Managing System Software for Cray XE and Cray XT™ Systems

S–2393–31

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Version 1.5 Published October 2006 Supports general availability (GA) release of Cray XT series systems running the Cray XT series Programming Environment 1.5, UNICOS/lc 1.5, and System Management Workstation 1.5 releases.

Version 2.0 Published October 2007 Supports general availability (GA) release of Cray XT series systems running the Cray XT series Programming Environment 2.0, UNICOS/lc 2.0, and System Management Workstation 3.0.1 releases.

Version 2.1 Published November 2008 Supports the general availability (GA) release of Cray XT systems running the Cray Linux Environment (CLE) 2.1 release and the System Management Workstation (SMW) 3.1 release as of the SMW 3.1.09 update.

Version 2.2 Published July 2009 Supports the general availability (GA) release of Cray XT systems running the Cray Linux Environment (CLE) 2.2 release and the general availability (GA) release of the System Management Workstation (SMW) 4.0 release.

Version 3.0 Published March 2010 Supports the Cray Linux Environment (CLE) 3.0 release and the System Management Workstation (SMW) 5.0 release.

Version 3.1 Published June 2010 Supports the Cray Linux Environment (CLE) 3.1 release and the System Management Workstation (SMW) 5.1 release.

New Features

Managing System Software for Cray XE and Cray XT™ Systems S–2393–31

This manual has been updated extensively; significant changes include:

- Added the following:
  - The new SMW software installation feature consists of the `SMWinstall`, `SMWconfig`, and `SMWinstallCLE` system administrator commands. These SMW installation commands automate the SMW software installation process significantly. See System Management Workstation (SMW) on page 35.
  - Gemini-specific physical component naming conventions were added; see Table 1.
  - Description of Gemini NIDs was added; see Node ID (NID) for Cray XE Systems on page 60.
  - The `xtcon` command is a console interface for service nodes; see Connecting the SMW to the Console of a Service Node on page 65.
  - Use the new `xtcli mark_node` command to mark nodes in a compute blade as either a service node or a compute node; these nodes are set as compute nodes by default; see Marking a Compute Node as a Service Node on page 84.
  - Examples of finding node information using the `xtnid2str` command; see Finding Node Information Using the `xtnid2str` Command on page 85.
  - You can `cat` the new `/opt/cray/etc/smw-release` file to display the installed SMW release level; see Displaying Installed SMW Release Level on page 93.
  - You can `cat` the new `/etc/opt/cray/release/clerelease` file to display the installed CLE release level; see Displaying Installed CLE Release Level on page 93.
  - The `SMWinstall`, `SMWconfig`, and `SMWinstallCLE` commands create several detailed log files in the `/var/adm/cray/logs` directory; see Examining Log Files on page 96.
  - New section: System-wide Default Modulefiles on page 116.
  - New section: Maintaining `*rc.local` Scripts on page 118.
  - New section: Configuring Failover for Boot and SDB Nodes on page 172.
  - New section: Callout to `rc.local` During Boot on page 182.
  - New section: Creating a Cray System Management Workstation (SMW) Bootable Backup Drive on page 218.
  - New section: Setting Up the Bootable Backup Drive as an Alternate Boot Device on page 225.
  - New section: SMW Recovery on page 231.
  - New section: Using Persistent SCSI Device Names on page 232.

- New section: Manually Cleaning ALPS and PBS After Downed Login Node on page 252.
- New section: ALPS and Node Health Monitoring Interaction on page 253.
- New section: Disabling Project Accounting on page 271.
- New section: Cleanup Version 1 Actions (`apmgrcleanup`) on page 257 and Cleanup Version 2 Actions on page 259 to document new ALPS cleanup.
- New chapter: Chapter 11, Dynamic Shared Objects and Cluster Compatibility Mode in the Cray Linux Environment on page 281. This chapter contains information previously provided in *Configuring and Using Dynamic Shared Objects and Libraries for the Cray Linux Environment (CLE)* and new material regarding configuration of the Cluster Compatibility Mode feature.
- New chapter: Chapter 12, OpenFabrics Interconnect Drivers for CLE Systems on page 295. This documentation was previously provided as *OpenFabrics Interconnect Drivers for Cray XT Systems*.
- New Chapter: Chapter 13, Cray XE Network Resiliency on page 309.
- New procedures:
  - Procedure 38 on page 168
  - Procedure 56 on page 225
  - Procedure 60 on page 231
  - Procedure 63 on page 252
  - Procedure 67 on page 271
  - New example: Example 14

- Revised the following:
  - The `XTinstall` installation program and `XTinstall.conf` installation configuration file have been renamed to `CLEinstall` and `CLEinstall.conf`. Examples in this guide were updated to reflect the change.
  - The `xtdiscover` command replaced the Central Data Repository (CDR); see `xtdiscover` Command on page 53.
  - `xtcli comp_hist` command replaced the `xtcli err_hist` command; see Showing the Component Alert, Warning, and Location History on page 103.
  - The synopsis line changed for the following `xtcli` commands: `clr_alert`, `clr_warn`, `disable`, `enable`, `set_empty`, and `status`. Examples in this guide were updated to reflect the change.
  - The Node Health Checker (NHC) section was updated to reflect the NHC enhancements for this release; see Configuring Node Health Checker (NHC) on page 157.
  - Several procedures were updated.
  - In Configuring ALPS on page 243, added information about the `ALPS_NIDORDER -Oy` option,

which sets NID ordering for Cray XE systems; and `cleanup_version`, which indicated which ALPS clean up routines to use.

  - The location of the `xtshutdown.conf` file is now `/etc/opt/cray/init-service/xtshutdown.conf`, and the location of the `xt_shutdown_local` file is now `/etc/opt/cray/init-service/xt_shutdown_local`; see Shutting Down Service Nodes Using the `xtshutdown` Command on page 76.
  - The `/etc/node_classes` file was moved to `/etc/opt/cray/sdb/node_classes`.
  - The `/etc/attr.defaults` file was moved to `/etc/opt/cray/sdb/attr.defaults`.
  - The `/etc/attr.xthwinv` file was moved to `/etc/opt/cray/sdb/attr.xthwinv`.
  - The `/etc/xt.conf` file was moved to `/etc/sysconfig/xt`.
  - The `/etc/nids` file was moved to `/etc/opt/cray/configuration/nids`.
  - The `rsipd.conf` file was moved to `/etc/opt/cray/rsipd/rsipd.conf`.
  - The `/usr/sbin/rsipd` daemon was moved to `/opt/cray/rsipd/default/sbin/rsipd`.
  - The `/etc/csa.conf` file was moved to `/etc/opt/cray/csa/csa.conf`.
  - References to `cray_faillog` changed to `cray_pam`.
  - The following commands are deprecated:
    - `xtkill`, `xtps`, `xtuname`, and `xtwho`
  - The following appendixes were updated:
    - Appendix A, SMW and CLE System Administration Commands on page 327
    - Appendix B, System States on page 333
    - Appendix C, Error Codes on page 335
    - Appendix D, Remote Access to the SMW on page 347
    - Appendix E, Updating the Time Zone on page 351
    - Appendix G, PBS Professional Licensing for Cray Systems on page 359

- Removed the following:
  - The System Environment Data Collections (SEDC) documentation is now contained in *Using and Configuring System Environment Data Collections (SEDC)*, S–2491, which is provided with Cray System Management Workstation (SMW) release packages.
  - Section titled "`apmgrcleanup` Actions," which was replaced by new sections Cleanup Version 1 Actions (`apmgrcleanup`) on page 257 and Cleanup Version 2 Actions on page 259.
  - XTGUI documentation; the XTGUI is no longer supported.

- Warning manager documentation; the warning manager and related command, `xtwm`, are no longer supported. Using SEDC is the preferred method to get cabinet-level environmental information.
- Removed all documentation about the following deleted SMW commands: `mkcrayhosts`, `parser_test`, `smwhotbackup`, `smwsnapshot`, `xtcdr_gen_args`, `xtcdr_generator`, `xtibmbist`, `xtinitmodule`, `xtlcbdump`, `xtrcaproxy`, `xtnodelist`, `xtnxn`, `xtsmwrelswitch`, and `xtsync`.
- Removed the section and related procedure about keeping a hot-spare SMW synchronized with the production SMW.
- Removed documentation about the following deleted CLE commands: `xtappackage`, `xtchecklink`, and `xthostname`.
- Removed the `ldump xt` command-line string name that was previously deprecated ; it is no longer accepted as an alias for the `ldump xt-ssi` access method.
- Removed Appendix H, Utilities for Cray Service Personnel Use.
- Removed documentation throughout manual about Cray X2 system settings and options.

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Introduction [1]

Note: In this guide, references to Cray systems mean Cray XE and Cray XT systems, unless a specific series of systems is noted.

A Cray system is a massively parallel processing (MPP) system that has a shared-root file system available to all service-processing elements nodes). Cray has combined commodity and open-source components with custom-designed components to create a system that can operate efficiently at immense scale.

The Cray Linux Environment (CLE) operating system includes Cray's customized version of the SUSE Linux Enterprise Server (SLES) 11 operating system, with a Linux 2.6.16.27 kernel. This full-featured operating system runs on the Cray system's service nodes. Service nodes perform the functions needed to support users, administrators, and applications running on compute nodes. Above the operating system level are specialized daemons and applications that perform functions unique to each service node.

Cray compute nodes run the *CNL* compute node operating system, which runs a Linux 2.6.16.27 kernel. The kernel provides support for application execution without the overhead of a full operating-system image. The kernel interacts with an application process in very limited ways. It provides virtual memory addressing and physical memory allocation, memory protection, access to the message-passing layer, and a scalable job loader. Support for I/O operations is limited inside the compute node's kernel. For a more complete description, see Compute Partition on page 43.

Note: Functionality marked as deferred in this documentation is planned to be implemented in a later release.

1.1 Audience for This Guide

The audience for this guide is system administrators and those who manage the operation of a Cray system. Prerequisites for using this guide include a working knowledge of Linux to administer the system and a review of the Cray system administration documentation listed in Cray System Administration Publications and in Related Publications on page 30, of this guide. This guide assumes that you have a basic understanding of your Cray system and the software that runs on it.

1.2 Cray System Administration Publications

This publication is one of a set of related manuals that cover information about the structure and operation of your Cray system. See also:

- *Cray System Management Workstation (SMW) Software Release Overview* (S–2482)
- *Installing Cray System Management Workstation (SMW) Software* (S–2480)
- *Cray System Management Workstation (SMW) Software Release Errata*
- *Cray Linux Environment (CLE) Software Release Overview* (S–2425)
- *Installing and Configuring Cray Linux Environment (CLE) Software* (S–2444)
- *Limitations for the CLE Release*
- *CLE Release Errata*
- *Using Cray Management Services (CMS)* (S–2484)
- *Using and Configuring System Environment Data Collections (SEDC)* (S–2491)
- *Managing Lustre for the Cray Linux Environment (CLE)* (S–0010)
- *Introduction to Cray Data Virtualization Service* (S–0005)
- *Cray Application Developer's Environment Installation Guide* (S–2465)
- *Cray Application Developer's Environment Supplement Installation Guide* (S–2485)
- *Workload Management and Application Placement for the Cray Linux Environment* (S–2496)

1.3 Related Publications

Because your Cray system runs a combination of software developed by Cray, other vendors' software, and open-source software, the following websites may be useful:

- Linux Documentation Project — See http://www.tldp.org
- SLES 11 and Linux documentation — See http://www.novell.com/linux
- Data Direct Networks documentation — See http://www.ddnsupport.com/manuals.html
- LSI Engenio storage system documentation — See http://www.lsi.com/storage_home/products_home/external_raid/index.html
- MySQL documentation — See http://www.mysql.com/documentation

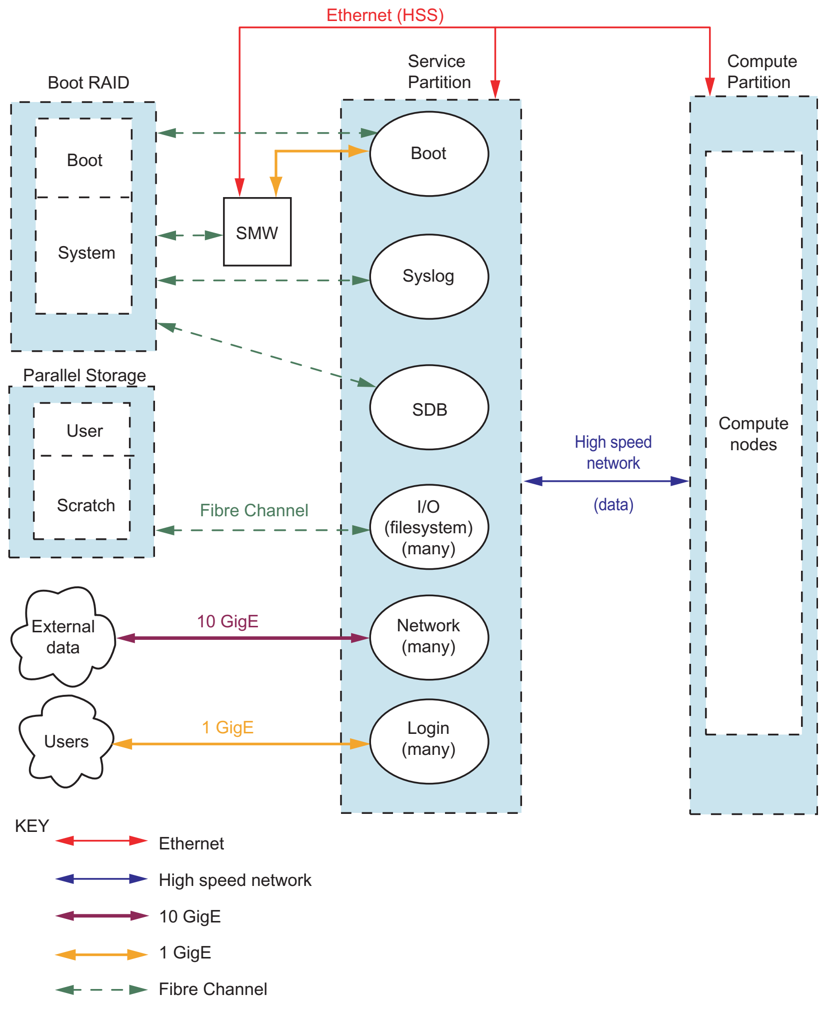
- Lustre File System documentation — See http://www.lustre.org and http://www.sun.com/software/products/lustre
- Batch system documentation:

PBS Professional:	Altair Engineering, Inc.	http://www.altair.com/
Moab and TORQUE:	Adaptive Computing Enterprises Inc.	http://www.adaptivecomputing.com/
Platform LSF:	Platform Computing Corporation	http://www.platform.com/

Introducing System Components [2]

Cray systems separate calculation and monitoring functions. Figure 1 shows the components of a Cray system that an administrator manages.

Figure 1. Administrative Components of a Cray System



A Cray system contains operational components plus storage:

- The System Management Workstation (SMW) is the single point of control for system administration. (For additional information about the SMW, see System Management Workstation (SMW) on page 35.)
- The Hardware Supervisory System (HSS) monitors the system and handles component failures. The HSS is an integrated system of hardware and software that monitors components, manages hardware and software failures, controls system startup and shutdown, manages the system interconnection network, and maintains system states. (For additional information about HSS, see Hardware Supervisory System (HSS) on page 47.)
- Cray Management Services (CMS) provides the infrastructure to the Application Level Placement Scheduler (ALPS) for a fast cache of node attributes, reservations, and claims. ALPS reservation and claim information is forwarded to the CMS log manager on the SMW to enable system administrators to search the history of jobs, error messages which occurred during a job, and the job utilization on the system. (For additional information about CMS, see *Using Cray Management Services (CMS)*, S–2484.)
- The Cray Linux Environment (CLE) operating system is the operating system for Cray systems. (For additional information about CLE, see CLE on page 36.)
- The service partition performs the management functions that enable the computations to occur. (For additional information about service partitions, see Service Partition on page 37.)
- The compute partition is dedicated to computation. (For additional information about compute partitions, see Compute Partition on page 43.)
- RAID is partitioned for a variety of storage functions such as boot RAID, database storage, and parallel and user-file system storage. (For additional information about RAID, see Boot Root File System on page 37 and Storage on page 54.)

A Cray system has six network components:

- The 10-GigE network is a high-speed Ethernet pipe that provides external NFS access. It connects to the network nodes and is specifically configured to transfer large amounts of data in and out of the system.
- Users access a 1-GigE network server connection to the login nodes. Logins are distributed among the login nodes by a load-leveling service through the Domain Name Service (DNS) that directs them to the least loaded login node.
- Fibre Channel networks connect storage to the system components.
- The RAID controllers connect to the SMW through the HSS network. This storage sends log messages to the SMW when a failure affects the ability of the disk farm to reliably store and retrieve data.
- The *system interconnection network* includes custom Cray components that provide high-bandwidth, low-latency communication between all the service processing elements and compute processing elements in the system. The system interconnection network is often referred to as the *high-speed network (HSN)*.
- The HSS network performs the reliability, accessibility, and serviceability functions. The HSS consists of an internet protocol (IP) address and associated control platforms that monitor all nodes.

2.1 System Management Workstation (SMW)

The SMW is the administrator's console for managing a Cray system. The SMW is a server that includes a tower and a flat-panel monitor; it runs a combination of the SUSE Linux Enterprise Server (SLES) 11 operating system, Cray developed software, and third-party software. The SMW is also a single point of control for the HSS. The HSS data is stored on the internal hard drive of the SMW. For more information about the HSS, see Hardware Supervisory System (HSS) on page 47. CMS provides the infrastructure to ALPS for a fast cache of node attributes, reservations, and claims. For additional information about CMS, see *Using Cray Management Services (CMS)* (S–2484).

The SMW software installation feature consists of the `SMWinstall`, `SMWconfig`, and `SMWinstallCLE` system administrator commands. These SMW installation commands automate the SMW software installation process significantly. The `SMWinstall`, `SMWconfig`, and `SMWinstallCLE` commands create several detailed log files in the `/var/adm/cray/logs` directory. The log files are named using the PID of the `SMWinstall` or the `SMWinstallCLE` command; the exact names are displayed when the command is invoked. Using the `SMWconfig` and `SMWinstall` commands, you can specify the SMW configuration file that you want to use for the installation. The `SMWinstall.conf` file contains information about the type of Cray system, the days-to-keep for logging, and the Network Time Protocol (NTP) server names. This information is required for initial installations and is otherwise detected or reused for upgrades and updates of the SMW. An example `SMWinstall.conf` file is included on the SMW installation media, but a customized `SMWinstall.conf` file is expected to be located by default in `/home/crayadm/`. For additional information, see the `SMWinstall`(8), `SMWconfig`(8), and `SMWinstallCLE`(8) man pages.

You log on to an SMW window on the console to perform SMW functions. From the SMW, you can log on to a disk controller or log on to the boot node. From the SMW, you cannot log on directly (`ssh`) to any service node except the boot node.

Most system logs are collected and stored on the SMW. The SMW plays no role in computation after the system is booted. From the SMW, you can initiate the boot process, access the database that keeps track of system hardware, and perform standard administrative tasks.

2.2 CLE

CLE is the operating system for Cray systems. CLE is the Cray customized version of the SLES 11 operating system with a Linux 2.6.16.27 kernel. This full-featured operating system runs on the Cray service nodes. Compute nodes run a kernel developed to provide support for application execution without the overhead of a full operating-system image.

CLE commands enable administrators to perform administrative functions on the service nodes to control processing. The majority of CLE commands are launched from the boot node, making the boot node the focal point for CLE administration.

For a complete list of Cray developed CLE administrator commands, see Appendix A, SMW and CLE System Administration Commands on page 327.

