. Starting with PRM C.03.02, PRM supports Extended Regular Expressions in alternate names. This support enables you to create application records for listener processes. To put the listener processes in the same PRM groups as their database instances, use the following application records:

```
/u01/app/oracle/product/10.2.0/db_1/bin/tnslsnr::::Sales,'tnslsnr.*Sales'
```

```
/u01/app/oracle/product/10.2.0/db_1/bin/tnslsnr::::Mktg, 'tnslsnr.*Mktg'
/u01/app/oracle/product/10.2.0/db_1/bin/tnslsnr::::Support, 'tnslsnr.*Support'
```

Launching a script under PRM
To always run a script in a specific PRM group, use an application record. In this record, specify the full path of the shell or interpreter used in the script as the application. Also, give the name - without the path - of the script as an alternate name.
For example, consider a script named foo.sh that uses sh to execute its contents. In this scenario, an application record might look like this:

```
        /sbin/sh::::GroupA,foo.sh
```

NOTE: The full path of the shell/interpreter used in the script must appear in either the file `/etc/shells` or the file `/opt/prm/shells`.
Because the full pathname is not required for the script, a rogue user can get access to PRM groups - that otherwise would not be accessible - by using the name of the script for new script wrappers.

In the Oracle example above the groups ORA_ORM and ORA_BFL were created.
Additionally the following two groups exist but do not have to be specified:

PRM_SYS
PRM automatically assigns system processes to the group PRM_SYS (PRMID 0) and calculates this group's resource needs. You do not need to specify the PRM_SYS group in the PRM configuration file.
Non root users cannot have access to the system group PRM_SYS (PRMID 0).

OTHERS
The user default group, OTHERS (PRMID 1), is required in the PRM configuration file.

Resource Entitlement per PRM Group

The command prmavail(1) displays a quick information about the available system resources:

```
# prmavail
16 CPUs
8388608 real memory pages or 32768 MB available (PRM estimate)
5 volume groups
        /dev/vg00
        /dev/vgora
        /dev/vgdbt
```

Now you need to decide how to divide the resources (CPU, MEMORY, DISK) among the PRM groups. Basically there are two different approaches:

1) Analytic Approach

The command prmanalyze(1) reads standard HP-UX accounting information and allows an estimate of the resource consumption per process. Therefore process accounting needs to be running for some time to deliver statistically valuable information.

$ /usr/sbin/acct/accton /var/adm/pact switches accounting on

Check if the file /var/adm/pacct grows over time.

$ /usr/sbin/acct/accton switches accounting off again

$ prmanalyze -1 -p

```
summary CPU report by command name : 10736 records processed
unique id   processes    ave secs   peak secs    total secs  % total
agdbserv            2       98.38      196.01        196.75     1.94
alarmgen            2      378.17      754.16        756.34     7.45
cmcld               2     1453.49     2896.64       2906.98    28.64
dced                2      107.14      213.76        214.27     2.11
mib2agt             2      149.62      298.00        299.24     2.95
midaemon            2      779.75     1554.00       1559.49    15.36
netfmt              2       65.00      129.63        130.01     1.28
opcmona             2      107.27      213.86        214.54     2.11
rep_serv            2      135.79      270.56        271.59     2.68
scopeux             2      243.03      484.40        486.07     4.79
scrdaemo            2       83.74      167.18        167.48     1.65
snmpdm              2      136.94      272.71        273.87     2.70
```

The -1 option filters out all processes that have used less than 1% CPU time.
The -p option includes all processes that are currently running.