2.3 Boot Root File System

The boot node has its own root file system, `bootroot`, which is created on the boot RAID during installation. You install and configure the boot RAID from the SMW before you boot the boot node. The boot node mounts the `bootroot` from the boot RAID.

2.4 Shared Root File System

A Cray system has a root file system that is distributed as a read-only shared file system among all the service nodes except the boot node. Each service node has the same directory structure, which is made up of a set of symbolic links to the shared-root file system. For most files, only one version of the file exists on the system, so if you modify the single copy, it affects all service nodes. This makes the administration process similar to that of a single system.

You manage the shared-root file system from the boot node through the `xtopview` command (see Managing System Configuration with the `xtopview` Tool on page 129).

If you need unique files on a specific node or class of nodes (that is, nodes of a certain type), you can set up a modified directory structure. This process, called *specialization*, creates a new directory hierarchy that overlays the existing root directory on the specified nodes and contains symbolic links that point to the unique files. For information about the shared root and file specialization, see Configuring the Shared-root File System on Service Nodes on page 123.

2.5 Service Partition

The service partition includes the following physical nodes and the services that run on them:

- Boot node
- SDB node
- Syslog node
- Login nodes
- Network nodes
- I/O nodes

Nodes in the service partition run the CLE operating system. The administrator commands for these nodes are standard Linux commands and Cray system-specific commands.

Documentation may use the terms *SIO node* (Service and I/O node with SeaStar application-specific integrated circuit (ASICs)), *XIO node* (Service and I/O node with Gemini ASICs), or I/O node as a generic reference to the SDB and I/O nodes.

You log on to the boot node through the SMW console, then from the boot node you can log on to the other service nodes.

2.5.1 Service Nodes

Service nodes perform the functions needed to support users, administrators, and applications running on compute nodes. As the system administrator, you define service node classes by the service they perform. Configuration information in the service database on the SDB node determines the functions of the other nodes and services, such as where a batch subsystem runs. In small configurations, some services can be combined on the same node: for example, the SDB and syslog services can both run on the SDB node.

You can start services system-wide or on specific nodes in the service partition. You can start services during the boot process or later on specific nodes of a running system. How you start a service depends on the type of service.

Service nodes, unlike compute nodes, are generally equipped with Peripheral Component Interconnect (PCI) protocol card slots to support external devices.

A full-featured operating system runs on the service nodes. Service nodes run a version of Linux. Service node kernels are configured to enable Non-Uniform Memory Access (NUMA), which minimizes traffic between sockets by using socket-local memory whenever possible.

System management tools are a combination of Linux commands and Cray system commands that are analogous to standard Linux commands but operate on more than one node. For more information about Cray system commands, see Monitoring Multiple Nodes on page 94, and Appendix A, SMW and CLE System Administration Commands on page 327. After the system is up, you can access any service node from any other service node, provided you have the correct permissions.

2.5.1.1 Boot Node

Use the boot node to manage files, add users, and mount and export the shared-root file system to the rest of the service nodes. These shared-root files are mounted from the boot node as read-only.

The boot node is the first node to be booted, which is done through the boot node blade control processor (L0 controller) (see Blade Control Processor (L0 Controller) and Cabinet Control Processors (L1 Controller) on page 48). You can bring up an `xterm` window on the SMW to log on to the boot node.

Note: For Cray XE (Gemini) systems, boot blades have only one node with two PCIe slots (node 1). Of the remaining three nodes on the blade, node 0 has no PCIe I/O connectivity and nodes 2 and 3 have the typical configuration of one PCIe slot per node. There can be only one dual-slot node per blade.

You can configure two boot nodes in a service partition, one primary and one for backup (secondary). The two boot nodes must be located on different blades so that failure in a single blade does not affect more than one boot node. When the primary boot node is booted, the backup boot node also begins to boot. But the backup boot node is suspended until a primary boot-node failure event is detected. For information about configuring boot-node failover, see Configuring Boot-node Failover on page 172.

2.5.1.2 Service Database (SDB) Node

The SDB node hosts the service database (SDB), which is a MySQL database that resides on a separate file system on the boot RAID. The SDB is accessible to every service node (see Changing the Service Database (SDB) on page 184). The SDB provides a central location for storing information so that it does not need to be stored on each node. You can access the SDB from any service node after the system is booted, provided you have the correct authorizations.

The SDB stores the following information:

- Global state information of compute processors. This information is used by the Application Level Placement Scheduler (ALPS), which allocates compute processing elements for compute nodes running CNL. For more information about ALPS, see Application Level Placement Scheduler (ALPS) for Compute Nodes on page 42.
- System configuration tables that list and describe processor and service information.

The SDB node is the second node that is started during the boot process.

You can configure two SDB nodes in a service partition, one primary and one for backup (secondary). The two SDB nodes must be located on different blades so that failure in a single blade does not affect more than one SDB node. For more information, see Configuring SDB Node Failover on page 176.

2.5.1.3 Syslog Node

The syslog node connects to the HSN. A syslog daemon, `syslog-ng`, runs on all service nodes and directs log file information to the `syslog-ng` on the syslog node. The syslog data from the `syslog-ng` daemons on the boot node and the syslog node (commonly the SDB node) is forwarded to the CMS log manager daemon on the SMW. The CMS log manager aggregates the logs to enable system-wide searches and association of events and log messages. You can modify the `/etc/syslog-ng/syslog-ng-conf.in` file to change where the log information is saved. For more information, see Changing the Location to Log `syslog-ng` Information on page 210.

The syslog services may be run on a dedicated syslog node, on the same node as the SDB node, or on the boot node.

2.5.1.4 Login Nodes

Users log on to a login node, which is the single point of control for applications that run on the compute nodes. Users do not log on to the compute nodes.

You can use the Linux `lbnamed` load balancer software provided to distribute user logins across login nodes (see Configuring the Load Balancer on page 155). The number of login nodes depends upon the installation and user requirements. For typical interactive usage, a single login node handles 20 to 30 batch users or 20 to 40 interactive users with double this number of user processes.

Caution: Login nodes, as well as other service nodes, do not have swap space. If users consume too many resources, Cray service nodes can run out of memory. When an out of memory condition occurs, the node can become unstable or may crash. System administrators should take steps to manage system resources on service nodes. For example, resource limits can be configured using the `pam_limits` module and the `/etc/security/limits.conf` file. For more information, see the `limits.conf`(5) man page.

2.5.1.5 Network Nodes

Network nodes connect to the external network with a 10-GigE card. These nodes are designed for high-speed data transfer.

2.5.1.6 I/O Nodes

I/O nodes host the Lustre file system; see Lustre File System on page 42.

Cray Data Virtualization Service (Cray DVS) servers run on an I/O node; see Cray Data Virtualization Service (Cray DVS) on page 42. DVS servers cannot run on the same I/O nodes as Lustre servers.

The I/O nodes connect to the RAID subsystems that contain the Lustre file system. Two I/O nodes connect to each RAID device for resiliency; each I/O node has full accessibility to all storage on the connected RAID device. Cray provides support for RAID subsystems from two different vendors, Data Direct Networks (DDN) and LSI Logic Corporation.

2.5.2 Services on the Service Partition

Service nodes provide the services described in this section.

2.5.2.1 Resiliency Communication Agent (RCA)

The RCA is the message path between the CLE operating system and the HSS. The RCA runs on all service nodes and compute nodes.

The `service_config` table of the SDB maintains a list of services that RCA starts. For the services listed in the `service_config` table, the RCA daemon (`rcad_svcs`) starts and restarts all services that must run on a node. You can determine or modify services available through the SDB `service_config` table by using the `xtservconfig` command. For additional information about using this command, see Changing Services on page 188.

> **Note:** Services can also be started manually or automatically by using standard Linux mechanisms (see Adding and Starting a Service Using Standard Linux Mechanisms on page 214).

The SDB `serv_cmd` table stores information about each service, such as, service type, service instance, heartbeat interval, and restart policy.

The configuration file for service nodes is `/etc/opt/cray/rca/rcad_svcs.service.conf`. By default, this configuration file starts the `rca_dispatcher` and the failover manager by default.

The RCA consists of a kernel-mode driver and a user-mode daemon on CLE. The Cray SeaStar chip and the L0 controller on each blade provide the interface from the RCA to the HSS through application programming interfaces (APIs). The RCA driver, `rca.ko`, runs as a kernel-loadable module for the service partition. On compute nodes, the RCA operates through system calls and communicates with the HSS to track the heartbeats (see Blade Control Processor (L0 Controller) and Cabinet Control Processors (L1 Controller) on page 48) of any programs that have registered with it and to handle event traffic between the HSS and the applications that register to receive events. The RCA driver starts as part of the kernel boot, and the RCA daemon starts as part of the initialization scripts.

2.5.2.2 Lustre File System

Cray systems running CLE support the Lustre file system that provides a high-performance, highly scalable, POSIX-compliant shared file system. You can configure Lustre file systems to operate in the most efficient manner for the I/O needs of applications, ranging from a single metadata server (MDS) and object storage target (OST) to a single MDS with up to 128 OSTs. User directories and files are shared and are globally visible from all compute and service nodes.

For more information, see *Managing Lustre for the Cray Linux Environment (CLE)* (S–0010) and *Installing and Configuring Cray Linux Environment (CLE) Software* (S–2444).

2.5.2.3 Cray Data Virtualization Service (Cray DVS)

The Cray Data Virtualization Service (Cray DVS) is a parallel I/O forwarding service that provides for transparent use of multiple file systems on Cray systems with close-to-open coherence, much like NFS.

For additional information, see the *Installing and Configuring Cray Linux Environment (CLE) Software* (S–2444) and *Introduction to Cray Data Virtualization Service* (S–0005).

2.5.2.4 Application Level Placement Scheduler (ALPS) for Compute Nodes

For compute nodes running CNL, the Application Level Placement Scheduler (ALPS) is provided. ALPS provides application placement, launch, and management functionality and cooperates with third-party batch systems for application scheduling. The third-party batch system (such as PBS Professional, Moab, TORQUE, or Platform LSF) makes the policy and scheduling decisions, and ALPS provides a mechanism to place and launch the applications contained within batch jobs. ALPS also supports placement and launch functionality for interactive applications.

An Extensible Markup Language (XML) interface is provided by ALPS for communication with third-party batch systems. This interface is available through use of the `apbasil` client. ALPS uses application resource reservations to guarantee resource availability to batch system schedulers.

The ALPS application placement and launch functionality is provided for applications executing on compute nodes only; ALPS does not provide placement and launch functionality for service nodes.

> **Note:** Only one application can be placed per node; two different executables cannot be run on the same node at the same time.

ALPS is automatically loaded as part of the CNL environment when booting CNL. The RCA starts the ALPS `apinit` daemon on the compute nodes.

When a job is running on CNL compute nodes, the `aprun` process (see Job Launch Commands on page 45) interacts with ALPS to keep track of the processors that the job uses.

For more information about ALPS, see Chapter 8, Using the Application Level Placement Scheduler (ALPS) on page 235.

2.5.2.5 Cluster Compatibility Mode

Cluster Compatibility Mode (CCM) provides the services needed to run most cluster-based independent software vendor (ISVs) applications "out of the box." CCM is tightly coupled to the workload management system. It enables users to execute cluster applications alongside workload-managed jobs running in a traditional MPP batch or interactive queue. Support for dynamic shared objects and expanded services on compute nodes, using the compute node root runtime environment (CNRTE), provide the services to compute nodes within the cluster queue. Essentially, CCM uses the batch system to logically designate part of the Cray system as an emulated cluster for the duration of the job. For more information about CCM, see Chapter 11, Dynamic Shared Objects and Cluster Compatibility Mode in the Cray Linux Environment on page 281.

2.5.2.6 IP Implementation

Ethernet interfaces handle IP connectivity to external components. Both IPv4 and IPv6 are supported; IPv4 is the default.

Note: The IPv6 capability is limited to the Ethernet interfaces and `localhost`. Therefore, IPv6 connectivity is limited to service nodes that have Ethernet cards installed. Routing of IPv6 traffic between service nodes across the HSN is not supported.

For more information about Native IP (SSIP), see Native IP (SSIP) on page 63, and Configuring Native IP (SSIP) on page 199.

2.6 Compute Partition

Several libraries and compilers are linked at the user level to support I/O and communication service. PGI, PathScale, and the GNU Compiler Collection (GCC) C, C++, and Fortran 90 compilers are supported. Applications statically link to these libraries. Users can set their desired compiler target architecture environment by loading the `xtpe-target-cnl` modulefile. For information about using modulefiles, see User Access to a Compiler Environment Using Modulefiles on page 117. For information about the libraries that Cray systems host, see the *Cray Application Developer's Environment User's Guide* (S–2396).

2.6.1 Compute Nodes

Compute nodes run the CNL compute node operating system. CNL is a lightweight compute node operating system. It includes a run-time environment based on the SLES distribution, with a Linux 2.6.16.27 kernel and with Cray specific modifications. Device drivers for hardware not supported on Cray systems were eliminated from the kernel. CNL features scalability; only the features required to run high-performance computing applications are available on CNL compute nodes. Other features and services are available from service nodes. Cray has configured and tuned the kernel to minimize processing delays caused by inefficient synchronization. CNL compute node kernels are configured to enable Non-Uniform Memory Access (NUMA), which minimizes traffic between sockets by using socket-local memory whenever possible. CNL also includes a set of supported system calls and standard networking.

The Resiliency Communication Agent (RCA) daemon, `rcad-svcs`, handles node services (see Services on the Service Partition on page 41).

The Application Level Placement Scheduler (ALPS), handles application launch, monitoring, and signaling and coordinates batch job processing with third-party batch systems. If you are running ALPS, use the `xtnodestat` command to report job information.

The following user-level BusyBox commands are functional on CNL compute nodes: `ash`, `BusyBox`, `cat`, `chmod`, `chown`, `cp`, `cpio`, `free`, `grep`, `gunzip`, `kill`, `killall`, `ln`, `ls`, `mkdir`, `mktemp`, `more`, `ps`, `rm`, `sh`, `tail`, `test`, `vi`, and `zcat`. For information about supported command options, see the `BusyBox`(1) man page.

The following administrator-level `Busybox` commands and associated options are functional on CNL compute nodes:

- `dmesg -c -n -s`
- `fuser -m -k -s -4 -6 -SIGNAL`
- `logger -s -t -p`
- `mount -a -f -n -o -r -t -w`
- `ping -c -s -q`
- `sysctl -n -w -p -a -A`
- `umount -a -n -r -l -f -D`

A compute-node failure affects only the job running on that node; the rest of the system continues running.

The `xtclone` and `xtpackage` utilities run on the SMW. Use these commands to set up CNL compute node images or service node images. You can boot CNL on compute nodes. For more information, see Preparing a Service Node and Compute Node Boot Image on page 66, the `xtclone`(8), `xtpackage`(8), and `xtnodestat`(8) man pages, and the *Installing and Configuring Cray Linux Environment (CLE) Software* (S–2444).

2.7 Job Launch Commands

Users run applications from a login node and use the `aprun` command to launch CNL applications. The `aprun` command provides options for automatic and manual application placement. With automatic job placement, `aprun` distributes the application instances on the number of processors requested, using all of the available nodes.

With manual job placement, users can control the selection of the compute nodes on which to run their applications. Users select nodes on the basis of desired characteristics (*node attributes*), allowing a placement scheduler to schedule jobs based on the node attributes. To provide the application launcher with a list of nodes that have a particular set of characteristics (attributes), the user invokes the `cnselect` command to specify node-selection criteria. The `cnselect` script uses these selection criteria to query the table of node attributes in the SDB; then it returns a node list to the user based on the results of the query. For an application to be run on CNL compute nodes, the nodes satisfying the requested node attributes are passed by the `aprun` utility to the ALPS placement scheduler as the set of nodes from which to make an allocation. For detailed information about ALPS, see Chapter 8, Using the Application Level Placement Scheduler (ALPS) on page 235.

For more information about the `aprun` and `cnselect` commands, see the `aprun`(1) and `cnselect`(8) man pages.

2.8 Node Health Checker (NHC)

NHC is automatically invoked by ALPS upon the termination of an application. ALPS passes a list of compute nodes associated with the terminated application to NHC. NHC performs specified tests to determine if compute nodes allocated to the application are healthy enough to support running subsequent applications. If not, it removes any compute nodes incapable of running an application from the resource pool. The CLE installation and upgrade processes automatically install and enable NHC software; there is no need for you to change any installation configuration parameters or issue any commands. To configure NHC tests and to optionally configure NHC to use the secure sockets layer (SSL) protocol, see Configuring Node Health Checker (NHC) on page 157.

2.9 Comprehensive System Accounting (CSA)

Comprehensive System Accounting (CSA) is open-source software that includes changes to the Linux kernel so that CSA can collect more types of system resource usage data than under standard Fourth Berkeley Software Distribution (BSD) process accounting. CSA software also contains interfaces for the Linux process aggregates (`paggs`) and jobs software packages. The CSA software package includes accounting utilities that perform standard types of system accounting processing on the CSA generated accounting files. CSA, with Cray modifications, is included with CLE and runs on login nodes and compute nodes only. For more information, see Chapter 9, Using Comprehensive System Accounting on page 261.

2.10 Checkpoint/Restart (CPR)

Checkpoint/Restart (CPR) provides a way to stop applications at specified points and later restart them from that point. The CLE CPR feature is built upon the Berkeley Lab Checkpoint/Restart (BLCR) for Linux. Specific third-party batch system software releases are required for checkpoint/restart support (see Optional Workload-management (Batch) System Software Products on page 47). For detailed information about the CLE implementation of CPR, see Chapter 10, Using Checkpoint/Restart on Cray Systems on page 275.

2.11 Portals Message-passing Interface for Cray XT Systems

Portals is a message-passing interface (MPI) that connects service nodes and compute nodes for Cray XT systems, which have SeaStar ASICs. All internode communication over the high-speed network goes through Portals. The administrator has no part in this communication.

Both user-level and kernel-level processes use Portals. Application processes communicate with one another over the system interconnection network by linking libraries that support the Portals protocol. The microprocessor in SeaStar ASICs runs Portals firmware.

Portals communication is connectionless; that is, the state is not maintained across consecutive communications. A single Portals message cannot be longer than 2 GB.

Note: For Cray XE systems, the Gemini ASIC logic does not require the use of Portals messaging or firmware files. The Gemini ASIC logic handles message passing.

2.12 Optional Workload-management (Batch) System Software Products

For information about optional batch systems software products for Cray systems, see the following websites.

PBS Professional:	Altair Engineering, Inc.	http://www.altair.com/
Moab and TORQUE:	Cluster Resources, Inc.	http://www.clusterresources.com/
Platform LSF:	Platform Computing Corporation	http://www.platform.com/

Note: Specific third-party batch system software releases are required for Checkpoint/Restart (CPR) support. For more information, access the **3rd Party Batch SW** link on the CrayPort website at crayport.cray.com.

2.13 Hardware Supervisory System (HSS)

The HSS is an integrated system of hardware and software that monitors the hardware components of the system and proactively manages the health of the system. The HSS communicates with nodes and with the management processors over an internal (private) Ethernet network that operates independently of the system interconnection network. The HSS data is stored on the internal hard drive of the SMW.

For a complete list of Cray developed HSS commands, see Appendix A, SMW and CLE System Administration Commands on page 327.

The HSS includes the following components:

- The HSS network (see HSS Network on page 48).
- The HSS interface (see HSS Interface on page 48).
- Blade and cabinet control processors (L0 and L1 controllers) (see Blade Control Processor (L0 Controller) and Cabinet Control Processors (L1 Controller) on page 48).
- Network Time Protocol (NTP) server (see NTP Server on page 49).
- Event router (see Event Router on page 49).
- HSS managers (see HSS Managers on page 50).
- `xtdiscover` command (see `xtdiscover` Command on page 53).
- Various logs (see Event Logs on page 54, Boot Logs on page 54, Dump Logs on page 54).

2.13.1 HSS Network

The SMW, with its HSS Ethernet network, performs reliability, accessibility, and serviceability tasks. The HSS commands monitor and control the physical aspects of the system.

The SMW manages the HSS network. A series of Ethernet switches connects the SMW to all the cabinets in the system.

2.13.2 HSS Interface

The HSS has a command-line interface to manage and monitor your system. You can use the command-line interface to manage your Cray system from the SMW. For usage information, see Chapter 3, Managing the System on page 65 and Chapter 4, Monitoring System Activity on page 93. For a list of all HSS system administration commands, see Appendix A, SMW and CLE System Administration Commands on page 327.

2.13.3 Blade Control Processor (L0 Controller) and Cabinet Control Processors (L1 Controller)

A blade control processor *(L0 controller)* is hierarchically the lowest component of the monitoring system. One L0 controller resides on each compute blade and service blade, monitoring only the nodes and Cray SeaStar chips. It provides access to status and control registers for the components of the blade. The L0 controller also monitors the general health of components, including items such as voltages, temperature, and other failure indicators. A version of Linux optimized for embedded controllers runs on each L0 controller.

Note: In some contexts, the L0 controller is referred to as a *slot*, as in `xtcli power down_slot`. See Powering Down a Single Blade on page 79 for more information.

Each cabinet has a cabinet control processor (L1 controller) that monitors and controls the power supplies, the temperature of the blades, and all the L0 controllers in the cabinet. It sends a periodic heartbeat to the SMW to indicate cabinet health.

The L1 controller connects to the chassis controller and in turn the chassis controller connects to the L0s (via the backplane) on each blade by Ethernet cable and routes HSS data to and from the SMW. The L1 controller runs embedded Linux.

The monitoring system operates by periodic heartbeats. Processes send heartbeats within a time interval. If the interval is exceeded, the system monitor generates a fault event that is sent to the state manager. The fault is recorded in the event log, and the state manager (see State Manager on page 50) sets an alert flag for the component (L0 or L1 controller) that spawned it.

The L1 and L0 controllers use `ntpclient` to keep accurate time with the SMW.

You can dynamically configure the L1 system daemon and the L0 system daemon with the `xtdaemonconfig --`*daemon_name* command (see the `xtdaemonconfig`(8) man page for detailed information).

Note: There is no NV write protection feature on the L1 and L0 controllers; you should not assume the write protection functionality on the L1 front panel display will protect the NV memory on the L1 and L0 controllers.

2.13.4 NTP Server

The SMW workstation is the primary NTP server for the Cray system. The L0 controllers use the HSS network to update themselves according to the NTP protocol. To change the NTP server, see Configuring the SMW to Synchronize to a Site NTP Server on page 213.

2.13.5 Event Router

HSS functions are event-driven. The event router daemon, `erd`, is the root of the HSS. It is a system daemon that runs on the SMW, L1 controllers, and L0 controllers. The SMW runs a separate thread for each L1. The L1 runs a separate thread for each L0. HSS managers subscribe to events and inject events into the HSS system by using the services of the `erd`. (For descriptions of HSS managers, see HSS Managers on page 50) The event router starts as each of the devices (SMW, L1, L0) are started.

When the event router on the SMW receives an event from either a connected agent or from another event router in the hierarchy, the event is logged and then processed. The `xtcli` commands, which are primary HSS control commands, also access the event router to pass information to the managers.

The `xtconsumer` command (see Monitoring Events on page 102) monitors the `erd`. The `xtconsole` command (see Monitoring Node Console Messages on page 103) operates a shell window that displays all node console messages.

2.13.6 HSS Managers

HSS managers are located in `/opt/cray/etc`. They report to the event router and get information from it. HSS has the following managers:

- state manager
- boot manager
- system environmental data collections (SEDC) manager
- diagnostics manager (for Cray XT systems only; not used by Cray XE systems)
- power manager
- flash manager
- router manager
- NID manager

The HSS managers are started by running the `/etc/init.d/rsms start` command.

You can configure HSS daemons dynamically by executing the `xtdaemonconfig` command. For further information, see the `xtdaemonconfig`(8) man page.

2.13.6.1 State Manager

Every component has a state at all times. The state manager, `state_manager`, runs on the SMW and maintains the state of the components in the HSS database. The state manager performs the following functions:

- Updates and maintains component state information (see Appendix B, System States on page 333)
- Monitors events to update component states
- Detects and handles state notification upon failure
- Provides state and configuration information to HSS applications so that they do not interfere with other applications working on the same component

The state manager listens to the `erd`, records changes of states, and shares those states with other daemons.

2.13.6.2 Boot Manager

The boot manager, `bootmanager`, runs on the SMW. It controls the acts of placing kernel data into node memories and requesting that they begin booting.

During the boot process, the state manager provides state information that allows the nodes to be locked for booting. After the nodes boot, the state manager removes the locks and notifies the boot manager. The boot manager logging facility includes a timestamp on log messages.

2.13.6.3 System Environmental Data Collections (SEDC) Manager

The System Environment Data Collections (SEDC) manager, `sedc_manager`, monitors the system's health and records the environmental data and status of hardware components such as power supplies, processors, temperature, and fans. SEDC can be set to run at all times or only when a client is listening. The SEDC configuration file provided by Cray has automatic data collection set as the default action.

The SEDC configuration file (`/opt/cray/etc/sedc_srv.ini` by default) configures the SEDC server. In this file, you can also create sets of different configurations as groups so that the L0/L1 daemons can scan components at different frequencies. The `sedc_manager` sends out the scanning configuration for specific groups to the L1s and L0s and records the incoming data by group. For information about configuring the SEDC manager, see *Using and Configuring System Environment Data Collections (SEDC)* and the `sedc_manager`(8) man page.

To view System Environment Data Collections (SEDC) scan data, use the `xtsedcviewer` command-line interface. This utility allows you to view the server configurations (groups) as well as the SEDC scan data from L0 and L1 controllers. For information about viewing SEDC server configuration and the SEDC scan data, see *Using and Configuring System Environment Data Collections (SEDC)* and the `xtsedcviewer`(8) man page.

2.13.6.4 Diagnostics Manager for Cray XT Systems (Not Used by Cray XE Systems)

The diagnostics manager is used by Cray XT systems. The diagnostics manager operates on the SMW. The `xtcli diag` command runs offline diagnostics for the HSS. Offline diagnostics run through the use of the `xtcli diag` command are intended for use by Cray service personnel for Cray XT systems. For information about running diagnostics for Cray XT Cray systems, see the `xtcli_diag`(8) man page.

Note: Cray XE systems, which use a different set of diagnostic test suites than Cray XT systems, do not use or require the diagnostics manager or the `xtcli diag` command. The diagnostics BMS interface for Cray XE systems handles the equivalent functionality.

2.13.6.5 Power Manager

The power manager, `powermanager`, runs on the SMW to control power sequencing of blades, SeaStar chips, and nodes. It responds to `xtcli power up`, `xtcli power down`, `xtcli power up_slot`, and `xtcli power down_slot` events.

For more information, see the `xtcli_power`(8) man page.

2.13.6.6 Flash Manager

The flash manager, `fm`, runs on the SMW. Run the flash manager only as needed. The `fm` command is intended for use by Cray Service Personnel only; improper use of this restricted command can cause serious damage to your computer system. `fm` is used to transfer an updated L0 and L1 controller system image to a specified target to update the firmware in its L0 and L1 controllers and to program processor Programmable Intelligent Computer (PIC) firmware.

The `xtflash` command uses the flash manager to flash memory on one or more L0 and L1 controllers. The `xtflash` command updates only out-of-date L0 and L1 controllers. For more information, see the `xtflash`(8) man page.

2.13.6.7 Router Manager

The router manager, `rtr_manager`, runs on the SMW and initializes system routing for Cray ASICs and nodes that communicate with each other. The `rtr_manager` is always running; use the `rtr` command to perform a variety of routing-related tasks. The `rtr` command is also invoked as part of the `xtbootsys` process.

For more information, see the `rtr`(8) man page.

2.13.6.8 NID Manager

The NID (node ID) manager, `nid_mgr`, runs on the SMW and provides a NID mapping service for the rest of the HSS environment.

Along with the ability to assign NIDs automatically, the `nid_mgr` supports a mechanism that allows an administrator to control the NID assignment; this is useful for handling unique configurations. Administrator-controlled NID assignment is accomplished through a NID assignment file. This is specified with the `nid_mgr -f` argument and defaults to `/etc/opt/cray/nids.ini`. If no file is specified on the command line and the default file does not exist, the `nid_mgr` runs with the default NID assignment. No error is issued. The syntax of the `nids.ini` file is a list of components and an optional NID value. For a large component, such as a chassis or cabinet, a single NID value is the starting NID value for all nodes within that component. If the NID value is not given, the next available NID is used from the previous component. Therefore, you can provide a list of components, and the NIDs will be assigned in that order.

Typically, after a NID mapping is defined for a system, this mapping is used until some major event occurs, such as a hardware configuration change (see Updating the System Configuration After A Hardware Change on page 206). This may require the NID mapping to change, depending on the nature of the configuration change. Adding additional cabinets to the ends of rows does not typically result in a new mapping. Adding additional rows most likely does result in a new mapping. If the configuration change is such that the topology class of the system is changed, this will require a new NID mapping. Otherwise, the NID mapping remains static.

For Cray XE (Gemini) systems, the `nid_mgr` generates a list of mappings between the physical location and Network Interface Controller ID (NIC ID) and distributes this information to the L0. The L0s, in turn, forward the mappings to the RCA on each node. Because the operating system always uses node IDs (NIDs), the HSS converts these to NIC IDs when sending them onto the HSS network and back to NIDs when forwarding events from the HSS network to a node.

For more information about node IDs, see Identifying Components on page 55 and Node ID (NID) for Cray XT Systems on page 59.

2.13.7 `xtdiscover` Command

The `xtdiscover` command automatically discovers the hardware components on a Cray system and creates entries in the system database to reflect the current hardware configuration. The `xtdiscover status` command can correctly identify missing or nonresponsive cabinets, empty or nonfunctioning slots, the blade type (service or compute) in each slot, and the CPU type and other attributes of each node in the system. When it has finished, you can use the `xtcli` command to display the current configuration. No previous configuration of the system is required; the hardware is discovered and made available, and you can modify the components after `xtdiscover` has finished creating entries in the system database.

The `xtdiscover` interface steps a system administrator through the discovery process. The `xtdiscover.ini` file allows you to predefine values such as topology class, cabinet layout, and so on. A template `xtdiscover.ini` file is installed with the SMW software. The default location of the file is `/opt/cray/etc/xtdiscover.ini`.

The `xtdiscover` command does not use or configure the Cray High Speed Network (HSN). The HSN configuration is done when booting the system with the `xtbootsys` command.

The state manager uses a relational database (also referred to as the *HSS database*) to read and write the system state. The state manager keeps the database up to date with the current state of components and retrieves component information from the database when needed. In addition, the dynamic system state persists between boots.

If there are changes to the system hardware, such as adding a new cabinet or removing a blade and replacing it with a blade of a different type (for example, a service blade that is replaced with a compute blade), then `xtdiscover` must be executed again, and it will perform an incremental discovery of the hardware changes without disturbing the rest of the system.

For more information, see the `xtdiscover`(8) man page.

2.13.8 Event Logs

The event router records events to the event log in the `/opt/craylog/eventlog` file. When the log grows beyond a reasonable size, it turns over and its contents are stored in a numbered file in the directory.

2.13.9 Boot Logs

The `/opt/craylog/bootlogs` directory is a repository for files collected by commands such as `xtbootsys`, `xtconsole`, `xtconsumer`, and `xtnetwatch`.

For more information about examining log files, see Managing Log Files Using CLE and HSS Commands on page 95.

2.13.10 Dump Logs

The `/opt/craydump` directory is a repository for files collected by the `xtdumpsys` command. It contains time-stamped dump files.

For more information about examining log files, see Managing Log Files Using CLE and HSS Commands on page 95.

2.14 Cray Management Services (CMS)

The CMS software provides a hierarchy of control and authority that originates on the SMW, delegating control to local agents such as Hardware Supervisory System (HSS) cabinet and blade controllers.

For detailed information, see *Using Cray Management Services (CMS)*, S–2484.

2.15 Storage

The Cray system RAID storage is a disk farm that supports high bandwidth and shared access to and backup of large volumes of data.

Every independent Fibre Channel host interface in each controller provides full-speed access to all the disk storage on its RAID device. Each tier is configured with a parity disk. There are redundant controllers for each RAID.

Boot RAID is partitioned for boot and system (database) functions.

Parallel storage contains user partitions and scratch partitions.

Common storage vendors for a Cray system are DDN devices from DataDirect Networks and LSI devices from LSI Logic Corporation.

CLE supports the capability to configure multiple I/O paths to the controllers on a disk array. One path is designated as the active primary path and the remaining paths are considered inactive or alternate paths. When the primary path to the array is lost due to a failure, disk-specific multi-pathing functionality automatically switches the data access to an alternate path. For Data Direct Networks (DDN) devices, multi-pathing functionality is provided using Device Mapper (DM) functionality that is included in the Linux kernel. With CLE, DM multi-pathing is only supported on DDN 9900 arrays. For LSI devices, multi-pathing functionality is provided using the LSI Redundant Disk Array Controller (RDAC). LSI RDAC is a self-contained module that operates as a device driver. This module has no external interfaces; it interacts directly with Linux kernel I/O functionality. For Cray systems, the LSI RDAC driver module must be integrated into the OS boot image so that the RDAC module is loaded before the Fibre Channel Driver is loaded. You must configure system boot scripts to recognize service nodes with LSI connections and load the RDAC and Qlogic driver modules in the correct order. For more information, contact your Cray service representative.

⚠ **Caution:** Because the system RAID disk is accessible from the SMW, the service database (SDB) node, the boot node, and backup nodes, it is important that you NEVER mount the same file system in more than one place at the same time. If you do so, the Linux operating system will corrupt the file system.

For more information about configuring RAID, see the *Installing and Configuring Cray Linux Environment (CLE) Software* (S–2444) and *Managing Lustre for the Cray Linux Environment (CLE)* (S–0010).

2.16 Other Administrative Information

This section contains additional information that is helpful for the administrator.

2.16.1 Identifying Components

System components (nodes, blades, chassis, cabinets, etc.) are named and located by node ID, IP address, physical ID, or class number. Some naming conventions are specific to CLE.

Component naming does not change for single-core, dual-core, or quad-core processors. Applications start on CPU 0 and are allocated to CPUs either on the same or different processors.

2.16.1.1 Physical ID

The physical ID identifies the cabinet's location on the floor and the component's location in the cabinet as seen by the HSS.

Table 1 shows the physical ID naming conventions. Descriptions assume that you are standing in front of the system cabinets.

Note: You cannot interchange "n" with "s" with Cray XE (Gemini) systems. On Cray XT (SeaStar) systems, accessing SeaStar memory or SeaStar MMRs can be done using, for example, `c0-1c2s3n0` or `c0-1c2s3s0`. On Cray XE (Gemini) systems, Gemini MMR space **must** use a "g" name, possibly with a NIC identifier; and processor memory **must** use an "n" name.

Table 1. Physical ID Naming Conventions

Component	Format	Description
SMW	`s0`, `all`	All components attached to the SMW. `xtcli power up s0` powers up all components attached to the SMW.
cabinet	`c`*X*`-`*Y*	Position: row (X) and row (Y) of cabinet; also used as L1 controller host name. For example: `c12-3` is cabinet 12 in row 3.
chassis	`c`*X*`-`*Y*`c`*#*	Physical unit within cabinet: `c`*X*`-`*Y*; `c`*#* is chassis and # is 0-2. chassis are numbered bottom to top. For example: `c0-0c2` is chassis 2 of cabinet `c0-0`.
blade or slot or module	`c`*X*`-`*Y*`c`*#*`s`*#*	Physical unit within a slot of a chassis `c`*X*`-`*Y*`c`*#*; `s`*#* is the slot of the blade and # is 0-7; also used as L0 controller host name. Blades are numbered left to right. For example: `c0-0c2s4` is slot 4 of chassis 2 of cabinet `c0-0`. For example: `c0-0c2s*` is all slots (0...7) of chassis 2 of cabinet `c0-0`.

Component	Format	Description
node	`c`*X*`-`*Y*`c#s#n#`	Node on a blade; `n#` is the location of the node and # is 0-3 for compute blades and 0 or 3 for service blades. For example: `c0-0c2s4n0` is node 0 on blade 4 of chassis 2 of cabinet `c0-0`. For example: `c0-0c2s4n*` is all nodes on blade 4 of chassis 2 of cabinet `c0-0`.
Gemini ASIC	`c`*X*`-`*Y*`c#s#g#`	Gemini ASIC within a module; `g#` is the location of the Gemini ASIC within a module and # is 0 or 1. For example: `c0-1c2s3g0`
LCB within a Gemini chip	`c`*X*`-`*Y*`c#s#g#l`*RC*	LCB within a Gemini chip; these are numbered according to their tile location. There are 6 rows and 8 columns in the tile grid. The row/column numbers are octal. Valid values are: 0-7 for row (*R*) and 0-7 for column (*C*). For example: `c1-0c2s3g0l57` (row 5, column 7) **Note:** The number of LCBs per Gemini ASIC is 48. Of these, LCBs (octal) 123, 124, 133, 134, 143, 144 and 153, 154 are normally used as processor links and not as network links. For this reason a display of the status of LCBs will normally show these LCBs in a different state than the remaining LCBs.
SeaStar chip	`c`*X*`-`*Y*`c#s#s#`	Cray SeaStar chip on module; `s` is the chip and # is 0-3. For example: `c0-0c2s4s3` is Cray SeaStar chip 3 in slot 4 of chassis 2 of cabinet `c0-0`. For example: `c0-0c2s4s*` is all Cray SeaStar chips on slot 4 of chassis 2 of cabinet `c0-0`.

Component	Format	Description
SeaStar link	c*X*-*Y*c#s#s#l#	Physical link port of a Cray SeaStar chip; l is the port and # is 0-5; numbers designate links to a neighboring Cray SeaStar chip in X-positive, X-negative, Y-positive, Y-negative, Z-positive, and Z-negative directions. For example: c0-0c2s4s3l4 is port 4 of Cray SeaStar chip 3 in slot 4 of chassis 2 of cabinet c0-0.
section	t*A*-*B*	Grouping of cabinets; *A* is the start cabinet number and *B* is the end cabinet number in the x direction. A section refers to all cabinets in all columns (y-coordinate) in the A through B rows. Section names are defined when the xtdiscover command is executed (see *Installing Cray System Management Workstation (SMW) Software*, S–2480 and the xtdiscover(8) man page). For example: For a site with four rows of 31 cabinets, the section t0-1 refers to c0-0, c0-1, c0-2, c0-3, c1-0, c1-1, c1-2, and c1-3.
logical machine (partition)	p#	A partition is a group of components that make up a logical machine. Logical systems are numbered from 0 to the maximum number of logical systems minus one. A configuration with 32 logical machines would be numbered p0 through p31 (see Logical Machines on page 63).
SerDes macro within a Gemini chip	c*X*-*Y*c#s#g#m#	SerDes macro within a Gemini chip. Each macro implements 4 LCBs. Valid values are 0-9. For example: c0-1c2s3g0m1
Gemini socket	c*X*-*Y*c#s#n#s#	Gemini socket within a physical node. Valid values are 0-7. For example: c0-1c2s3n0s1

Component	Format	Description
Die within a Gemini socket	`cX-Yc#s#n#s#d#`	Die within a Gemini physical socket. Valid values are 0-3. For example: `c0-1c2s3n0s1d2`
For Gemini ASICs: Core within a die	`cX-Yc#s#n#s#d#c#`	For Gemini ASICs: Core within a die. Valid values are 0-15. For example: `c0-1c2s3n0s0d1c2`
For Gemini ASICs: Memory controller within a die	`cX-Yc#s#n#s#d#m#`	For Gemini ASICs: Memory controller within a die. Valid values are 0-3. For example: `c0-1c2s3n0s0d1m0`
For Gemini ASICs: DIMM associated with a physical node	`cX-Yc#s#n#d#`	For Gemini ASICs: DIMM associated with a physical node. Valid values are 0-31. For example: `c0-1c2s3n0d3`
Gemini NIC	`cX-Yc#s#g#n#`	NIC (Network Interface Controller) within a Gemini ASIC. Valid values are 0 and 1. For example: `c0-1c2s3g0n1`
Gemini VERTY	`cX-Yc#s#v#`	VERTY (voltage converter/regulator) associated with a Gemini module. Valid values are 0-15. For example: `c0-1c2s3v0`
FPGA	`cX-Yc#s#f#`	FPGA. 0 is the L0E and 1 is the l0G on Gemini systems; 0 is the L0FPGA on SeaStar systems. For example: `c0-1c2s3f1` is the L0G on a Gemini system.