$ prmanalyze -1 -p -r mem

```
summary memory report by command name : 10301 records processed
unique id   processes       ave KB     peak KB    KB minutes  % total
automoun            2      156.79      158.76   17712288741.64    1.59
biod               32        7.90        9.26   14272290774.21    1.28
cmclconf            9       73.61      115.67   21106092748.33    1.89
cmcld               2      625.02     2119.00   89601638011.65    8.04
cmlvmd              2      242.69      357.00   34790978934.67    3.12
cmsnmpd             2      103.80      117.46   14886363987.98    1.34
dced                2      366.15      382.66   52508918875.98    4.71
disp+wor            8     3603.40     5910.00   85128425600.00    7.64
dmisp               2      155.43      407.00   22289890807.85    2.00
hpuxci              2      266.43      275.70   38207763568.95    3.43
mib2agt             2      102.05      103.89   14634840165.09    1.31
mibmond             2      150.38      169.37   21558326270.47    1.93
midaemon            2      614.04      778.00   88056096650.69    7.90
nfsd               21      122.47      214.00   60223461496.00    5.40
opcctla             2      405.29      506.00   58101720266.34    5.21
opcmsgi             2      110.04      138.67   15775275584.00    1.41
```

```
opcuisrv            2      210.32      247.86  30151185915.25     2.70
prm3d               6      857.77     1024.00  73680510360.90     6.61
rep_serv            2      267.61      338.00  38375920535.21     3.44
rpcbind             2      157.79      187.04  22636186149.09     2.03
scopeux             2      389.66      557.00  55879680622.10     5.01
snmpdm              2      205.46      226.95  29465439020.68     2.64
```

```
$ prmanalyze -1 -p -r disk
summary disk report by command name : 1961 records processed
unique id   processes     ave Bps    peak Bps      total KB  % total
diagmond            1      265.43      265.43    8685980.47     3.01
disp+wor            8     8435.80    66413.13  195128029.79    67.67
dmisp               2       21.05       89.43    2948265.72     1.02
instl_bo            1      870.52      870.52   28489607.62     9.88
mib2agt             1      133.84      133.84    4380250.00     1.52
oracle             14      376.39     1338.61   15243801.86     5.29
pwgrd               2       31.71      100.54    4441540.62     1.54
scopeux             2       36.87       56.04    5163305.76     1.79
snmpdm              2       36.31      155.38    5085586.52     1.76
```

You may sort the output by User-ID:

```
$ prmanalyze -p -s uid
summary CPU report by user id : 10736 records processed
unique id   processes    ave secs   peak secs    total secs  % total
root            10610        0.96     2896.64      10146.12    99.95
daemon              1        0.02        0.02          0.02     0.00
n07adm             12        0.19        0.91          2.33     0.02
oran07              4        0.08        0.26          0.32     0.00
awernig            93        0.02        0.13          1.69     0.02
adernier           14        0.03        0.17          0.45     0.00
hosterka            2        0.34        0.64          0.68     0.01
```

Details can be found in the `prmanalyze(1)` man page or in the HP Process Resource Manager User Guide.

2) Empiric Approach

It is usually a good idea to start with an initial configuration based on estimated entitlements. After monitoring the resource consumption with PRM active for some days this initial configuration may be modified to meet the actual demands.

Because the different resources cannot be isolated from each other, it is recommended not to limit all resources at once but to start with CPU entitlement.

NOTE:

A process that has to wait for memory cannot use up its CPU entitlement.

In this example the initial configuration is as follows:

PRM Group	PRM-ID	CPU	MEM	DISK
OTHERS	1	10%	10%	/
EXPRESS	2	15%	20%	/
ORA_ORM	3	30%	10%	/
ORA_BFL	4	25%	15%	/
OAS	5	20%	15%	/

(PRM-ID 1 is reserved for group OTHERS)

Configuration

Creating the PRM Configuration File /etc/prmconf

The PRM configuration is contained in the ASCII file /etc/prmconf.

Use the `prmloadconf` command to create a template. Specify a file name using the –f option. Default file name is /etc/prmconf:

```
$ prmloadconf [-f file]
```