2.16.1.2 Node ID (NID) for Cray XT Systems

The node ID (NID) is a decimal numbering of all CLE nodes. NIDs are sequential numberings of the nodes (SeaStar ASICs) starting in cabinet c0-0. Each cabinet starts on an even 128 boundary; so, cabinet 0 has NIDs 0-95, cabinet 1 has NIDs 128 - 223, cabinet 3 has 256 - 351, and so on. The empty nodes (1 and 2) on service blades are included in the count; so the service module in cabinet 0, cage 0, slot 0 has NIDs 0 and 3.

Use the `xtnid2str` command to convert a NID to a physical ID. For information about using the `xtnid2str` command, see the `xtnid2str`(8) man page.

2.16.1.3 Node ID (NID) for Cray XE Systems

The node ID (NID) is a decimal numbering of all CLE nodes. NIDs are sequential numberings of the nodes starting in cabinet c0-0. Each additional cabinet continues from the highest value of the previous cabinet; so, cabinet 0 has NIDs 0-95, and cabinet 1 has NIDs 96 - 191, and so on.

A single Gemini ASIC connects to two nodes. A cabinet contains three chassis; chassis 0 is the lower chassis in the cabinet. Each chassis contains eight blades and each blade contains four nodes. The lowest numbered NID in the cabinet is in chassis 0 slot 0 (lower left corner); slots (blades) are numbered left to right (slot 0 to slot 7; as you face the front of the cabinet). In cabinet 0 the lower two nodes in chassis 0 slot 0 are numbered NIDs 0 and 1, the numbering continues moving to the right across the lower two node of each slot; so the lower nodes in slot 1 are NIDs 2 and 3 and so on to slot 7 where the lower two nodes are NIDs 14 and 15. The numbering continues with the upper two nodes on each blade, the upper two nodes on slot 7 are 16 and 17 and continues to the left to slot 0; chassis 0 slot 0 then has NIDs numbered 0, 1, 30, and 31. The numbering continues to chassis 1, so slot 0 in chassis 1 has NIDs 32, 33, 62, and 63. Then chassis 3 slot 0 has NIDs 64, 65, 94, and 95.

When identifying components in the system, remember that a single Gemini ASIC is connected to two nodes. If node 61 reported a failure and the HyperTransport (HT) link was the suspected failure, then Gemini 1 on that bladed would be one of the suspect parts. Node 61 is in cabinet 0, chassis 1, slot 1 or c0-0c1s1n3. Nodes 0 and 1 (c0-0c1s1n0 and c0-0c1s1n1) are connected to Gemini 0 (c0-0c1s1g0) and nodes 2 and 3 (c0-0c1s1n2 and c0-0c0s1n3) are connected to Gemini 1 (c0-0c1s1g1).

Use the `xtnid2str` command to convert a NID to a physical ID. For information about using the `xtnid2str` command, see the `xtnid2str`(8) man page.

2.16.1.4 Class Name

Class names are a CLE construct. Classes and the service nodes associated with them are site-defined and are stored in the `service_processor` table. The `/etc/opt/cray/sdb/node_classes` file is created as part of the system installation; you maintain the file manually thereafter (see the *Installing and Configuring Cray Linux Environment (CLE) Software*, S–2444). The `service_processor` table is populated from this file during the boot process and can be changed if you add or remove nodes (see Updating Database Tables on page 186). There is no restriction on how you name the classes or how many you specify; however, you must use the same class names when you invoke the `xtspec` specialization command (see Specializing Files on page 132).

Change the class of a node (see Changing the Class of a Node on page 137) when you change its function, for example, when you have added an additional login node.

The `/etc/opt/cray/sdb/node_classes` file describes the nodes associated with each class.

Example 1. Sample `/etc/opt/cray/sdb/node_classes` file

```
# node:classes
0:service
3:service
4:login
8:login
```

2.16.2 Topology Class

Each Cray system is given a topology class based in the number of cabinets and their cabling. Some commands, such as `xtbounce`, let you specify topology class as an option.

You can see the class value of your system in a number of places, such as `xtcli status` output, `rca-helper -o` command output (`rca-helper` is run from a Cray node), or by using the `xtclass` command from the SMW:

```
smw:~> xtclass
1
```

2.16.3 Persistent `/var` Directory

You can set up a persistent, writable `/var` directory on each service node served with NFS. The boot node has its own root file system and its own `/var` directory; the boot node `/var` is not part of the NFS exported `/snv` file system.

Persistent `/var` retains the contents of `/var` directories between system boots. Because the Cray system root file system is read-only, some subdirectories of `/var` are mounted on `tmpfs` (memory) and not on disk. You must take this extra step to keep your files. Configure the values VAR_SERVER, VAR_PATH, and VAR_MOUNT_OPTIONS in the `/etc/sysconfig/xt` file so the service nodes NFS mount that path at boot time.

Boot scripts and the `xtopview` utility (see Managing System Configuration with the `xtopview` Tool on page 129) respect these configuration values and mount the correct `/var` directory.

For more information, see the *Installing and Configuring Cray Linux Environment (CLE) Software* (S–2444).

2.16.4 Default Network IP Addresses

The default IP addresses for network components are described in the *Installing Cray System Management Workstation (SMW) Software* (S–2480).

2.16.5 `/etc/hosts` Files

The host file on the boot node is for the system interconnect network. The hosts file on the SMW is for the HSS network.

The `xtcdr2proc` utility takes information from the Resiliency Communication Agent (RCA) to build the `/etc/hosts` file on the boot node. The `/etc/hosts` file on the boot node maps IP addresses to node IDs on the system interconnection network (see Node ID (NID) for Cray XT Systems on page 59). The file can also contain aliases for the physical ID location of the system interconnection network components and class names. The following example shows part of the boot node `/etc/hosts` file. The file is updated or created at boot time and contains the default hostname mappings as well as service and HSS names. The upper two octets of the IP address are derived from the `/etc/sysconfig/xt` file, the lower two are derived by the NID. The NID is a sequential numbering of nodes from cabinet 0 up. NIDs start on 128-count boundaries per cabinet, so cabinet 0 has NIDs 0-95, cabinet 1 starts at 128, and so on. In this example, NID is node ID and component naming information is found in Identifying Components on page 55.

> **Note:** For CNL compute nodes, the `/etc/hosts` file on the boot node is generated at boot time to include CNL compute nodes. Also, the installation and upgrade process modifies the `/etc/hosts` file on the boot root to include CNL compute nodes if they are not included.

The `/etc/hosts` file on the SMW contains `physID`s (physical IDs that map to the physical location of HSS network components), such as the L0 and L1 controllers (see Physical ID on page 56).

The default system IP addresses are shown in the *Installing Cray System Management Workstation (SMW) Software* (S–2480).

The `xtdb2etchosts` command converts service information in the SDB to an `/etc/hosts` style file. The resulting `/etc/hosts` file has lines of the following form, where the first column is the IP address, the second column is the NID, and the third column is the service type and class ID of the node:

```
172.1.2.3  nid12345  boot001
172.4.5.6  nid67890  boot002
172.7.8.9  nid55512  login001
```

The service configuration table (`service_config`) in the SDB XTAdmin database provides a line for each service IP address of the form, where `SERV1` and `SERV2` are the service names in the `service_config` table:

```
1.2.3.1   SERV1
1.2.3.2   SERV2
```

The `xtdb2etchosts` command is documented on the `xtdb2etchosts`(8) man page.

2.16.6 Native IP (SSIP)

Native IP (`ssip`) provides IP services through SeaStar hardware. This enables standard UNIX networking programs and protocols such as `telnet`, `ssh`, and `ftp` to work between service nodes over the system interconnection network.

To configure Native IP (SSIP), see Configuring Native IP (SSIP) on page 199.

2.16.7 Realm-Specific IP Addressing (RSIP) for CNL Compute Nodes

Realm-Specific IP Addressing (RSIP) allows CNL compute nodes and the service nodes to share the IP addresses configured on the external Gigabit and 10 Gigabit Ethernet interfaces of network nodes. By sharing the external addresses, you may rely on your system's use of private address space and do not need to configure compute nodes with addresses within your site's IP address space. The external hosts see only the external IP addresses of the Cray system.

To configure RSIP for CNL compute nodes, see Configuring Realm-Specific IP Addressing (RSIP) on page 200.

2.16.8 Security Auditing

Cray Audit is a set of Cray specific extensions to standard Linux security auditing. When the Cray Audit is configured, separate logs are generated for each audited node on a Cray system. Cray specific utilities simplify administration of auditing options and log files across a large number of nodes. For more information, see Security Auditing and Cray Audit Extensions on page 142.

2.16.9 Logging Failed Login Attempts

The `cray_pam` module is a Pluggable Authentication Module (PAM) that, when configured, provides information to the user at login time about any failed login attempts since their last successful login. For more information, see Using the `cray_pam` PAM to Log Failed Login Attempts on page 148.

2.16.10 Logical Machines

You can subdivide a single Cray system into two or more logical machines (partitions), which can then be run as independent systems. An operable logical machine has its own compute nodes and service nodes, external network connections, boot node, and SDB node. Each logical machine can be booted and dumped independently of the other logical machines. Once booted, a logical machine appears as a normal Cray system to the users, limited to the set of hardware included for the logical machine.

The HSS is common across all logical machines. Because logical machines apply from the system interconnection network layer and up, the HSS functions continue to behave as a single system for power control, diagnostics, low-level monitoring, and so on.

In addition,

- Each logical machine must be routable for jobs to run.
- Cray recommends that you do not configure more than one logical machine per cabinet. That way, if you power down a cabinet, you do not affect more than one logical machine. A logical machine can include more than one cabinet.
- A job is limited to running within a single logical machine.
- Although the theoretical maximum allowable logical machines per physical Cray system is 32 logical machines, you must consider your hardware requirements to determine a practical number of logical machines to configure.
- You can run only a single instance of SMW software.
- Boot and routing commands affect only a single logical machine.

To create logical machines, see Creating Logical Machines on page 177.

Managing the System [3]

Important: SCSI device names (`/dev/sd*`) are not guaranteed to be numbered the same from boot to boot. This inconsistency can cause serious system problems following a reboot. When installing CLE, you must switch to persistent device names for file systems on your Cray system. This does **not** apply to SMW disks. For additional information, see Using Persistent SCSI Device Names on page 232.

3.1 Connecting the SMW to the Console of a Service Node

The `xtcon` command is a console interface for service nodes. When it is running, the `xtcon` command provides a two-way connection to the console of any running service node.

Example 2. Establishing a two-way connection between the SMW and console of service node `c0-0c0s0n0`

```
smw:~> xtcon c0-0c0s0n0
--- Console for node c0-0c0s0n0.  Use ^] to quit ---
```

See the `xtcon`(8) man page for additional information.

3.2 Logging On to the Boot Node

The standard Cray configuration has a single GigE connection between the SMW and boot node. You can access other service nodes from the boot node.

Procedure 1. Logging on to the boot node

- From the SMW, log on to the boot node.

  ```
  crayadm@smw:~> ssh boot
  crayadm@boot:~>
  ```

  Note: You can open an administrator window on the SMW to access the boot node:

  ```
  crayadm@smw:~> xterm -ls -vb -sb -sl 2049 6&
  ```

  After the window opens, use it to `ssh` to the boot node.

3.3 Preparing a Service Node and Compute Node Boot Image

This section describes how to prepare a Cray service node and compute node boot image.

A *boot image* is an archive containing all the components necessary to boot Cray service nodes and CNL compute nodes. In general, a boot image contains the operating system kernel, ramdisk, and boot parameters used to bring up a node. A single boot image can contain multiple sets of these files to support booting service nodes and compute nodes from the same boot image as well as booting different versions of compute node operating systems. The operating systems supported by a particular boot image are described through load files. A *load file* is simply a manifest of operating system components to include (represented as files) and load address information to provide to the boot loader. Load files should not be edited by the administrator.

The `xtclone`, `xtpackage` and `xtbootimg` utilities run on the SMW. Use these utilities to set up CNL compute nodes or service node images.

Note: You must have root privileges to invoke the `xtclone` and `xtpackage` commands.

You can create a boot node image on the SMW using a four-step process:

1. Run the `xtclone` utility to create your work area, copied from the master work area.
2. In your work area, make necessary changes, for example, install RPMs, edit configuration files, or add or remove scripts.
3. Run the `xtpackage` utility to properly package the operating system components and prepare a load file for use by `xtbootimg`.
4. Run the `xtbootimg` utility to create a boot image (an archive or `cpio` file) from your work area. The `xtbootimg` utility collects the components described by one or more load files into a single archive. The load files themselves are also included in the archive, along with other components, such as Portals firmware, BIOS, and sources listed in the load file from `xtpackage`.

The following is a sample service node load file (`SNL0.load`):

```
#Kernel source: /opt/xt-images/p1/service/boot/vmlinuz-2.6.27.42-0.1.1_1.0300.4999-cray_ss_s
SNL0/vmlinuz-2.6.27.42-0.1.1_1.0300.4999-cray_ss_s.bin 0x100000
#Parameters source: /opt/xt-images/p1/service/boot/parameters-snl
SNL0/parameters 0x90800
SNL0/initramfs.gz 0xFA00000
SNL0/size-initramfs 0x9021C
```

Cray system compute and service nodes use a RAM disk for booting. Service nodes and CNL compute nodes use the same `initramfs` format and work space environment. This space is created in `/opt/xt-images/`*machine*`-`*xtrelease*`-`*partition*`/`*nodetype*, where *machine* is the Cray hostname, *xtrelease* is the CLE release level, *partition* describes a system partition or is omitted for a full system, and *nodetype* is either compute or service.

Note that in the preceding example, a simpler `/opt/xt-images/partition/nodetype` format was followed, that is, `/opt/xt-images/p1/service`. The *machine*`-`*xtrelease*`-`*partition* is still a useful convention.

To create load files for supporting, for example, different boot parameters or different RAM disk contents, use the `xtpackage` command with the `-L` option.

Use the `xtbootimg -L` option to specify the path to the CNL compute node load file and the path to the service node load file.

Example 3. Creating a Cray boot image from existing file system images

Make copies of the compute-node-side and service-node-side of the master work area.

> **Note:** It is recommended that your work area be in a subdirectory of `/opt/xt-images`, as shown in the example.

```
smw:~ # xtclone /opt/xt-images/test/compute
smw:~ # xtclone -s /opt/xt-images/test/service
```

Make any changes to your work area that are necessary for your site. For example, you can install or erase RPMs, change configuration files, or add or remove scripts. Use the `xtpackage -s` option to create a "service-node-only" boot image. When you are finished making changes, wrap up (package) the compute-node-side and service-node-side of your work area.

```
smw:~ # xtpackage /opt/xt-images/test/compute
smw:~ # xtpackage -s /opt/xt-images/test/service
```

> **Note:** The `xtpackage` utility automatically creates an `/etc/xt.snl` file in service node `initramfs`. This allows compute node hardware to boot service node images, if necessary.

Finally, make a boot image (a `cpio` file) from your work area.

```
smw:~ # xtbootimg -L ./my-image/service/SNL0.load  -L ./my-image/compute/CNL0.load \
-c /opt/xt-images/cpio/test/my-test-image.cpio
```

Another common path for the `xtbootimg` archive file is `/tmp/boot/`*my-test-image*`.cpio`.

Note: The directory path for *my-test-image*`.cpio` **must** exist on both the SMW and the boot node and the *my-test-image*`.cpio` file must be identical on both the SMW and the boot node.

Some configurations export `/opt/xt-images/cpio` via NFS, so the SMW and the boot node can see the same files in `/opt/xt-images/cpio`. Other configurations use a non-networked file system at `/tmp/boot`, in which case, you **must** put a copy of `smw:/tmp/boot/`*my-test-image*`.cpio` at `boot:/tmp/boot/`*my-test-image*`.cpio`. This is required for the boot node to be able to distribute *my-test-image*`.cpio` to the other service nodes.

For more information about these utilities, see the `xtclone`(8), `xtpackage`(8), and `xtbootimg`(8) man pages.

3.3.1 Using `shell_bootimage_`*label*`.sh` to Prepare Boot Images

The `CLEinstall` installation program creates a `/var/opt/cray/install/shell_bootimage_`*label*`.sh` script on the SMW. This script is unique to the system set label you installed, based on settings in the `CLEinstall.conf` and `/etc/sysset.conf` installation configuration files. You can re-use this script to automate some of the steps for creating boot images.

Procedure 2. Preparing a boot image for CNL compute nodes and service nodes

Invoke the `shell_bootimage_`*label*`.sh` script to prepare boot images for the system set with the specified *label*. This script uses `xtclone` and `xtpackage` to prepare the work space in `/opt/xt-images`.

`shell_bootimage_`*label*`.sh` accepts the following options:

`-c`	Create and set the boot image for the next boot. The default is to display `xtbootimg` and `xtcli` commands that will generate the boot image. Use the `-c` option to invoke these commands automatically.
`-b` *bootimage*	Specify *bootimage* as the boot image disk device or file name. The default *bootimage* is determined using values for the system set *label* when `CLEinstall` was run. Use this option to override the default and manage multiple boot images.
`-h`	Display help message.
`-v`	Run in verbose mode.

This script also includes the following parameters to indicate which optional RPMs to include in the CNL boot image. To include the RPM for an optional feature, edit the script and set the associated parameter to **`y`**.

```
CNL_AUDIT=
CNL_CSA=
CNL_DVS=
CNL_RSIP=
CNL_NTPCLIENT=
CNL_CPR
```

1. Run `shell_bootimage_`*label*`.sh`, where *label* is the system set label specified in `/etc/sysset.conf` for this boot image. For example, if the system set label is *BLUE*, log on to the SMW as root and type:

   ```
   smw:~# /var/opt/cray/install/shell_bootimage_BLUE.sh
   ```

   Upon completion, the script displays the `xtbootimg` and `xtcli` commands required to build and set the boot image for the next boot. If you specified the `-c` option, the script invokes these commands automatically and you should skip the remaining steps in this procedure.

2. Create a unified boot image for compute and service nodes using the suggested `xtbootimg` command.

In the following example, replace *bootimage* with the *mountpoint* for `BOOT_IMAGE0` in the system set defined in `/etc/sysset.conf`. Set *bootimage* to either a raw device; for example `/raw0` or a file name; for example `/bootimagedir/bootimage.new`.