This template needs to be modified. In this example the configuration looks as follows (detailed syntax in the table below):

```
$ cat /etc/prmconf

########## PRM group record ###################################
#
# GROUP:{PRMID | HIER}:SHARES::          (for FSS groups)
# GROUP:PSET:::[CPUS]:[CPU_LIST]         (for PSET groups)
#
OTHERS:1:10::
EXPRESS:2:15::
ORA_ORM:3:30::
ORA_BFL:4:25::
OAS:5:20::
#
# in this section the group names, group ids and cpu entitlements are defined
```

```
########## PRM memory record ######################################
#
# #!PRM_MEM:{PRMID|GROUP}:SHARES:[CAP]:[SUPPRESS]::[[IMPORT]:[EXPORT]:[LOCKABLE]]
#
#!PRM_MEM:OTHERS:10::::
#!PRM_MEM:EXPRESS:20::::
#!PRM_MEM:ORA_ORM:10::::
#!PRM_MEM:ORA_BFL:15::::
#!PRM_MEM:OAS:15::::
#
# in this section the memory entitlement are defined


########## PRM application record #################################
#
# APPLICATION::::GROUP[,ALTERNATE_NAME[, ...]]
#
/usr/contrib/bin/perl::::PRM_SYS
/oracle/app/oracle/product/8.1.5/bin/oracle::::ORA_BFL,ora*bfl
/oracle/app/oracle/product/8.0.6/bin/oracle::::ORA_ORM,ora*orm*
#
# in this section the executables and their sub-processes are
# assigned to PRM groups


########## PRM user record ########################################
#
# USER::::INITIAL_GROUP[,ALTERNATE_GROUP[, ...]]
#
dsuser::::PRM_SYS
oesdba::::EXPRESS
oesinit::::EXPRESS
oesguest::::EXPRESS
oraias::::OAS
#
# in this section the users are assigned to the PRM groups
# All other users from /etc/passwd, that are not explicitely specified
# here will be assigned to group OTHERS automatically. The root user
# always belongs to PRM_SYS group


########## PRM disk record ########################################
#
# VOLUME:{PRMID | GROUP}:SHARES::
#
# in this section the disk bandwidth is specified per volume group
# (not in this example)
```

Syntax for `prmconf(4)`. See also `prmconf(4)` man page.

Group record:

GROUP:PRMID:SHARES:[MAX]:	FSS PRM group
GROUP:HIER:SHARES::	hierarchical group

GROUP:PSET:::[CORES]:[CORE_LIST][:PSET_ATTR] PSET PRM group	
GROUP	The PRM group name. The PRM group can be the traditional PRM group (FSS PRM group) or a PSET PRM group. To use PSET PRM groups, you must have the PSET software installed.
PRMID	The FSS PRM group ID. PRMIDs for PSET PRM groups are assigned by PRM and are not specified in the group record.
HIER	Indicates the FSS PRM group is a parent group in a hierarchy.
PSET	Indicates the PRM group is a PSET PRM group. In this case, SHARES is not used. Instead, the CORES and CORE_LIST fields should be used.
SHARES	Is the FSS PRM group's CPU shares. Shares are integer values ranging from 1 to MAXINT (the largest integer value).
MAX	(Available for HP-UX 11i v3 and later.) MAX is an upper bound for CPU consumption for the FSS PRM group.
CORES	Is the number of cores assigned to the PSET PRM group. The range for this field is from 0 to MAX_CORE-1.
CORE_LIST	Is the comma-delimited list of core IDs for the cores to be assigned to the PSET PRM group.
PSET_ATTR	Passes attributes for the specified PSET to HP-UX. The only attribute currently available is the logical CPU (Hyper-Threading) feature, available starting with HP-UX 11i v3 (B.11.31).

Memory record:

#!PRM_MEM:{ PRMID | GROUP }:SHARES:[MAX]:::[[IMPORT]:[EXPORT]:] private #!SHARED_MEM:{ PRMID | GROUP }: MEGABYTES shared	
#!PRM_MEM	Identifies the start of a private memory record.
PRMID | GROUP	Is a PRM group ID or PRM group name.
SHARES	Is the PRM group memory shares. Shares are expressed as integer values between 1 and MAXINT.
MAX	Is optional and specifies an upper bound for any non-HIER PRM group's (FSS or PSET) memory usage.
IMPORT, EXPORT	Allow a PRM group to borrow or lend memory resources. Leave both fields blank to allow unrestricted borrowing and lending. Assign both fields a value of 0 to isolate a memory-critical group to ensure it gets exactly the memory you give it.
#!SHARED_MEM	Identifies the start of a shared memory record.
MEGABYTES	Is the size of the desired shared memory allocation for the PRM group in megabytes. This value serves as a request

	for a minimum allocation.

User record:

USER::::INITIALGROUP[,ALTERNATEGROUP[, ...]]	
USER	Is either an individual user's login name or a + character followed by a netgroup name. Login names must be in /etc/passwd. Netgroup names must be associated with a list of login names in /etc/netgroup.
INITIAL_GROUP	Is the name of the initial PRM group for the user or netgroup. This is the group login chooses when launching the user's login shell, as well as cron, when scheduling jobs for that user.
ALTERNATE_GROUP	Is the name of one of the alternate PRM groups for the user or netgroup. Alternate groups are groups other than the initial group that the user or netgroup members are allowed to run processes in.

Application record:

APPLICATION::::GROUP[,ALTERNATE_NAME[, ...]]	
APPLICATION	Is the full path of the application, the shell/interpreter in the case of a script, or your Java binary--starting with a slash (/).
GROUP	Is the name of the PRM group in which the application or script will run.
ALTERNATE_NAME	Is an alternate name the application is assigned when executed. For most binaries and scripts, it should match the first item in the COMMAND column. Alternate names are common for complex programs such as database programs that launch many processes and rename them. It is also common for shells and interpreters used in scripts; the names of the scripts are considered alternate names. For Java programs, the class names are considered alternate names.

Disk record:

VOLUME:{ PRMID | GROUP }:SHARES::

VOLUME	Is the name of a logical volume group (LVM) or a disk group (VxVM). This name must begin with /dev/v to be recognized as a disk record.
PRMID | GROUP	Is the FSS PRM group ID or FSS PRM group name. PRMIDs must be uniquely assigned integer values between 1 and 63 (inclusive) or between 1 and 255 (inclusive) starting with HP-UX 11i v2 Update 2. If you use disk bandwidth management for a volume group (or disk group), then all FSS PRM groups must have disk entitlements for that volume group (disk group).
SHARES	Is the FSS PRM group disk bandwidth shares.

Compartment record: (Available for HP-UX 11i v2 (B.11.23) and later.)

#!SCOMP:COMPARTMENT_NAME:{ GROUP | (NONE) }	
#!SCOMP	Identifies the start of a compartment record.
COMPARTMENT_NAME	Is the alphanumeric name (of no more than 255 characters) of an existing secure compartment that you created using the HP-UX feature Security Containment.
GROUP	The PRM group to which the secure compartment is to be mapped.
(NONE)	You can specify (NONE) in place of a group name if you would like to explicitly show in your configuration file that a compartment is not to be mapped to a PRM group.

Unix group record:

#!UXGRP:UNIX_GROUP_NAME:{ GROUP | (NONE) }	
#!UXGRP	Identifies the start of a Unix group record.
UNIX_GROUP_NAME	Is the alphanumeric name (of no more than 255 characters) of an existing Unix group. A Unix group can have no more than one record. This record type yields precedence to application records, compartment records, and user records.
GROUP	The PRM group to which the Unix group is to be mapped.

(NONE)	You can specify (NONE) in place of a group name if you would like to explicitly show in your configuration file that a Unix group is not to be mapped to a PRM group.

NOTE:
By default, PRM gives PRM_SYS 100 CPU shares. If you assign 100 shares to the PRM groups you create, PRM_SYS gets 50% (100/200) of the CPU resource. The PRM_SYS group must get at least 20% of the CPU resource. Thus, if you assign more than 400 shares to your groups, the total shares assigned is greater than 500, and the PRM_SYS group's 100 shares do not represent at least 20%. In this case, PRM scales the shares for your groups proportionately so they are less than or equal to 400 shares.

You can explicitly add the PRM_SYS (PRMID 0) group to a configuration file. However, if you explicitly add the PRM_SYS group to a configuration file, it gets the CPU shares you assign it, which must equate to at least 20%.

The "`prmmonitor -s`" output includes the PRM_SYS group in output.

Testing the Configuration

Use the "-s" option of prmconfig(1) in order to detect syntax errors in /etc/prmconf.

```
$ prmconfig -s
Configuration file check complete. No errors found.
```