Caution: If *bootimage* is a file, verify that the file exists in the same path on both the SMW and the boot root.

```
smw:~# xtbootimg \
-p /opt/cray-xt-firmware/default/lib/firmware/accel_driver.ppcb \
-L /opt/xt-images/xthostname-CLE_version/compute/CNL0.load \
-L /opt/xt-images/xthostname-CLE_version/service/SNL0.load \
-c bootimage
```

3. At the prompt 'Do you want to overwrite', type **y** to overwrite the existing boot image file.

4. If *bootimage* is a file, mount the boot node root file system to `/bootroot0`, copy the boot image file from the SMW to the same directory on the boot root, and then unmount the boot node root file system. If *bootimage* is a raw device, skip this step. For example, if the *bootimage* file is `/bootimagedir/bootimage.new` and `bootroot_dir` is set to `/bootroot0`, type these commands.

```
smw:~ # mount /dev/bootrootdevice /bootroot0
smw:~ # cp -p /bootimagedir/bootimage.new /bootroot0/bootimagedir/bootimage.new
smw:~ # umount /bootroot0
```

5. Set the boot image for the next system boot using the suggested `xtcli` command.

   The `shell_bootimage_`*label*`.sh` program suggests an `xtcli` command to set the boot image based on the value of `BOOT_IMAGE0` for the system set that is being used. The `-i` *bootimage* option specifies the path to the boot image and is either a raw device, for example, `/raw0` or `/raw1`, or a file such as `/bootimagedir/bootimage.new`.

   Caution: The next boot, anywhere on the system, uses the boot image you set here.

   a. Display the boot image currently in use. Record the output of this command.

      If the partition variable in `CLEinstall.conf` is `s0`, type:

      ```
      smw:~# xtcli boot_cfg show
      ```

      Or

      If the partition variable in `CLEinstall.conf` is a partition value such as `p0`, `p1`, and so on, type:

      ```
      smw:~# xtcli part_cfg show pN
      ```

b. Invoke `xtcli` with the `update` option to set the default boot configuration used by the boot manager.

If the partition variable in `CLEinstall.conf` is `s0`, type this command to select the boot image to be used for the entire system.

```
smw:~# xtcli boot_cfg update -i bootimage
```

Or

If the partition variable in `CLEinstall.conf` is a partition value such as `p0`, `p1`, and so on, type this command to select the boot image to be used for the designated partition.

```
smw:~# xtcli part_cfg update pN -i bootimage
```

3.4 Changing Boot Parameters

Caution: Some of the default boot parameters are mandatory. The system may not boot if they are removed.

Updating the parameters passed to the Linux kernel requires recreating the boot image with the `xtpackage` and `xtbootimg` commands. You can either edit the files in the file system image or specify a path to a file containing parameters. If editing the files, the default service and compute node parameters can be found in `boot/parameters-snl` and `boot/parameters-cnl`, respectively.

Example 4. Making a boot image with new parameters for service and CNL compute nodes

```
smw:~ # xtpackage -s -p /tmp/parameters-service.new  /opt/xt-images/test/service
smw:~ # xtpackage -p /tmp/parameters-compute.new /opt/xt-images/test/compute

smw:~ # xtbootimg -L /opt/xt-images/test/service/SNL0.load \
-L /opt/xt-images/test/compute/CNL0.load -c /raw0
```

3.5 Booting Nodes

This section describes how to manually boot your boot node and service nodes and the CNL compute nodes. It also describes how to reboot a single compute node, and reboot login or network nodes.

For information about modifying boot automation files, see Modifying Boot Automation Files on page 182.

3.5.1 Booting the System

Use the `xtbootsys` command to manually boot your boot node, service nodes, and CNL compute nodes.

Note: You can also boot the system using both user-defined and built-in procedures in automation files, for example, `auto.generic.cnl`. Before you modify the `auto.generic.cnl` file, Cray recommends copying it first because it will be replaced by an SMW software upgrade. For related procedures, see *Installing and Configuring Cray Linux Environment (CLE) Software*.

Procedure 3. Manually booting the boot node and service nodes

Warning: If you are installing a new CLE release on one system set and have the Cray booted from another system set for the same Cray partition, the Cray partition must be shut down before booting the new boot image.

Note: The Lustre file system should start up before the compute nodes, and compute nodes should be shut down before shutting down the Lustre file system.

Note: If you run more than one boot image, execute the `xtcli update` or `xtcli show` command to display the `cpio` image you are booting.

1. As `crayadm`, use the `xtbootsys` command to boot the boot node.

   ```
   crayadm@smw:~> xtbootsys
   ```

   Note: If you have a partitioned system, invoke `xtbootsys` with the `--partition p`*n* option.

   The `xtbootsys` command prompts you with a series of questions. Cray recommends that you answer yes by typing **Y** to each question.

   The session pauses at:

```
Enter your boot choice:
       0) boot bootnode ...
       1) boot sdb ...
       2) boot compute ...
       3) boot service ...
       4) boot all (not supported) ...
       5) boot all_comp ...
       10) boot bootnode and wait ...
       11) boot sdb and wait ...
       12) boot compute and wait ...
       13) boot service and wait ...
       14) boot all and wait (not supported) ...
       15) boot all_comp and wait ...
       17) boot using a loadfile ...
       18) turn console flood control off ...
       19) turn console flood control on ...
       20) spawn off the network link recovery daemon (xtnlrd)...(for Cray XE systems only)
       q) quit.
```

   Choose option **10** to boot the boot node and wait.

You are prompted to confirm your selection. Press the `Enter` key or type **`Y`** to each question to confirm your selection.

```
Do you want to boot the boot node ? [Yn] Y
Do you want to send the ec_boot event ('no' means to only load memory) ? [Yn] Y
```

2. After the boot node has finished booting, the process returns to the boot choice menu. Choose option **11** to boot the SDB node and wait.

   You are prompted to confirm your selection. Press the `Enter` key or type **`Y`** to each question to confirm your selection.

```
Do you want to boot the sdb node ? [Yn] Y
Do you want to send the ec_boot event ('no' means to only load memory) ? [Yn] Y
```

3. Next, select option **13** to boot the service nodes and wait.

   You are prompted to enter a list of the service nodes to be booted. To display service node information, type one of the following commands. Use the `s0` option for the entire system or the `p`*n* option for a partition; for example:

   ```
   smw:~# xtcli status s0 | grep service
   smw:~# xtcli status p2 | grep service
   ```

4. Type a list of service nodes to be booted; for example:

   ```
   c0-0c0s1n0 c0-0c0s1n3 c0-0c0s2n0 c0-0c0s2n3
   ```

   You can also use this format for specifying the same service nodes:

   ```
   c0-0c0s1 c0-0c0s2
   ```

   Alternatively, type **`all_serv`** to boot all remaining service nodes.

5. You are prompted to confirm your selection. Press the `Enter` key or type **`Y`** to each question to confirm your selection.

```
Do you want to boot service c0-0c0s1n0,c0-0c0s1n3,c0-0c0s2n0,c0-0c0s2n3 ? [Yn] Y
Do you want to send the ec_boot event ('no' means to only load memory) ? [Yn] Y
```

   After the specified service nodes are booted, you are prompted to `Enter your boot choice` again. **Do not close** the `xtbootsys` window. You will use this terminal session to boot the compute nodes.

6. Log on to any service nodes for which there are local configuration or startup scripts (such as starting Lustre) and run the scripts.

Procedure 4. Booting CNL compute nodes

1. After all service and login nodes are booted and Lustre has started (if configured at this time), return to the `xtbootsys` menu.
2. Select **17** from the `xtbootsys` menu. A series of prompts are displayed. Type the responses indicated in the following example. For the `component list` prompt, type **`p0`** to boot the entire system, or **`p`***N* (where *N* is the partition number) to boot a partition. At the final three prompts, press the `Enter` key.

```
Enter your boot choice: 17
Enter a boot type string (or nothing to do nothing): CNL0
Enter a boot type option (or nothing to do nothing): compute
Enter a component list (or nothing to do nothing): p0
Enter 'any' to wait for any console output,
   or 'linux' to wait for a linux style boot,
   or 'mtk', 'threadstorm', 'ts', or 'xmt' to wait for a MTK style boot,
   or anything else (or nothing) to not wait at all: Enter
Enter an alternative CPIO archive name (or nothing): Enter
Do you want to send the ec_boot event ('no' means to only load memory) ? [Yn] Enter
```

3. After all the compute nodes are booted, return to the `xtbootsys` menu. Type **q** to exit the `xtbootsys` program.

Note: If the system was shut down using `xtshutdown` or `xtbootsys -s last -a auto.xtshutdown`, remove the `/etc/nologin` file from all service nodes to permit a non-root account to log on.

```
smw:~# ssh root@boot
boot:~# xtunspec -r /rr/current -d /etc/nologin
```

3.5.2 Using the `xtcli boot` Command to Boot a Node or Set of Nodes

To boot a specific image or load file on a given node or set of nodes, you can execute the HSS `xtcli boot` *boot_type* command, as shown in the following examples.

Note: When using a file for the boot image, the same file must be on both the SMW and the `bootroot` at the same path.

Example 5. Booting all service nodes with a specific image

The following example boots all service nodes with the specific image located at `/raw0`:

```
crayadm@smw:~> xtcli boot all_serv_img -i /raw0
```

Example 6. Booting all CNL compute nodes with a specific image

The following example boots all CNL compute nodes with the specific image located at */bootimagedir/bootimage*:

```
crayadm@smw:~> xtcli boot all_comp_img -i /bootimagedir/bootimage
```

Example 7. Booting CNL compute nodes using a load file

The following example boots all compute nodes in the system with CNL using a load file name `CNL0`:

```
crayadm@smw:~> xtcli boot CNL0 -o compute s0
```

3.5.3 Rebooting a Single CNL Compute Node

You can initiate a warm boot with the `xtbootsys` command's `--reboot` option. This operation performs minimal initialization followed by a boot of only the selected compute nodes. Unlike the sequence that is used by the `xtbounce` command, there is no power cycling of the Cray ASICs or of the node itself, so the high-speed network (HSN) routing information is preserved. Do not specify a session identifier (`-s` or `--session` option) because `--reboot` continues the last session and adds the selected components to it.

Example 8. Rebooting a single CNL compute node

```
crayadm@smw:~> xtbootsys --reboot c1-0c2s1n2
```

3.5.4 Rebooting Login or Network Nodes

Login or network nodes cannot be rebooted via a `shutdown` or reboot command issued on the node; they must be restarted through the HSS system using the `xtbootsys --reboot` *idlist* SMW command. The HSS must be used so that the proper kernel is pushed to the node.

Note: Do not attempt to warm boot nodes running other services in this manner.

Example 9. Rebooting login or network nodes

```
crayadm@smw:~> xtbootsys --reboot idlist
```

For additional information, see the `xtbootsys` man page.

3.6 Requesting and Displaying System Routing

Use the HSS `rtr` command to request routing for the system interconnection network, to verify your current route configuration, or to display route information between nodes. Upon startup, `rtr` determines whether it is making a routing request or an information request.

Example 10. Routing the entire system

The `rtr -R|--route-system` command sends a request to the router manager to perform system routing. If no components are specified, the entire configuration is routed as a single routing domain based on the configuration information provided by the state manager to the router manager. If a component list (*idlist*) is provided, routing is limited to the listed components. The state manager configuration further limits the routing domain to omit disabled blades, nodes, and links and empty blade slots.

```
crayadm@smw:~> rtr --route-system
```

For more information about displaying system routing information, see the `rtr`(8) man page.

3.7 Shutting Down Service Nodes Using the `xtshutdown` Command

The `xtshutdown` command runs from the boot node to shut down the services on service nodes and then shut down the service nodes of the Cray system. It executes a series of commands locally on the boot node and on the service nodes to shut down the system in an orderly fashion.

Procedure 5. Shutting down service nodes

- Modify the `/etc/opt/cray/init-service/xtshutdown.conf` file or in the file specified by the `XTSHUTDOWN_CONF` environment variable to define the sequence of shutdown steps and the nodes on which to execute them. (The `/etc/opt/cray/init-service/xtshutdown.conf` file resides on the boot node.)

⚠ **Caution:** The `xtshutdown` command does not shut down compute nodes. To shut down CNL compute nodes and service nodes, see Shutting Down the System or Part of the System Using the `xtcli shutdown` Command on page 77.

The `xtshutdown` command uses `pdsh` to invoke commands on the service nodes you select. You can choose the boot node, SDB node, a class of nodes, or a single host. You can define functions to execute when the system is shut down. Place these functions in the `/etc/opt/cray/init-service/xt_shutdown_local` file or the file defined by the `XTSHUTDOWN_LOCAL` environment variable.

Note: You must be root user to use the `xtshutdown` command. Passwordless `ssh` must be enabled for the root user from the boot node to all service nodes.

After you have shut down the software on the nodes, you can halt the hardware, reboot, or power down.

For information about shutting down service nodes, see the `xtshutdown`(8) man page.

3.8 Shutting Down the System or Part of the System Using the `xtcli shutdown` Command

The HSS `xtcli shutdown` command allows you to shut down the system or a part of the system. To shut down CNL compute nodes, execute the `xtcli shutdown` command. Under normal circumstances, for example to successfully disconnect from Lustre, invoking the `xtcli shutdown` command attempts to gracefully shut down the specified CNL nodes.

Example 11. Shutting down all CNL compute nodes

To gracefully shut down all CNL nodes, execute the following command:

```
crayadm@smw:~> xtcli shutdown compute
```

Example 12. Shutting down specified CNL compute nodes

To gracefully shut down only CNL compute nodes in cabinet `c13-2`:

```
crayadm@smw:~> xtcli shutdown c13-2
```

Example 13. Shutting down all nodes of a system

The `xtcli shutdown` command allows you to shut down the system; to shut down a partition, use the `p`*n* command, where *n* is the partition you want to shut down.

```
crayadm@smw:~> xtcli shutdown s0
```

Example 14. Forcing nodes to shut down

To force nodes to shut down, for example when all nodes of a system must be halted immediately, use the `-f` argument; you can force a shutdown by using the `-f` argument, even if the nodes have an alert status present. For example:

```
crayadm@smw:~> xtcli shutdown -f s0
```

After you have shut down the software on the nodes, you can halt the hardware, reboot, or power down.

For information about shutting down nodes using the `xtcli shutdown` command, see the `xtcli`(8) man page.

3.9 Shutting Down the System Using the `auto.xtshutdown` File

You can shut down the system using both user-defined and built-in procedures in the `auto.xtshutdown` file, which is located on the SMW in the `/opt/cray/etc` directory. For related procedures, see *Installing and Configuring Cray Linux Environment (CLE) Software*. For more information about using automation files, see the `xtbootsys`(8) man page.

3.10 Stopping System Components

When you remove, stop, or power down components, any applications and compute processes that are running on those components are lost.

3.10.1 Reserving a Component

If you want the applications and compute processes to complete before you stop components, use the HSS `xtcli set_reserve` *idlist* command to select the nodes you want to remove. This prevents them from accepting new jobs.

Note: If you are running CNL and using ALPS, after a node is reserved it is considered to be `down` by ALPS. The output from `apstat` will show the node as down (DN), even though there may be an application running on that node. This DN designation indicates that no other work will be placed on the node after the currently running application has terminated.

Procedure 6. Reserving a component

- Type:

```
crayadm@smw:~> xtcli set_reserve idlist
```

3.10.2 Powering Down a Node

Warning: Power down the cabinets with software commands. Tripping the circuit breakers may result in damage to system components.

Warning: Ensure the operating system is not running before you power down a node.

Power commands are hierarchical; that is, there are a number of ways to power down a lower-level component. For example, to power down a node, power it down directly or power down a component of which it is a part.

Procedure 7. Powering down a node directly

- Type:

```
crayadm@smw:~> xtcli power down node
```

3.10.3 Powering Down a Component

If you power down a higher-level component, you also power down the nodes within it. For example, powering down the slot powers down all Cray ASICs and all nodes on the blade.

Warning: Power down the cabinets with software commands. Tripping the circuit breakers may result in damage to system components.

Procedure 8. Powering down a higher component to power down a node

Note: You cannot power down a link independently.

- Type:

```
crayadm@smw:~> xtcli power down component
```

Warning: Although a component such as a blade is powered off, the HSS in the cabinet is live and has power.

It is good practice to plan the order in which you power down the components. Do not turn off components in a way that isolates parts of the system and prevents processes from completing. Use the `xtnodestat` command to observe which nodes have jobs running on them (see Displaying the Status of Nodes from the Operating System on page 83).

For information about disabling and enabling components, see Disabling Hardware Components on page 86, and Enabling Hardware Components on page 87, respectively. For information about powering down a component, see the `xtcli_power`(8) man page.

3.10.4 Powering Down a Single Blade

Use the HSS `xtcli power down_slot` command in the SMW window to power down selected blades and their subcomponents. The cabinets containing the blades must be in the READY state (see Appendix B, System States on page 333).

Warning: This command is intended for emergency shutdown or for service personnel use.

Warning: Power down the cabinets with software commands. Tripping the circuit breakers may result in damage to system components.

Procedure 9. Powering down selected blades

The `xtcli power down_slot` command has the form:

```
xtcli power down_slot physIDlist
```

where *physIDlist* is a comma-separated list of components you want to power down.

- Type:

  ```
  crayadm@smw:~> xtcli power down_slot blade
  ```

  For example, to power down blades 1 and 2 in chassis 0 of cabinet `c3-0`, including the L0s, type the following command:

  ```
  crayadm@smw:~> xtcli power down_slot c3-0c0s1,c3-0c0s2
  ```

  If the cabinet containing the blades is not in the `READY` state (see Appendix B, System States on page 333), the command fails. For more information, see the `xtcli`(8) and `xtcli_power`(8) man pages.

3.10.5 Forcing Components to Power Down

You can force chosen components to power down regardless of their current state with the HSS `xtcli power force_down` command.

Warning: Power down the cabinets with software commands. Tripping the circuit breakers may result in damage to system components.

Procedure 10. Forcing a component to power down

- Type:

  ```
  crayadm@smw:~> xtcli power force_down component
  ```

You can also use the `-f` (force) flag on other `xtcli power` commands to force immediate powerdown; for example, to force the state manager to re-synchronize with the true state of components within a cabinet that has lost power. If you choose this option, the power manager ignores the operational state of the components (see Appendix B, System States on page 333) that are acted upon. This could result in data loss.

Example 15. Resynchronizing the state manager with the true state of components within a cabinet that has lost power

```
smw:~> xtcli power -f down c2-0
smw:~> xtcli power up c2-0
```

For more information about powering down components, see the `xtcli_power`(8) man page.

3.10.6 Halting Selected Nodes

You can halt selected nodes with the HSS `xtcli halt` command.

Procedure 11. Halting a node

The command has the form:

```
xtcli halt node
```

- Type:

  ```
  crayadm@smw:~> xtcli halt node
  ```

For more information about halting a node, see the `xtcli`(8) man page.

3.10.7 Powering Off L0 Controllers or Slots

If you use the HSS `xtcli power down` command to power down a node and its Cray ASICs, the L0 controller remains running.

If you use the `xtcli power down_slot` command, the L0 controller is powered off as well.

All the L0 controllers in the cabinet are powered down only when the cabinet is powered down. For more information about powering down components, see the `xtcli_power`(8) man page.

3.11 Restarting a System Component

Change the state of the hardware only when the operating system is not running or is shut down. Use the HSS `xtcli power up` command to restart a component.

Procedure 12. Power up blades in a cabinet

You can start components through the command line with the HSS `xtcli power up` command. The command has the form:

```
xtcli power up physIDlist
```

where *physIDlist* is a comma-separated list of components present on the system (see Physical ID on page 56). All components in the cabinet are powered up.