Configuring the Startup Script

The default startup configuration is as follows:

```
$ cat /etc/rc.config.d/prm

#!/sbin/sh
#
# @(#) HP PRM C.03.05 (20081113_062452) hpux_11.23
#
# PRM configuration.  See prmconfig(1)
#
# To configure (and enable) PRM automatically at boot time, a PRM configuration
# file must have been previously created and specified below.
#
# Initial configuration file values:
#
# PRM_CONFIG=0
# PRM_CONFIG_FILE=/etc/prmconf
# PRM_ENABLE=0
# PRM_SLEEP=0
# PRM_CAPPING=0
# PRM_INT_APPL=0
# PRM_INT_MEM=0
# PRM_LOG_APPL=0
# PRM_LOG_MEM=0
# PRM_SNMPAGT=0
# PRM_USE_REALUID=0
#
# PRM_CONFIG:      Set to 1 to configure PRM
# PRM_CONFIG_FILE:  Set filename for PRM configuration
# PRM_ENABLE:      Set to 1 to enable PRM when configured
# PRM_SLEEP:       Set seconds to sleep after PRM is configured
# PRM_CAPPING:     Set to 1 to start PRM in CPU capping mode when enabled
# PRM_INT_APPL:    Set seconds for PRM APPL manager interval when enabled
# PRM_INT_MEM:     Set seconds for PRM MEM manager interval when enabled
# PRM_LOG_APPL:    Set to 1 to start PRM in APPL mgr. logging mode when enabled
# PRM_LOG_MEM:     Set to 1 to start PRM in MEM mgr. logging mode when enabled
# PRM_SNMPAGT:     Set to 1 to spawn prmagt at boot time
# PRM_USE_REALUID:  Set to 1 to use real uid for PRM user records at boot time
#
# NOTE: to use PRM_CONFIG=1, you must set PRM_CONFIG_FILE=filename
# NOTE: to use PRM_CONFIG_FILE=filename, you must set PRM_CONFIG=1
# NOTE: to use PRM_ENABLE=1, you must set PRM_CONFIG=1
# NOTE: to use PRM_SLEEP=n, you must set PRM_CONFIG=1
# NOTE: to use PRM_CAPPING=1, you must set PRM_ENABLE=1
# NOTE: to use PRM_INTR_APPL=n, you must set PRM_ENABLE=1
# NOTE: to use PRM_INTR_MEM=n, you must set PRM_ENABLE=1 and have memory records
# NOTE: to use PRM_LOG_APPL=1, you must set PRM_ENABLE=1
# NOTE: to use PRM_LOG_MEM=1, you must set PRM_ENABLE=1 and have memory records
#
PRM_CONFIG=0
PRM_CONFIG_FILE=/etc/prmconf
PRM_ENABLE=0
PRM_SLEEP=0
PRM_CAPPING=0
PRM_INT_APPL=0
PRM_INT_MEM=0
PRM_LOG_APPL=0
PRM_LOG_MEM=0
PRM_SNMPAGT=0
PRM_USE_REALUID=0
```

If you want PRM enabled after a reboot, you need to set PRM_CONFIG and PRM_ENABLE to 1. If you want PRM to run in capping mode, set PRM_CAPPING to 1 additionally.

Activation

Starting and Stopping PRM

The command prmconfig(1) activates PRM. Example:

```
$ prmconfig -i -e APPL
```

-i Configure (or reconfigure) PRM using the default configuration file. This option does not alter the current state of any resource until a PRM resource manager is enabled for that resource. In ther words, if the HP-UX scheduler is in effect, it remains in effect. Similarly, if PRM is already managing resources, it continues to do so. Use -e to enable PRM resource management.

-e Enable PRM resource and application managers. The current configuration is not changed. You must enable the application manager for PRM to place application processes, user processes, compartment processes, and Unix group processes in their assigned groups.

The -P option of the ps(1) command displays the PRM group and allows you to check if the configuration has been applied properly:

$ ps -efP | grep ORA_ORM

```
kdoi22 ORA_ORM 14649    1 0 19:26:06 ?      0:01 oracleormq (LOCAL=NO)
kdoi22 ORA_ORM  5872    1 0  Jan 10  ?    0:25 ora_smon_ormt
kdoi22 ORA_ORM  5870    1 0  Jan 10  ?    5:33 ora_ckpt_ormt
kdoi22 ORA_ORM  5868    1 4  Jan 10  ?    4:24 ora_lgwr_ormt
kdoi22 ORA_ORM  5851    1 0  Jan 10  ?    2:10 ora_pmon_ormt
kdoi22 ORA_ORM  5864    1 0  Jan 10  ?    0:00 ora_arch_ormt
kdoi22 ORA_ORM  5874    1 0  Jan 10  ?    0:02 ora_reco_ormt
kdoi22 ORA_ORM  5861    1 2  Jan 10  ?    2:55 ora_dbw0_ormt
kdoi22 ORA_ORM  6059    1 0  Jan 10  ?    2:16 ora_dbw0_ormq
kdoi22 ORA_ORM  6057    1 0  Jan 10  ?    2:13 ora_pmon_ormq
kdoi22 ORA_ORM  6069    1 0  Jan 10  ?    5:41 ora_ckpt_ormq
kdoi22 ORA_ORM  6062    1 0  Jan 10  ?    0:00 ora_arch_ormq
kdoi22 ORA_ORM  6071    1 0  Jan 10  ?    0:20 ora_smon_ormq
kdoi22 ORA_ORM  6066    1 0  Jan 10  ?    2:48 ora_lgwr_ormq
kdoi22 ORA_ORM 14679    1 0 19:26:07 ?      0:18 oracleormq (LOCAL=NO)
kdoi22 ORA_ORM  6073    1 0  Jan 10  ?    0:01 ora_reco_ormq
kdoi22 ORA_ORM  2817    1 0 14:00:57 ?     0:00 oracleormt (LOCAL=NO)
kdoi22 ORA_ORM 14543    1 0 19:26:02 ?      0:05 oracleormq (LOCAL=NO)
...
...
```

The PRM group is shown in the second column.

The command

$ prmconfig -e

enables **all** configured PRM resource managers (CPU, APPL, MEM, DISK).

You may do initialization and enablement in one single step:

$ prmconfig -ie

ATTENTION:

If you like to activate the CPU capping feature (i.e. unused CPU time will not be given to PRM groups going beyond their entitlement), you need to specify the -M option with `prmconfig`:

$ prmconfig -ie -M CPUCAPON

Details regarding the capping and other features can be found in the man pages and the HP Process Resource Manager User Guide.

The commands prmconfig(1)and prmlist(1) let you display the PRM groups:

# prmconfig

```
PRM configured from file:  /etc/prmconf
File last modified:        Thu Mar  1 17:22:57 2009

PRM CPU scheduler state:  Enabled

PRM Group                      PRMID    CPU Entitlement
-------------------------------------------------------
OTHERS                             1             55.56%
SETI                               3              2.78%
WWW                                2             41.67%

PRM memory manager state:  Not Running

PRM User                       Initial Group                  Alternate Group(s)
-------------------------------------------------------------------------------
ohaensel                       SETI
root                           PRM_SYS
www                            WWW

PRM application manager state:  Enabled  (polling interval: 30 seconds)

Disk manager state:  Disabled
```

# prmlist

```
PRM configured from file:  /etc/prmconf
File last modified:        Thu Mar  1 17:22:57 2009

PRM Group                      PRMID    CPU Entitlement
-------------------------------------------------------
OTHERS                             1             55.56%
SETI                               3              2.78%
WWW                                2             41.67%

PRM User                       Initial Group                  Alternate Group(s)
-------------------------------------------------------------------------------
ohaensel                       SETI
root                           PRM_SYS
www                            WWW

PRM Application                Assigned Group                 Alternate Name(s)
```

```
------------------------------------------------------------------------------
/home/ohaensel/seti           SETI
/home/ohaensel/seti           SETI
/home/ohaensel/seti           SETI
```

You can log PRM memory messages to a file. These messages contain information similar to that of the `prmmonitor` command. Messages are logged in the file `/var/adm/syslog/syslog.log`. Example:

```
# prmconfig -L APPL
# tail /var/adm/syslog/syslog.log
...
...
Jul 11 19:56:27 grcdg455 HP-PRM: [7639]: prm1d: Application manager has been enabled
Jul 11 19:56:32 grcdg455 HP-PRM: [7639]: prm1d: Application manager polling interval is 30 seconds.
Jul 11 20:31:57 grcdg455 HP-PRM: [7639]: prm1d: Application manager logging is ON
Jul 11 20:33:12 grcdg455 HP-PRM: [7639]: prm1d: moved pgrp 7654 (top) to PRMID 20
```

To stop PRM logging messages:

```
# prmconfig -L APPL STOP
```

Monitoring

Monitoring the Resource Consumption

You can monitor and verify your PRM configuration with a number of commands:

- `prmmonitor`
- `prmconfig`
- `prmlist`
- `id -P`
- `ps [ -P ][ -R group_list ]`
- `acctcom [ -P ][ -R group ]`
- `prmanalyze`
- Glance
- PerfView Analyzer