If a blade is powered off (see Powering Down a Single Blade on page 79) and the cabinet is up, you can start selected blades, their Cray ASICs, and nodes with the HSS `xtcli power up_slot` command.

- Power up the selected component:

  ```
  crayadm@smw:~> xtcli power up_slot blade
  ```

  This powers up the slot and the L0 controller.

For more information about restarting components, see the `xtcli_power`(8) man page.

3.12 Aborting Active Sessions on HSS Managers

Use the HSS `xtcli session abort` command to abort sessions in the boot, diagnostic, or power manager. A session corresponds to running a specific command such as `xtcli power up`, `xtcli boot`, or `xtcli diag`.

Example 16. Aborting a session running on the boot manager

To display all running sessions in the boot manager, execute the following command.

```
crayadm@smw:~> session show BM all
```

Execute the following HSS `xtcli session abort` command to abort session 1 running on the boot manager:

```
crayadm@smw:~> xtcli session abort BM 1
```

Use this command if you have started an `xtcli power`, `xtcli diag`, or `xtcli boot` command but want to stop it before the command has completed.

> **Note:** Only the boot manager supports multiple simultaneous sessions. The diagnostic and power managers execute only one session at a time, so you do not need to include a session ID in the `xtcli session abort DM` or the `xtcli session abort PM` command.

For more information about manager sessions, see the `xtcli`(8) and man page.

3.13 Displaying and Changing Software System Status

There are a number of tools that enable you to inspect and change the status of compute nodes on a running system.

3.13.1 Displaying the Status of Nodes from the Operating System

The user command `xtnodestat` provides a display of the status of nodes: how they are allocated and to what jobs. The `xtnodestat` command provides current job and node status summary information, and it provides an interface to ALPS and jobs running on CNL compute nodes. You must be running ALPS in order for `xtnodestat` to report job information.

For more information, see the `xtnodestat`(1) man page.

3.13.2 Viewing and Changing the Status of Nodes

Use the `xtprocadmin` command on a service node to view the status of components of a booted system in the `processor` table of the SDB. The command enables you to retrieve or set the processing mode (`interactive` or `batch`) of specified nodes. You can display the state (`up`, `down`, `admindown`, `route`, or `unavailable`) of the selected components, if needed. You can also allocate processor slots or set nodes to become unavailable at a particular time. The node is scheduled only if the status is `up`.

Example 17. Looking at node characteristics

```
$ xtprocadmin
Connected
   NID    (HEX)    NODENAME     TYPE    STATUS        MODE
     0      0x0  c0-0c0s0n0  service        up       batch
     3      0x3  c0-0c0s0n3  service      down       batch
     4      0x4  c0-0c0s1n0  service        up       batch
     7      0x7  c0-0c0s1n3  service        up       batch
     8      0x8  c0-0c0s2n0  service        up       batch
    11      0xb  c0-0c0s2n3  service        up       batch
    12      0xc  c0-0c0s3n0  compute        up       batch
    13      0xd  c0-0c0s3n1  compute        up       batch
    14      0xe  c0-0c0s3n2  compute        up       batch
    15      0xf  c0-0c0s3n3  compute        up       batch
.
.
.
```

Example 18. Viewing all node attributes

Use the `xtprocadmin` command to view current node attributes. The `xtprocadmin -A` option lists all attributes of selected nodes. For example:

```
$ xtprocadmin -A
Connected
    NID   (HEX)    NODENAME     TYPE ARCH       OS  CORES AVAILMEM PAGESZ CLOCKMHZ LABEL0 LABEL1 LABEL2 LABEL3
      0      0x0  c0-0c0s0n0  service   xt (service)     2     8000   4096 2600
      3      0x3  c0-0c0s0n3  service   xt (service)     2     8000   4096 2600
      4      0x4  c0-0c0s1n0  service   xt (service)     2     8000   4096 2600
<snip>
     20     0x14  c0-0c0s5n0  compute   xt       CNL    12    12000   4096 2400
     21     0x15  c0-0c0s5n1  compute   xt       CNL    12    12000   4096 2400
     22     0x16  c0-0c0s5n2  compute   xt       CNL    12    12000   4096 2400
     23     0x17  c0-0c0s5n3  compute   xt       CNL    12    12000   4096 2400
<snip>
    988    0x3dc  c7-0c2s7n0  compute   xt       CNL    12    32000   4096 2400
```

```
  989    0x3dd  c7-0c2s7n1  compute   xt       CNL    12    32000   4096 2400
  990    0x3de  c7-0c2s7n2  compute   xt       CNL    12    32000   4096 2400
  991    0x3df  c7-0c2s7n3  compute   xt       CNL    12    32000   4096 2400
```

Example 19. Viewing selected node attributes of selected nodes

The `xtprocadmin -a` *attr1*`,`*attr2* option lists selected attributes of selected nodes. For example:

```
$ xtprocadmin -n 7 -a arch,clockmhz,os,cores
Connected
NID (HEX)   NODENAME   TYPE     ARCH   CLOCKMHZ OS  CORES
7   0x7     c0-0c0s1n3 service  xt     2000     CNL 1
```

Example 20. Disabling a node

To mark a node as `admindown` and not allow it to be allocated, type the following command:

```
crayadm@nid00004:~> xtprocadmin -n c0-0c0s3n1 -k s admindown
```

Example 21. Disabling all processors

To mark all processors as `admindown` and to disable the system's ability to change their state, type the following command:

```
crayadm@nid00004:~> xtprocadmin -k s admindown
```

Note: When the `xtprocadmin -ks` option is used, then the option can either a normal argument (`up`, `down`, etc.), or it can have a colon in it to represent a conditional option; for example, the option of the form `up:down` means "if state was up, mark down".

For more information, see the `xtprocadmin`(8) man page.

3.13.3 Marking a Compute Node as a Service Node

Use the `xtcli mark_node` command to mark a node in a compute blade to have a role of `service` or `compute`; `compute` is the default. It is **not** permitted to change the role of a node on a service blade, which always has the `service` role.

Marking a node on a compute blade as `service` or `compute` allows you to load the desired boot image at boot time. Compute nodes marked as `service` can run software-based services. A request to change the role of a running node (that is, the node is in the `ready` state and the operating system is running) will be denied.

For more information, see the `xtcli`(8) man page.

3.13.4 Finding Node Information

3.13.4.1 Finding Node Information Using the `xtnid2str` Command

The `xtnid2str` command converts numeric node identification values to their physical names. This allows conversion of Node ID values, Cray Gemini ASIC NIC address values, or Cray Gemini ID values.

Example 22. Finding the physical ID for node 38

```
smw:~> xtnid2str 38
node id 0x26 = 'c0-0c1s1n2'
```

Example 23. Finding the physical ID for nodes 0, 1, 2, and 3

```
smw:~> xtnid2str 0 1 2 3
node id 0x0 = 'c0-0c0s0n0'
node id 0x1 = 'c0-0c0s0n1'
node id 0x2 = 'c0-0c0s0n2'
node id 0x3 = 'c0-0c0s0n3'
```

Or:

```
smw:~> echo 0 1 2 3 | xtnid2str
node id 0x0 = 'c0-0c0s0n0'
node id 0x1 = 'c0-0c0s0n1'
node id 0x2 = 'c0-0c0s0n2'
node id 0x3 = 'c0-0c0s0n3'
```

Example 24. Finding the physical IDs for Gemini IDs 0-7

```
smw:~> xtnid2str -g 0-7
gem id 0x0 = 'c0-0c0s0g0'
gem id 0x1 = 'c0-0c0s1g0'
gem id 0x2 = 'c0-0c0s2g0'
gem id 0x3 = 'c0-0c0s3g0'
gem id 0x4 = 'c0-0c0s4g0'
gem id 0x5 = 'c0-0c0s5g0'
gem id 0x6 = 'c0-0c0s6g0'
gem id 0x7 = 'c0-0c0s7g0'
```

For additional information, see the `xtnid2str`(8) man page.

3.13.4.2 Finding Node Information Using the `xtuname` Command

Use the `xtuname` command on a service node to view information about the service node you are on. You can identify the node's class, its NID, and the boot string provided to the node.

Deprecated: The `xtuname` command is deprecated; will be removed in a future release.

The command has the form:

xtuname [*options*]

Use the `xtuname` command without options to print an aggregate of the node-specific options.

Example 25. Finding a node's NID using the `xtuname` command

To print the NID of the node on which the command has been run:

```
$ xtuname -N
132
```

Example 26. Finding a node's class the `xtuname` command

To print the class of the node on which the command has been run:

```
$ xtuname -C
login
```

For more information, see the `xtuname`(1) man page.

3.14 Displaying and Changing Hardware System Status

You can run commands that look at and change the status of the hardware.

Caution: Run commands that change the status of hardware only when the operating system is shut down.

3.14.1 Generating HSS Physical IDs

Run the HSS `xtgenid` command to generate HSS physical IDs, for example, to create a list of L0 identifiers for input to the flash manager. You can restrict your selections to components that are of a particular type.

Note: Only user `root` can execute the `xtgenid` command.

Example 27. Creating a list of node identifiers that are not in the `DISABLE`, `EMPTY`, or `OFF` state

```
smw:~ # xtgenid -t node --strict
```

For more information, see the `xtgenid`(8) man page.

3.14.2 Disabling Hardware Components

If links, nodes, or Cray ASICs have hardware problems, you can direct the system to ignore the components with the `xtcli disable` command.

By default, when disabling a component, this command takes into consideration the hierarchy of components, performs the action upon the identified component(s) and cascades that action to any subcomponent of the identified component(s), unless the `-n` option is specified.

Note: The `-n` option with the disable command must be used carefully because this may create invalid system state configurations.

For detailed information about using the `xtcli disable` command, see the `xtcli`(8) man page.

Procedure 13. Disabling a Cray ASIC

- The `xtcli disable` command has the form:

  ```
  xtcli disable -a -t type
  ```

  where *physIDlist* is a comma-separated list of components you want the system to ignore. The system disregards these links or nodes.

  Example 28. Disabling the Cray SeaStar ASIC c3-2c0s2s3

  1. Determine that the Cray SeaStar ASIC is in the `OFF` state.

     ```
     crayadm@smw:~> xtcli status -t sicproc c3-2c0s2s3
     ```

  2. If the Cray SeaStar ASIC is not in `OFF` state, power down the nodes and Cray ASICs.

     ```
     crayadm@smw:~> xtcli power down c3-2c0s1
     ```

  3. Disable the Cray SeaStar ASIC.

     ```
     crayadm@smw:~> xtcli disable c3-2c0s1s3
     ```

  4. Power up the slot containing the disabled Cray SeaStar ASIC.

     ```
     crayadm@smw:~> xtcli power up c3-2c0s1
     ```

  For more information, see the `xtcli`(8) man page.

3.14.3 Enabling Hardware Components

If links, nodes, or Cray ASICs that have been disabled are later fixed, you can add them back to the system with the `xtcli enable` command.

By default, when enabling a component, this command takes into consideration the hierarchy of components, performs the action upon the identified component(s) and cascades that action to any subcomponent of the identified component(s), unless the `-n` option is specified.

Note: The `-n` option with the disable command must be used carefully because this may create invalid system state configurations.

Procedure 14. Enabling a Cray ASIC

- The `xtcli enable` command has the form:

  ```
  xtcli enable -a -t type
  ```

  where *physIDlist* is a comma-separated list of components you want the system to recognize.

The state of `off` means that a component is present on the system. If the component is an L0, node, or ASIC, then this will also mean that the component is powered off. If you disable a component, the state shown becomes `disabled`. When you use the `xtcli enable` command to enable that component for use once again, its state switches from `disabled` to `off`. In the same manner, enabling an empty component means that its state switches from `empty` to `off`.

Example 29. Enabling Cray Gemini ASIC `c0-0c1s3g0`

```
crayadm@smw:~> xtshow_disabled s0 | grep c0-0c1s3
   c0-0c1s3g0:        -          OP|    disabled      [noflags|]
c0-0c1s3g0l00:        -          OP|    disabled      [noflags|]
c0-0c1s3g0l01:        -          OP|    disabled      [noflags|]
c0-0c1s3g0l02:        -          OP|    disabled      [noflags|]
c0-0c1s3g0l03:        -          OP|    disabled      [noflags|]
c0-0c1s3g0l04:        -          OP|    disabled      [noflags|]
.
.
.

smw:~> xtcli enable c0-0c1s3g0
Network topology: class 0

All components returned success.
```

For more information about stopping components, see Stopping System Components on page 78 and the `xtcli`(8) man page.

3.14.4 Setting Components to Empty

Use the `xtcli set_empty` command to set a selected component to the empty state. HSS managers and the `xtcli` command ignore empty or disabled components.

Setting a selected component to the empty state is typically done when a component, usually a blade, is physically removed. By setting it to empty, the system ignores it and routes around it.

By default, when enabling a component, this command takes into consideration the hierarchy of components, performs the action upon the identified component(s) and cascades that action to any subcomponent of the identified component(s), unless the `-n` option is specified.

Note: The `-n` option with the disable command must be used carefully because this may create invalid system state configurations.

Example 30. Setting a blade to the EMPTY state

Set the blade and all its components to EMPTY:

```
crayadm@smw:~> xtcli set_empty -a c0-0c1s7
```

For more information, see the `xtcli`(8) man page.

3.14.5 Locking Components

Components are automatically locked when a command that can change their state is running. As the command is started, the state manager locks these components so that nothing else can affect their state while the command runs. When the manager is finished with the command, it unlocks the components.

Use the HSS `xtcli lock` command to lock components.

Example 31. Locking cabinet `c0-0`

The lock command identifies the session ID. Locking a component prints out the state manager session ID.

```
crayadm@smw:~> xtcli lock -l c0-0
```

Example 32. Show all session (lock) data

You can use the `xtcli lock show` command to show session (lock) information.

```
crayadm@smw:~> xtcli lock show
```

3.14.6 Unlocking Components

Use the HSS `xtcli lock` command to unlock components.

Example 33. Unlocking cabinet `c0-0`

The `xtcli lock` command is useful when a manager fails to unlock some set of components. You can manually check for locks with the `xtcli status` command and unlock them. Unlocking a component does not print out the state manager session ID. The `-u` option must be used to unlock a component.

```
crayadm@smw:~> xtcli lock -u c0-0
```

Unlocking does nothing to the state of the component other than to release locks associated with it. HSS managers cannot affect components that are locked by a different session.

3.14.7 Determining How Service Nodes Are Configured by Looking at Hardware

Nodes are sometimes defined by the interfaces installed in them. For example, an I/O node only has a Fibre Channel card. A login node only has an Ethernet GigE card. Table 2 shows node types and typical default configurations.

Table 2. Default Service Node Configuration and Cabling

Node Class	Number of Nodes	Slot 0	Slot 1
Boot	1	GigE	Fibre Channel – 1 Fibre cable connected
Backup boot	1	GigE	Fibre Channel – 1 Fibre cable connected
Service database	1	Empty	Fibre Channel – 1 Fibre cable connected
Syslog	1	Empty	Fibre Channel – 1 Fibre cable connected
I/O	1 or more site-specific	Empty	Fibre Channel – 2 Fibre cables connected
Login	1 or more site-specific, one or more	Empty	GigE
Network	Site-specific	Empty	10-GigE

3.15 Performing Parallel Operations on Nodes

Use the `pdsh` command, which is the CLE parallel remote shell utility, on a service node to issue commands to groups of nodes in parallel. You can select the nodes on which to use the command, exclude nodes from the command, and limit the time the command is allowed to execute. You must be user root to execute the `pdsh` command. The command has the form:

`pdsh [`*options*`]` *command*

Example 34. Restarting the NTP service

To restart the network time protocol (NTP) service on the first 9 login nodes, type:

```
boot:~ # pdsh -w 'login[001-009]' /etc/init.d/ntp restart
```

For more information, see the `pdsh`(1) man page.

3.16 Handling Component Failures

Components that fail are replaced as field replaceable units (FRUs). FRUs include compute blade components, service blade components, and power and cooling components.

When a field replaceable unit (FRU) problem arises, contact your Customer Service Representative to schedule a repair.

Check the nodes running jobs with the `xtnodestat` command. If there appears to be few active nodes, use the `xtprocadmin` command to identify the nodes that are down, for example:

Example 35. Identifying nodes that are down

```
$ xtprocadmin | grep down
```

For more information, see the `xtprocadmin`(8) man page.

3.17 Capturing and Analyzing System-level and Node-level Dumps

3.17.1 Dumping Information Using the `xtdumpsys` Command

The `xtdumpsys` command collects and analyzes information from a Cray system that is failing or has failed, has crashed, or is hung. Analysis is performed on, for example, event log data, active heartbeat probing, voltages, temperatures, health faults, in-memory console buffers, and high-speed interconnection network errors. When failed components are found, detailed information is gathered from them.

To collect similar information for components that have not failed, invoke the `xtdumpsys` command with the `--add` option and name the components from which to collect data. The HSS `xtdumpsys` command saves dump information in `/opt/craydump/`*timestamp* by default.

Choose the `--snapshot` option to perform a quick analysis of the running system or the `--summary` option to perform an analysis of a previous dump. Neither option creates new files.

Example 36. Dumping information about a working component

To dump the entire system and collect detailed information from all L0s in chassis `0` of cabinet `0`, type:

```
crayadm@smw:~> xtdumpsys --add c0-0c0s0
```

> **Note:** An example file, `example.xtdumpsys-plugin`, is included in the `/opt/cray/etc` directory and provides techniques to help you customize your own `xtdumpsys` plugin so it can collect additional data during an `xtdumpsys` session.

For more information, see the `xtdumpsys`(8) man page.

3.17.2 `ldump` and `lcrash` Utilities for Node Memory Dump and Analysis

The `ldump` and `lcrash` utilities may be used to analyze the memory on any Cray service node or CNL compute node. The `ldump` command is used to dump node memory to a file. After `ldump` completes, you may then use the `lcrash` utility on the dump file generated by `ldump`.

Cray recommends running the `ldump` utility only if a node has panicked or is hung, or if a dump is requested by Cray.

To select the desired access method for reading node memory, use the `ldump -r` *access* option. Valid access methods are:

- For Cray XE systems (Cray Gemini based system interconnection network) `xt-bhs`: The `xt-bhs` method uses a basic hardware system server that runs on the SMW to access and read node memory. `xt-bhs` is the default access method for these systems.
- For Cray XT systems (Cray SeaStar based system interconnection network) `xt-ssi`: The `xt-ssi` method uses the SeaStar SSI channel to the Cray system's network application-specific integrated circuit (ASIC) chip to read node memory. `xt-ssi` is the default access method for these systems.
- `xt-hsn`: The `xt-hsn` method utilizes a proxy that reads node memory via the High-speed Network (HSN). The `xt-hsn` method is faster than the `xt-ssi` method and the `xt-bhs` method, but there are situations where it will not work (for example, if the Cray network ASIC chip is not functional). However, the `xt-hsn` method is preferable because the dump completes in a short amount of time and the node can be returned to service sooner.

To dump Cray node memory, *access* takes the following form:

method[@*host*]

For additional information, see the `ldump`(8) and `lcrash`(8) man pages.

3.18 Using `xtnmi` Command to Collect Debug Information from Hung Nodes

Caution: This is not a harmless tool to use to repeatedly get information from a node at various times; only use this command when you need debugging data from nodes that are in trouble. The `xtnmi` command output may be used to determine problems such as a core hang.

The sole purpose of the `xtnmi` command is to collect debug information from unresponsive nodes. As soon as that debug information is displayed to the console, the node panics.

For additional information, see the `xtnmi`(8) man page.