The commands prmonitor(1)and prmlist(1) report the current resource consumption of the PRM groups:

```
# prmmonitor
PRM configured from file:  /etc/prmconf
```

```
File last modified:        Thu Mar  1 17:22:57 2009

HP-UX grcdg071 B.11.11 U 9000/800    03/05/01

Mon Mar  5 09:24:27 2009    Sample:  1 second
CPU scheduler state:  Enabled
                                                CPU      CPU
PRM Group                       PRMID   Entitlement     Used
____________________________________________________________
OTHERS                              1        55.56%    0.00%
WWW                                 2        41.67%    0.00%
SETI                                3         2.78%    0.00%

PRM application manager state:  Enabled  (polling interval: 30 seconds)
```

# prmanalyze -s prmid

```
summary CPU report by PRM id : 56436 records processed
unique id   processes    ave secs   peak secs    total secs  % total
  0             54220        0.43     7888.64      23465.12    98.01
  1              2209        0.22      161.42        475.84     1.99
  2                 7        0.05        0.06          0.35     0.00
```

This should help to locate potential performance problems or to fine-tune the configuration.

Glance and MeasureWare are also aware of PRM groups. In Glance you can access the PRM screen by pressing key ‘P’.

Modifying the Configuration

If it seems that the chosen entitlements need to be tuned, then the PRM configuration can be changed online, i.e. without stopping any processes. After modifying the configuration file /etc/prmconf the changes can be applied immediately.

Modify the current configuration:
# vi /etc/prmconf

Check the configuration file:
# prmconfig -c

Load the configuration using one of the commands below:
To initialize, moving user processes to the owners’ initial groups and moving applications to their assigned groups, use the command:
# prmconfig -i

To keep the existing assignments of users, processes, and groups, use the command:
# prmconfig -k

Enable PRM:

# prmconfig -e

Confirm that the processes are running in the appropriate PRM groups:
# ps -efP

It is also possible to change a configuration using cron jobs.

PRM Interfaces

PRM con be configured on the command line or through SMH and SIM:

HP System Management Homepage (SMH) enables you to perform various system administration tasks on a system through a single web interface. You can also configure and monitor PRM through SMH.

The PRM integration with HP Systems Insight Manager (HP SIM) allows system administrators at a SIM Central Management Server (CMS) to perform the following PRM tasks on the nodes in the SIM cluster that have PRM installed:

- Monitor PRM Groups
- Configure PRM Groups
- Display Resource Usage
- List Resource Availability

Appendix

PRM Manual Pages

The following manual pages/commands are available with PRM:

prm(1)	PRM overview
`prmagt(1)`	HP PRM SNMP read-only agent
`prm1d(1)`	Process Resource Manager (PRM) daemons
prmanalyze(1)	Utility that uses the HP-UX system accounting log to generate PRM group usage statistics. This is useful for configuration planning, monitoring, and billing.
prmavail(1)	Displays resource availability to help plan PRM configurations.
prmconfig(1)	Configures, enables, disables and resets PRM. Running prmconfig prints current configuration, state, and mode information when no options are specified.
prmlist(1)	Displays PRM group, memory, user, compartment, application, disk, and Unix group record information for the currently loaded PRM configuration.
prmloadconf(1)	Creates a PRM configuration file or updates an existing configuration file according to user records defined in /etc/passwd.
prmmonitor(1)	Prints current Process Resource Manager (PRM) configuration and resource usage statistics by PRM group.
prmmove(1)	Moves one or more processes to the target PRM group PRMgroup.
prmrecover(1)	Use this command to recover from abnormal termination of the memory manager.
prmrun(1)	Launches an application in its assigned PRM group, in a specified PRMgroup, or in the user's initial PRM group.
prmconf(4)	Explains the syntax of the PRM configuration files /etc/prmconf.
`prmsmhconfig(1)`	Configure/unconfigure the PRM GUI for SMH.
`prminitconfig(1)`	Configure/unconfigure the PRM GUI for SIM
`prm2scomp(1)`	Generate a minimal configuration for Security Containment based on a PRM configuration (11.23 or later).
`scomp2prm(1)`	Generate a minimal PRM configuration from a running Security Containment system (11.23 or later).
`srpgen(1)`	Generate minimal configuration files for Secure Resource Partitions (11.23 or later).

PRM File Locations

/etc/prmconf	The default PRM configuration file
/etc/opt/prm/conf/*	The suggested location for additional PRM configurations
/opt/prm/conf/*	A location previously suggested for additional PRM configurations
/etc/rc.config.d/prm	Configuration file used by /sbin/init.d/prm
/opt/prm/bin/	PRM utilities and commands
/opt/prm/doc/	PDF version of the PRM User Guide
/opt/prm/lib/	PRM API libraries
/opt/prm/man/	Manual pages
/opt/prm/newconfig/RelNotes/	README file

PRM Quick Setup

This guide enables you to quickly set up PRM:

# prmavail	(information about # of CPUs, RAM, VGs)
# prmanalyze	(after turning accounting on: /usr/sbin/acct/accton /var/adm/pacct)
# prmloadconf [-f /etc/prmconf]	(create PRM configuration file)
# vi /etc/prmconf	(customize it)
# prmconfig –s	(check syntax)
# prmconfig –ie APPL	(initialize, i.e. assign running processes/applications to group)
# prmconfig -e [CPU]	(enable)
# ps -efP	(verify)
# prmconfig -d	(disable)
# vi /etc/prmconf	(modify the configuration)
# prmconfig -ie APPL	(takes effect)
# prmconfig -M CPUCAPON	(turn CPU capping mode on)
# vi /etc/rc.config.d/prm	(prmconfig -i /-e / CPUCAPON at startup or not)

CPU Hogger Source Code

The following C program is suited to test the functionality of PRM's CPU resource manager. It simply tries to consume as much CPU time as it can get.

```
# cat cpuhogger.c

main()
{
   while (1);
}
```

NOTE: A process can only execute on one CPU at a time. Hence a single cpuhogger process can never use 50% CPU time on an 8-way system. The maximum would be 12,5%. In order to exploit the CPU time of a PRM group you may need to start more than one cpuhogger process.

Workload Manager (WLM)

HP-UX Workload Manager (WLM) supplements the functionality of HP Process Resource Manager (PRM) by offering automatic resource allocation and dynamic application performance management through prioritized service-level objectives (SLOs) - based on goal-based, time-based, condition-based or usage-based criteria.

You can use WLM to manage system resources within resource partitions, in which case WLM creates and manages its own PRM configuration (PRM must be installed on the same system). You can use WLM to manage CPU resources across hard partitions and virtual partitions. WLM automatically moves cores between partitions based on the SLOs in the partitions. (Given the physical nature of hard partitions, the "movement" of cores among partitions is achieved by deactivating a core on one nPartition and then activating a core on another.) You can use WLM to manage resources within a virtual machine. On an Integrity Virtual Machines (Integrity VM) host, you can use WLM to manage resources across partitions; within an Integrity VM guest, you can use WLM to manage the HP-UX resources but not using Instant Capacity (iCAP, formerly known as HP Instant Capacity on Demand, or iCOD), Pay per use (PPU), or virtual partition integration.

Resource partitions - Resource partitions are provided by HP Process Resource Manager (PRM) to manage processor sets and Fair Share Scheduler (FSS) groups. These partitions enable you to partition system resources (including memory and disk bandwidth) within a single instance of HP-UX and consolidate multiple workloads within that instance. You can use these partitions within (but not across) hard partitions and virtual partitions.

What is the difference?

- PRM is entitlement-based in its management of CPU, memory and I/O resources
- WLM utilizes pre-defined policies and goals to facilitate the dynamic allocation of resources based on conditions such as time of day, application responsiveness, business priorities, etc.
- WLM can work across partitions on the same machine, and can dynamically re-allocate resources between these partitions

Refer to http://www.hp.com/go/wlm for further information about WLM.

Additional Information

The starting point for PRM documentation is:
http://www.hp.com/go/prm/

This website links to all information about PRM such as:

White papers

- HP Process Resource Manager overview (PDF, 704 KB)
- Using HP Process Resource Manager with Oracle (PDF, 205 KB)
- Technical Whitepaper (PDF, 1 MB)
- HP-UX Processor Sets technical white paper (PDF)

Technical documentation

- HP PRM Version C.03.05.01 Release Notes (PDF, 422 KB)
- HP Process Resource Manager Version C.03.05 User Guide (PDF)
- Processor Sets Product Note (PDF)
- Manpages

Training and support

- Training
- User forum
- Patches and support
- Documentation corrections