Monitoring System Activity [4]

4.1 Monitoring the System with the System Environmental Data Collector (SEDC)

To use the System Environmental Data Collector (SEDC) to collect data about internal cabinet temperatures, cooling system air pressures, critical voltages, etc., see *Using and Configuring System Environment Data Collections (SEDC)*.

4.2 Displaying Installed SMW Release Level

Following a successful installation, the file `/opt/cray/etc/smw-release` is populated with the installed SMW release level.

Example 37. Displaying installed SMW release level

```
% cat /opt/cray/etc/smw-release
5.0.UP00
```

4.3 Displaying Installed CLE Release Level

Following a successful installation, the file `/etc/opt/cray/release/clerelrease` is populated with the installed CLE release level.

Example 38. Displaying installed CLE release level

```
% cat /etc/opt/cray/release/clerelease
3.0.UP00
```

4.4 Displaying Boot Configuration Information

Use the `xtcli` command to display the configuration information for the primary and backup boot nodes, the primary and backup SDB nodes (backup SDB is Deferred implementation), and the `cpio` path.

Procedure 15. Showing boot configuration information for the entire system

- To display boot configuration information for the entire system, execute the `xtcli boot_cfg show` command:

```
crayadm@smw:~> xtcli boot_cfg show
Network topology: class 0
=== xtcli_boot_cfg ===
[boot]: c0-0c0s0n1:ready,c0-0c0s1n1:ready
[sdb]: c0-0c0s0n3:ready,c0-0c0s1n3:ready
[cpio_path]: /tmp/boot/cray_system-3.1.19blue.cpio
crayadm@smw:~>
```

Procedure 16. Showing boot configuration information for a partition of a system

- To display boot configuration information for a partition of a system, execute the `xtcli part_cfg show` command:

```
crayadm@smw:~> xtcli part_cfg show
```

4.5 Monitoring Multiple Nodes

Deprecated: The utilities described in this section are deprecated and will be removed in a future release; they were developed for Catamount systems, which are no longer supported. Comparable functionality is available using `pdsh` and the equivalent Linux command. For more information, see Performing Parallel Operations on Nodes on page 90 and the `pdsh`(1) man page.

Linux supports several commands that monitor nodes, but these commands operate only on the node where they are executed. Cray supplies system-specific Cray Linux Environment (CLE) commands with similar functions that let you monitor the entire system. These commands are also referred to as single image view utilities because they present results for all service nodes together. Table 3 shows the CLE system commands and equivalent Linux commands.

Table 3. CLE Monitor Commands

CLE Command	Equivalent Linux Command	Function on Cray System
`xtps` **Deprecated:** Will be removed in a future release.	`ps`	Lists running processes
`xtuname` **Deprecated:** Will be removed in a future release.	`uname`	Prints Cray system information
`xtwho` **Deprecated:** Will be removed in a future release.	`who`	Shows logged-in users by node ID (NID) or hostname
`xtkill` **Deprecated:** Will be removed in a future release.	`kill`	Kills processes running on service nodes

For more information, see the `xtkill`(1), `xtps`(1), `xtuname`(1), and `xtwho`(1) man pages.

4.6 Managing Log Files Using CLE and HSS Commands

Boot, diagnostic, and other Hardware Supervisory System (HSS) events are logged on the SMW in the `/opt/craylog` directory, which is created during the installation process.

CLE log files are saved on the `syslog` node in the `message` file located by default in the `/syslog/var/log` directory. (The directory path is set in the `sysset.conf` and `CLEinstall.conf` files.)

Linux system event log files are stored on the service partition.

4.6.1 Filtering the Event Log

The `xtlogfilter` command enables you to filter the event log for information such as the time a particular event occurred or messages from a particular cabinet.

Example 39. Finding information in the event log

To search for all console messages from node `c9-2c0s3n2`, type:

```
crayadm@smw:~> xtlogfilter -f /opt/craylog/eventlog c9-2c0s3n2
```

For more information, see the `xtlogfilter`(8) command.

4.6.2 Adding Entries to Log Files

You can add entries to the `syslog` with the `logger` command. For example, to identify the start or finish of system activities, use the `/bin/logger` command to log events into the system log, `/syslog/var/log/messages`. The message is then available to anyone who reads the log.

Example 40. Adding entries to `syslog` file

To mark the start of a new system test, type:

```
node/4/:/ # logger -is "Start of test 4A $(date) "
Start of test 4A Thu Jul 14 16:20:43 CDT 2005
```

The system log shows:

```
Jul 14 16:20:43 nid00004 xx[21332]:
Start of test 4A Thu Jul 13 16:20:43 CDT 2005
```

For more information, see the `logger`(1) command.

4.6.3 Examining Log Files

Time-stamped log files of boot, diagnostic and other HSS events are located on the SMW in the `/opt/craylog` directory. The time-stamped `bootinfo`, `console`, `consumer`, and `netwatch` log files are located in the `/opt/craylog/bootlogs` directory by default.

For example, the HSS `xtbootsys` command starts the `xtconsole` command, which redirects the output to a time-stamped log file, such as `/opt/craylog/bootlogs/console.0708250731`.

The `SMWinstall`, `SMWconfig`, and `SMWinstallCLE` commands create several detailed log files in the `/var/adm/cray/logs` directory. The log files are named using the PID of the `SMWinstall` or the `SMWinstallCLE` command; the exact names are displayed when the command is invoked.

4.6.4 Removing Old Log Files

The HSS command `/opt/cray/bin/xtclean_logs` removes outdated HSS log files based on a user-specified cutoff date. This command is a bash script that checks the SMW directories `/opt/craylog`, `/opt/craylog/bootlogs`, `/opt/craylog/diaglogs`, and `/opt/craydump`.

Attach the `xtclean_logs` script to the desired `cron` job by copying it into the appropriate `cron` directory. The owner and group must be `root`, and permissions must be `755`. The script is triggered by `/usr/lib/cron/run-crons`.

To choose the log files to delete, modify the parameters to specify the number of days (age) that files are to be kept in the log directories. To turn off file deletion, set the parameter value(s) to 0. Parameters include:

`BOOT_DAYS_TO_KEEP`

Number of days after which files in `/opt/craylog/bootlogs` are deleted. Boot log file names indicate the start of the boot session, and this value is used to determine age. The default parameter setting provided by Cray is 30 days.

Note: Boot session files for the current boot session are not deleted, regardless of age.

`EVENT_DAYS_TO_KEEP`

Number of days after which files in `/opt/craylog/eventlog` are deleted. The age of each `eventlog` file is determined by its last modification time. The default parameter setting provided by Cray is 30 days.

`DIAG_DAYS_TO_KEEP`

Number of days after which diagnostic directories in `/opt/craylog/diaglogs` are deleted. Diagnostic subdirectory names include last modification time, and this value is used to determine age. The default parameter setting provided by Cray is 60 days.

`DUMP_DAYS_TO_KEEP`

Number of days after which dump directories in `/opt/craydump` are deleted. Dump subdirectory names include the last modification time, and this value is used to determine age. The default parameter setting provided by Cray is 30 days.

For more information, see the `xtclean_logs`(8) man page.

4.7 Managing Log Files Using the Cray Management Services (CMS) Log Manager

The CMS log manager provides the capability to collect, analyze, and display messages from the system. The data is collected from a variety of sources and loaded into the CMS database on the SMW. You can view and search the database for events of interest. Notification of events on the event router uses the `mzlogmanagerd` daemon; notification of events in the `syslog` uses the `mzsyslogd`.

For additional information, see *Using Cray Management Services (CMS)*.

4.8 Checking the Status of System Components

To check the status of the system or a component, use the `xtcli status` command on the SMW. By default, the `xtcli status` command returns the status of nodes.

Procedure 17. Showing the status of a component

- The `xtcli status` command has the form:

  `xtcli status [-n] [{-t` *type*`] [-a]}` *node_list*

  Note: The list should have component IDs only (no wild cards).

For Cray systems with the Cray Gemini based system interconnection network (Cray XE series), *type* may be: `node`, `l0`, `cage`, `l1`, `xdp`, `verty`, `dimm`, `socket`, `die`, `core`, `memctrl`, `gemini`, `nic`, `lcb`, `serdes_macro`, or `fpga`.

For Cray systems with the Cray SeaStar based system interconnection network (Cray XT series), *type* may be: `node`, `l0`, `cage`, `l1`, `xdp`, `sicproc` and `link`. `sicproc` is the same as `ss`; `ss` is still accepted.

For more information, see the `xtcli`(8) man page.

4.9 Checking the Status of Compute Processors

To check that compute nodes are available after the system is booted, use the `xtprocadmin` command on a service node.

Example 41. Identifying nodes in down or `admindown` state

To identify if there are any nodes that are in a `down` or `admindown` state, execute the following command from a node:

```
nid00007:~> xtprocadmin | grep down
```

Example 42. Display current allocation and status of each compute processing element and the application that it is running

Use the user `xtnodestat` command to display the current allocation and status of each compute processing element and the application that it is running. A simplified text display shows each processing element on the Cray system interconnection network. For example:

```
nid00007:~> xtnodestat
Current Allocation Status at Tue Feb 16 22:48:20 2010

     C0-0     C1-0     C2-0     C3-0
  n3 fff----- ff------ ff------ ff------
  n2 ffffffff ffffffff ffffffff ffffffff
  n1 ffffffff ffffffff ffffffff ffffffff
c2n0 --ffffff -fffffff -fffffff -fffffff
  n3 -------- -------- -------- --------
  n2 -------- -------- -------- --------
  n1 -------- -------- -------- -X------
c1n0 ddd----- dd------ ddd----- ddd-----
  n3 SSSSSddd dddddddd SSSSdddd dddddddd
  n2      ced bgggcehd     gced bggggchd
  n1      bbb aaaabbbb     abbb aaaabbbb
c0n0 SSSSSaaa aaaaaaaa SSSSaaaa aaaaaaaa
    s01234567 01234567 01234567 01234567

Legend:
   nonexistent node                 S  service node
;  free interactive compute node    -  free batch compute node
A  allocated, but idle compute node ?  suspect compute node
X  down compute node                Y  down or admindown service node
Z  admindown compute node
*  system dedicated node (DVS)

Available compute nodes:          0 interactive,        144 batch


Job ID     User       Size   Age            command line
--- ------ --------   -----  ---------   ----------------------------------
a   1196955 lynda      32     0h03m      slv2
b   1196957 marie      16     0h03m      slv2
c   1196961 johns      4      0h03m      slv2
d   1196967 jason      38     0h02m      gsam_TL959L10
e   1196963 tankr      3      0h02m      slv2
f   1196881 tankr      100    3h40m      jnova.mxx
g   1196959 tankr      8      0h03m      slv2
h   1196965 tankr      2      0h02m      slv2
```

For more information, see the `xtprocadmin`(8) and `xtnodestat`(1) man pages.

4.10 Checking CNL Compute Node Connection

Use the Linux `ping` command to verify that a compute node is connected to the network. The Linux `ping` command must be run from a node, not run on the SMW.

Example 43. Verifying that a compute node is connected to the network

```
nid00007:~> ping nid00004
PING nid00004 (192.168.0.5) 56(84) bytes of data.
64 bytes from nid00004 (192.168.0.5): icmp_seq=1 ttl=64 time=0.032 ms
64 bytes from nid00004 (192.168.0.5): icmp_seq=2 ttl=64 time=0.010 ms
```

For more information, see the Linux `ping`(8) man page.

4.11 Checking Link Control Block and Router Errors

The HSS `xtnetwatch` command monitors the Cray system interconnection network. It requests link control block (LCB) and router error information from the L0-based router daemons and specifies how often to sample for errors. It then detects events that contain the error information sent by these daemons and displays the information as formatted output in a log file.

You can specify which system components to sample and control the level of verbosity of the output, select the sampling interval, and log results to an output file.

Although the command can be invoked standalone from the SMW prompt, Cray recommends that you run `xtnetwatch` each time you boot the system with the `xtbootsys` command (the default). The output is a time-stamped log file such as:

```
/opt/craylog/bootlogs/netwatch.0708270830
```

Check the log file for fatal link errors and router errors. Fatal link errors signal faulty hardware. Fatal router errors can be generated either by hardware or software; they do not cause the network or individual links to become inoperable but imply that a single transfer was discarded.

Note: To turn off L0 high-speed interconnect link monitoring, use the `xtnetwatch -d` option.

Example 44. Running `xtnetwatch` to monitor the system interconnection network

Sample the network once every 10 seconds using the least verbose display format:

```
crayadm@smw:~> xtnetwatch -i 10
090604 10:50:31  ############  ####  ############  ######  ###########  ###########  ###########
090604 10:50:31                Port  Remote        Remote  Recoverable  Send or Rcv
090604 10:50:31  Node ID       Num   Node ID       Port    Rcv Errs     Fatal Errs   Router Errs
090604 10:50:31  ############  ####  ############  ######  ###########  ###########  ###########
090604 10:50:31  c4-0c2s4s3    5     c4-0c2s4s2    0       1            0            0
090604 10:51:31  c4-0c2s4s3    5     c4-0c2s4s2    0       1            0            0
090604 10:51:41  c4-0c2s4s3    5     c4-0c2s4s2    0       2            0            0
090604 10:51:51  c4-0c2s4s3    5     c4-0c2s4s2    0       1            0            0
090604 10:52:11  c4-0c2s4s3    5     c4-0c2s4s2    0       1            0            0
090604 10:52:21  c4-0c2s4s3    5     c4-0c2s4s2    0       2            0            0
090604 10:52:31  c4-0c2s4s3    5     c4-0c2s4s2    0       1            0            0
...
```

For more information, see the `xtnetwatch`(8) man page.

4.12 Monitoring the Status of Jobs Started Under a Third-party Batch System

To monitor the status of jobs that were started under a third-party batch system, use the command appropriate to your batch system. For more information, see the documentation provided by your batch system vendor.

4.13 Listing Running Jobs

Deprecated: The `xtps` command is deprecated and will be removed in a future release.

The `xtps` command enables you to list the jobs running on a class of service nodes. You must have login without a password enabled between nodes. For more information, see the `xtps`(1) man page.

4.14 Using the `cray_pam` Module to Monitor Failed Login Attempts

The `cray_pam` module is a Pluggable Authentication Module (PAM). When configured, the `cray_pam` module provides information to the user at login time about any failed login attempts since their last successful login. See Using the `cray_pam` PAM to Log Failed Login Attempts on page 148 and the procedure to configure the `cray_pam` module, Procedure 32 on page 149.

4.15 Monitoring DDN RAID

Use Data Direct Networks tools to monitor DDN RAID. These can be accessed by telnetting to the RAID device from the SMW. To configure remote logging of DDN messages, see the *Cray System Management Workstation (SMW) Software Installation Guide*. For additional information, see your DDN documentation.

4.16 Monitoring LSI Engenio RAID

Use Engenio tools to monitor Engenio RAID. The LSI Engenio storage system uses SNMP to provide boot RAID messages. For additional information, see your LSI Engenio Storage System documentation.

4.17 Monitoring HSS Managers

This section provides procedures to view active sessions and to check whether the diagnostic manager, the power manager, or the L0 or L1 controller daemons are running.

4.17.1 Examining Activity on HSS Managers

Use the HSS `xtcli session show` command to examine sessions in the boot, diagnostic, or power manager. A session corresponds to running a specific command such as `xtcli power up` or `xtcli boot`. This command reports on sessions, not daemons.

Example 45. Looking at a session running on the power manager

Execute the HSS `xtcli session show` command to view the session running on the power manager:

```
crayadm@smw:~> xtcli session show PM
```

For more information about manager sessions, see the `xtcli`(8) man page.

4.17.2 Checking the Health of HSS Managers

Use the HSS `xtalive` command to check whether the diagnostic manager, the power manager, or the L0 or L1 controller daemons are running.

Example 46. Checking the power manager

```
crayadm@smw:~> xtalive -l smw -a pm s0
```

For more information, see the `xtalive`(8) man page.

4.18 Monitoring Events

The HSS `xtconsumer` command enables you to monitor events mediated by the event router daemon `erd`, which runs passively.

Example 47. Monitoring for specific events

This command shows watching two events: `ec_heartbeat_stop`, which will be sent if either the node stops sending heartbeats or if the system interconnection network ASIC stops sending heartbeats, and `ec_l0_health`, which will be sent if any of the subcomponents of a L0 report a bad health indication.

```
crayadm@smw:~> xtconsumer -b ec_heartbeat_stop ec_l0_health
```

Example 48. Checking events except heartbeat:

To display all events except heartbeats:

```
crayadm@smw:~> xtconsumer -x ec_l1_heartbeat
```

For Cray systems with the Cray SeaStar based system interconnection network (Cray XT systems): If `xtconsumer` indicates a stopped heartbeat, use the `xtfwstat` and `xtfwlog` commands to investigate what has occurred.

Use the `xthb` command to confirm the stopped heartbeat. Use the `xthb` command only when you are actively looking into a known problem because it is intrusive and degrades system performance.

For more information, see the `xtconsumer`(8), `xtfwlog`(8), `xtfwstat`(8) and `xthb`(8) man pages.

4.19 Monitoring Node Console Messages

Use the HSS `xtconsole` command to monitor and display console messages of a specific node. The command can monitor a single node or multiple nodes.

Example 49. Obtaining node console messages

To view the console output of node `c30-0c0s0n0`, type:

```
crayadm@smw:~> xtconsole c30-0c0s0n0
```

To view the console output from all nodes, use the `xtconsole -a` command. Using the `xtconsole -at` command adds a timestamp as a prefix to the line (use `-t` to show the current time as the prefix. Use `-t -t` to show the current date and current time as the prefix):

```
crayadm@smw:~> xtconsole -at
[11:25:47][c0-0c0s2n0]LDISKFS-fs warning: maximal mount count reached, running e2fsck is recommended
[11:25:47][c0-0c0s2n3]LDISKFS-fs warning: maximal mount count reached, running e2fsck is recommended
[11:25:47][c0-0c0s2n3]LDISKFS-fs warning: maximal mount count reached, running e2fsck is recommended
[11:25:47][c0-0c0s2n0]LDISKFS-fs warning: maximal mount count reached, running e2fsck is recommended
[11:25:47][c0-0c0s2n0]LDISKFS-fs: file extents enabled
[11:25:47][c0-0c0s2n0]LDISKFS-fs: mballoc enabled
[11:25:47][c0-0c0s2n3]LDISKFS-fs warning: maximal mount count reached, running e2fsck is recommended
[11:25:47][c0-0c0s2n3]LDISKFS-fs: file extents enabled
[11:25:47][c0-0c0s2n3]LDISKFS-fs: mballoc enabled
[11:25:47][c0-0c0s2n3]LDISKFS-fs warning: maximal mount count reached, running e2fsck is recommended
[11:25:47][c0-0c0s2n3]LDISKFS-fs: file extents enabled
[11:25:47][c0-0c0s2n3]LDISKFS-fs: mballoc enabled
[11:25:47][c0-0c0s2n0]LDISKFS-fs: file extents enabled
[11:25:48][c0-0c0s2n0]LDISKFS-fs: mballoc enabled
[11:25:48][c0-0c0s2n0]LDISKFS-fs warning: maximal mount count reached, running e2fsck is recommended
[11:25:48][c0-0c0s2n0]LDISKFS-fs warning: maximal mount count reached, running e2fsck is recommended
[11:25:48][c0-0c0s2n0]LDISKFS-fs: file extents enabled
...
```

For more information, see the `xtconsole`(8) man page.

4.20 Showing the Component Alert, Warning, and Location History

Use the `xtcli comp_hist` command to display the component alert, warning, and location history. Either an error history, which displays alerts or warnings found on designated components, or a location history may be displayed.

Procedure 18. Displaying the location history for component `c0-0c0s0n0`

- Type:

```
crayadm@smw:~> xtcli comp_hist -o loc c0-0c0s0n0
```

For more information, see the `xtcli`(8) man page.

4.21 Displaying Component Information

Use the HSS `xtshow` command to identify compute and service components. Commands are typed as `xtshow --`*option_name*. You can also combine the `--service` or `--compute` option with other `xtshow` options to limit your selection to the specified type of node.

Example 50. Identifying all service nodes

```
crayadm@smw:~> xtshow --service
L1s ...
L0s ...
       c0-0c0s0: service         OP|      enable:       ready   [noflags|]
       c0-0c0s1: service         OP|      enable:       ready   [noflags|]
       c0-0c0s2: service         OP|      enable:       ready   [noflags|]
Nodes ...
     c0-0c0s0n0: service         OP|      enable:       ready   [noflags|]
     c0-0c0s0n1: service         OP|       empty:         off   [noflags|]
     c0-0c0s0n2: service         OP|       empty:         off   [noflags|]
     c0-0c0s0n3: service         OP|      enable:       ready   [noflags|]
     c0-0c0s1n0: service         OP|      enable:       ready   [noflags|]
     c0-0c0s1n1: service         OP|       empty:         off   [noflags|]
     c0-0c0s1n2: service         OP|       empty:         off   [noflags|]
     c0-0c0s1n3: service         OP|      enable:       ready   [noflags|]
     c0-0c0s2n0: service         OP|      enable:       ready   [noflags|]
     c0-0c0s2n1: service         OP|       empty:         off   [noflags|]
     c0-0c0s2n2: service         OP|       empty:         off   [noflags|]
     c0-0c0s2n3: service         OP|      enable:       ready   [noflags|]
SeaStars ...
     c0-0c0s0s0: service         OP|      enable:       ready   [noflags|]
     c0-0c0s0s1: service         OP|      enable:       ready   [noflags|]
     c0-0c0s0s2: service         OP|      enable:       ready   [noflags|]
     c0-0c0s0s3: service         OP|      enable:       ready   [noflags|]
     c0-0c0s1s0: service         OP|      enable:       ready   [noflags|]
     c0-0c0s1s1: service         OP|      enable:       ready   [noflags|]
     c0-0c0s1s2: service         OP|      enable:       ready   [noflags|]
     c0-0c0s1s3: service         OP|      enable:       ready   [noflags|]
     c0-0c0s2s0: service         OP|      enable:       ready   [noflags|]
     c0-0c0s2s1: service         OP|      enable:       ready   [noflags|]
     c0-0c0s2s2: service         OP|      enable:       ready   [noflags|]
     c0-0c0s2s3: service         OP|      enable:       ready   [noflags|]
Links ...
crayadm@smw:~>
```

Example 51. Showing compute nodes in the DISABLED state

```
crayadm@smw:~> xtshow --compute --disabled
L1s ...
L0s ...
Nodes ...
   c0-0c0s7n0:    -|  disabled  [noflags|]
SeaStars ...
Links ...
  c1-0c2s1s1l1:    -|  disabled  [noflags|]
```

4.22 Displaying Alerts and Warnings

Use the `xtshow` command to display alerts and warnings. Type commands as `xtshow --`*option_name*, where *option_name* is `alert`, `warn`, or `noflags`.

Note: Alerts are not propagated through the system hierarchy, so you only receive information for the component you are examining. A node can have an alert, but you would not see it if you ran the `xtshow --alert` command for a cabinet. In a similar fashion, you would not detect an alert on a cabinet if you checked the status of a node.

Alerts and warnings typically occur while the HSS `xtcli` command operates; these alerts and warnings are listed in the command output with an error message. After they are generated, alerts and warnings become part of the state for the component and remain set until you manually clear them. For example, the temporary loss of a heartbeat by the L0 controller may set a warning state on a chip.

4.23 Clearing Flags

Use the `xtclear` command to clear system information for components you select. Type commands as `xtclear --`*option_name*, where *option_name* is `alert`, `reserve`, or `warn`.

You must clear alerts, reserves, and warnings before a component can operate. Clearing an alert on a component frees its state so that subsequent commands can execute (see Appendix B, System States on page 333).

For more information, see the `xtclear`(8) man page.

Managing User Access [5]

For a description of administrator accounts that enable you to access the functions described in this chapter, see Administering Accounts on page 113.

5.1 Load Balancing Across Login Nodes

Having all users log on to the same login node may overload the node. (Also see Caution in Login Nodes on page 40.) For typical interactive usage, a single login node is expected to handle 20 to 30 batch users or 20 to 40 interactive users with double this number of user processes. You can use the `lbnamed` load-balancing software to distribute logins to different login nodes. The `lbnamed` daemon is a name server that gathers the output of `lbcd` client daemons to select the least loaded node, provides DNS-like responses, interacts with the corporate DNS server, and directs the user login request to the least busy login node.

Because `lbnamed` runs on the SMW, `eth0` on the SMW must be connected to the same network from which users log on the login nodes.

Note: If security considerations do not allow you to put the SMW on the public network, `lbnamed` may be installed on an external server. This can be any type of computer running the SUSE Linux Enterprise Server (SLES) operating system (not a 32-bit system). However, this option is not a tested or supported Cray configuration.

The behavior of the `lbnamed` daemon is site-configurable and determined by the contents of the `/etc/opt/cray-xt-lbnamed/lbnamed.conf` and `/etc/opt/cray-xt-lbnamed/poller.conf` configuration files. For details about configuring the load balancer, see Configuring the Load Balancer on page 155, and the `lbcd`(8), `lbnamed`(8), and `lbnamed.conf`(5) man pages.

5.2 Passwords

The default passwords for the `root` and `crayadm` accounts are the same for the System Management Workstation (SMW), the boot node, and the shared root.

Default passwords for the `root` and `crayadm` accounts are provided in the *Installing and Configuring Cray Linux Environment (CLE) Software*. Also, default MySQL passwords and an example of how to change them are provided in the *Installing and Configuring Cray Linux Environment (CLE) Software*. Cray recommends changing these default passwords as part of the software installation process.

5.2.1 Changing Default SMW Passwords After Completing Installation

After completing the installation, change the default SMW passwords. The SMW contains its own `/etc/passwd` file that is separate from the password file for the rest of the system. To change the passwords on the SMW:

```
smw:~# passwd root
smw:~# passwd crayadm
smw:~# passwd cray-vnc
smw:~# passwd mysql
```

5.2.2 Changing `root` and `crayadm` Passwords on Boot and Service Nodes

For security purposes, it is desirable to change the passwords for the `root` and `crayadm` accounts on a regular basis.

Use the Linux `passwd` command to change the `/etc/passwd` file. For information about using the `passwd` command, see the `passwd`(1) man page.

Procedure 19. Changing the `root` and `crayadm` passwords on boot and service nodes

1. The boot node contains its own `/etc/passwd` file that is separate from the password file for the rest of the system. To change the passwords on the boot node, use these commands. You will be prompted to type and confirm new root and administrative passwords.

   ```
   boot:~ # passwd root
   boot:~ # passwd crayadm
   ```

2. To change the passwords on the other service nodes, you must run these commands on the shared root. Again, you will be prompted to type and confirm new passwords for the `root` and `crayadm` accounts.

   Note: If the SDB node is not started, you must use the `xtopview -x /etc/opt/cray/sdb/node_classes` command when using the `xtopview` command in this procedure.

   ```
   boot:~ # xtopview
   default/:/ # passwd root
   default/:/ # passwd crayadm
   default/:/ # exit
   ```

For more information about using the `xtopview` command, see Managing System Configuration with the `xtopview` Tool on page 129, and the `xtopview`(8) man page.

5.2.3 Changing the `root` Password on CNL Compute Nodes

Procedure 20. Changing the `root` password on CNL compute nodes

For CNL compute nodes, update the `root` account password in the `/opt/xt-images/templates/default/etc/shadow` file on the SMW.

> **Note:** To make these changes for a system partition, rather than for the entire system, replace `/opt/xt-images/templates` with `/opt/xt-images/templates-p`*N*, where *N* is the partition number.

1. Copy the master password file to the template directory.

   ```
   smw:~ # cp /opt/xt-images/master/default/etc/shadow \
   /opt/xt-images/templates/default/etc/shadow
   ```

2. Edit the password file to include a new encrypted password for the `root` account.

   ```
   smw:~ # vi /opt/xt-images/templates/default/etc/shadow
   ```

3. After making these changes, update the boot image by following the steps in Procedure 2 on page 68.

5.2.4 Changing Default MySQL Passwords on the SDB

Procedure 21. Changing default MySQL passwords on the SDB

For security, you should change the default passwords for MySQL database accounts.

1. If you have not set a site-specific MySQL password for root, type the following commands. Press the `Enter` key when prompted for a password.

```
boot:~ # ssh root@sdb
sdb:~ # mysql -h sdb -u root -p
Enter password:
Welcome to the MySQL monitor.  Commands end with ; or \g.
Your MySQL connection id is 4
Server version: 5.0.64-enterprise MySQL Enterprise Server (Commercial)

Type 'help;' or '\h' for help. Type '\c' to clear the buffer.
mysql> set password for 'root'@'localhost' = password('newpassword');
Query OK, 0 rows affected (0.00 sec)
mysql> set password for 'root'@'%' = password('newpassword');
Query OK, 0 rows affected (0.00 sec)
mysql> set password for 'root'@'sdb' = password('newpassword');
Query OK, 0 rows affected (0.00 sec)
```

2. **(Optional)** Set a site-specific password for other MySQL database accounts.

   a. To change the password for the `sys_mgmt` account, type the following MySQL command. You must also update `.my.cnf` in step 4.

```
mysql> set password for 'sys_mgmt'@'%' = password('newpassword');
Query OK, 0 rows affected (0.00 sec)
```

   b. To change the password for the `basic` account, type the following MySQL command. You must also update `/etc/opt/cray/MySQL/my.cnf` in step 5.

```
mysql> set password for 'basic'@'%' = password('newpassword');
Query OK, 0 rows affected (0.00 sec)
```

   c. To change the password for the `mazama` account, type the following MySQL commands. You must also update `/etc/sysconfig/mazama` in step 6.

```
mysql> set password for 'mazama'@'%' = password('newpassword');
Query OK, 0 rows affected (0.00 sec)
mysql> set password for 'mazama'@'localhost' = password('newpassword');
Query OK, 0 rows affected (0.00 sec)
```

Note: When making changes to the MySQL database, your connection may time out; however, it will be automatically reconnected. If this happens, you will see messages similar to the following. These messages may be ignored.

```
ERROR 2006 (HY000): MySQL server has gone away
No connection. Trying to reconnect...
Connection id:    21127
Current database: *** NONE ***

Query OK, 0 rows affected (0.00 sec)
```

3. Exit from MySQL and the SDB.

```
mysql> exit
Bye
sdb:~ # exit
boot:~ #
```

4. **(Optional)** If you set a site-specific password for `sys_mgmt` in step 2, update the `.my.cnf` file for root with the new password.

   a. Edit `.my.cnf` for root on the boot node.

   ```
   boot:~ # cd ~root
   boot:~ # vi .my.cnf
   [client]
   user=sys_mgmt
   password=newpassword
   ```

   b. Edit `.my.cnf` for root in the shared root.

   ```
   boot:~ # xtopview
   default/:/ # vi /root/.my.cnf
   [client]
   user=sys_mgmt
   password=newpassword
   default/:/ # exit
   boot:~ #
   ```

5. **(Optional)** If you set a site-specific password for `basic` in step 2, update the `/etc/opt/cray/MySQL/my.cnf` file with the new password.

   a. Edit `/etc/opt/cray/MySQL/my.cnf` on the boot node.

   ```
   boot:~ # vi /etc/opt/cray/MySQL/my.cnf
   # The following options will be passed to all MySQL clients
   [client]
   user=basic
   password=newpassword
   ```

   b. Edit `/etc/opt/cray/MySQL/my.cnf` in the shared root.

   ```
   boot:~ # xtopview
   default/:/ # vi /etc/opt/cray/MySQL/my.cnf
   # The following options will be passed to all MySQL clients
   [client]
   user=basic
   password=newpassword
   default/:/ # exit
   boot:~ #
   ```

6. **(Optional)** If you set a site-specific password for `mazama` in step 2, update the `/etc/sysconfig/mazama` file with the new password. In addition, update the `mazama` MySQL account on the SMW to match.

   a. Edit `/etc/sysconfig/mazama` on the boot node.

   ```
   boot:~ # vi /etc/sysconfig/mazama
   ## Type:                  string
   ## Default:               mazama
   ## Config:                ""
   #
   # Default password for mazama user in the mazama database
   #
   passwd=newpassword
   ```

b. Edit `/etc/sysconfig/mazama` in the shared root.

```
boot:~ # xtopview
default/:/ # vi /etc/sysconfig/mazama
## Type:                string
## Default:             mazama
## Config:              ""
#
# Default password for mazama user in the mazama database
#
passwd=newpassword
default/:/ # exit
boot:~ #
```

c. To change the password for the MySQL accounts on the SMW, type the following MySQL commands.

```
boot:~ # exit
smw:~# mysql -u root -p
mysql> set password for 'mazama'@'%' = password('newpassword');
mysql> set password for 'mazama'@'localhost' = password('newpassword');
mysql> set password for 'mazama'@'smw' = password('newpassword');
mysql> exit
```

d. Update `/etc/sysconfig/mazama` on the SMW.

```
smw:~# vi /etc/sysconfig/mazama
## Type:                string
## Default:             mazama
## Config:              ""
#
# Default password for mazama user in the mazama database
#
passwd=newpassword
```

Make the following additional change, unless you are using a remote MySQL server for CMS logs.

```
## Type:                string
## Default:             mazama
# Default password for mazama user in the mazama Log database
#
log_passwd=newpassword
```

5.2.5 Assigning and Changing User Passwords

Because a Cray system has a read-only shared-root configuration, users cannot execute the `passwd` command on a Cray system to change their password. If your site has an external authentication service such as Kerberos or LDAP, users should follow your site instructions to update their passwords. If your site does not have external authentication set up, you can implement a manual mechanism, such as having users change their password on an external system and you periodically copying their entries in the external `/etc/passwd`, `/etc/shadow`, and `/etc/group` files to the equivalent Cray system files in the default `xtopview`.

Warning: Be careful to not overwrite Cray system accounts (`crayadm`, `cray_vnc` and standard Linux accounts such as `root`) in the `/etc/passwd`, `/etc/shadow`, and `/etc/group` files.

5.2.6 Logins That Do Not Require Passwords

All logins must have passwords; however, you can set up passwordless `ssh` by creating an `ssh` key with a null passphrase and distributing that `ssh` key to another computer.

While the key-based authentication systems such as OpenSSH are relatively secure, convenience and security are often mutually exclusive. Setting up passphrase-less `ssh` is convenient, but the security ramifications can be dire; if the local host is compromised, access to the remote host will be compromised as well.

If you wish to use passphrase-less authentication, Cray encourages you to consider using `ssh-agent` if available, or take other steps to mitigate risk.

5.3 Administering Accounts

Your Cray system supports several types of accounts:

- Boot node accounts allow only system administrator (`crayadm`) and superuser (`root`) access.
- Service accounts are present on all service nodes.
- User accounts are available on all service nodes.
- Accounts on the SMW are managed by SMW local files. Only system administrators (`crayadm`) and superuser (`root`) can access these accounts.
- Cray provides a Virtual Network Computing (VNC) account on the SMW (for details, see Appendix D, Remote Access to the SMW on page 347).

5.3.1 Managing Boot Node Accounts

The only accounts that are supported on the boot node are `root` (superuser), `crayadm` (administrator), and those for various services such as network time protocol (NTP). The boot node does not support user accounts.

The boot node has an `/etc/passwd` file that is separate from the password file for the rest of the system. For a list of default passwords, see *Installing and Configuring Cray Linux Environment (CLE) Software*.

To modify configuration files, the administrator must become superuser by supplying the `root` account password. It is recommended that sites configure and use `sudo` rather than routinely use root direct login to administrate systems.

5.3.2 Managing User Accounts on Service Nodes

User accounts are set up on the shared-root file system by using the `xtopview` command. Your Cray system supports 16-bit and 32-bit user IDs (UIDs). The 16-bit user IDs run 0-65535; that is 0-(2^{16}-1). The 32-bit user IDs run 0-(2^{32}-1), although Cray systems are limited to a maximum of 65,536 user accounts, including those that are predefined, such as `root`, `crayadm`, and `mysql`.

For more information about using the `xtopview` command, see Managing System Configuration with the `xtopview` Tool on page 129, and the `xtopview`(8) man page. For more information about `mysql` accounts, see Database Security on page 185.

5.3.2.1 Adding a User or Group

To add additional accounts to the shared root for login nodes, use the `groupadd` and `useradd` commands using the `xtopview login` class.

Example 52. Adding a group

To add the group `xtusers` with a gid of `5605`, type:

```
boot:~ # xtopview -c login
class/login/:/ # groupadd -g 5605 xtusers
class/login/:/ # exit
```

The above `groupadd` command adds group `xtusers` to `/etc/group`.

Example 53. Adding a user account

This example adds a new user `bobp` to the group `xtusers`. The new user account, `bobp`, has a user ID of 12645, a home directory `bobp`, and runs a `/bin/bash` login shell. Then, as `root`, create the user's home directory and `chown` the directory to the new user.

```
boot:~ # xtopview -c login
class/login/:/ # useradd -d /home/users/bobp -g 5605 -s /bin/bash -u 12645 bobp
class/login/:/ # exit
boot:~ # ssh root@login
login:~ # mkdir -p /home/bobp
login:~ # chown -R bobp:xtusers /home/bobp
```

After the account is created, use the `passwd` command to set a password in either `/etc/passwd` or `/etc/shadow`.

For more information, see the `useradd`(8), `passwd`(1), and `groupadd`(8) man pages.

5.3.2.2 Removing a User or Group

To remove a user account, first remove all files, jobs, and other references to the user. You remove users and groups by using Linux commands `/usr/sbin/userdel` and `/usr/sbin/groupdel`, respectively.

Example 54. Removing a user account

To remove the user `bobp` and the user's home directory, type:

```
boot:~ # xtopview -c login
class/login:/ # userdel -r bobp
class/login:/ # exit
boot:~ # ssh root@login
login:~ # rm -rf /home/bobp
login:~ # exit
```

For more information, see the `userdel`(8) and `groupdel`(8) man pages.

5.3.2.3 Changing User or Group Information

To change user and group information, use Linux commands. For more information, see the `usermod`(8) and `groupmod`(8) man pages.

5.3.2.4 Assigning Groups of Compute Nodes to a User Group

Use the `/etc/opt/cray/sdb/attr.defaults` file `label` attribute to assign groups of compute nodes to specific user groups without the need to partition the system. For more information, see Setting Node Attributes Using the `/etc/opt/cray/sdb/attr.xthwinv` and `/etc/opt/cray/sdb/attr.defaults` Files on page 192.

5.3.3 Setting Disk Quotas for a User on the Cray Local, Non-Lustre File System

The quota RPM is installed by default. You can activate disk quotas for a user on service nodes on the Cray local, non-Lustre file system. You must activate two boot scripts, as discussed in the SLES README file located in `/usr/share/doc/packages/quota`.

Note: When following the procedure in the SLES README file, use the `chkconfig` command instead of the Yast2 run level editor to turn on `quota` and `quotad` services; execute these `chkconfig` commands from `xtopview` in the default view:

```
boot:~ # xtopview
default/:/ # chkconfig boot.quota on
default/:/ # chkconfig quotad on
default/:/ # exit
```

After the quota tools have been installed, for each user you can use standard Linux quota commands to do the following:

- Enable quotas (`quotaon` command)
- Check quotas (`quotacheck` command)
- Set quotas (`edquota` command)

When a quota is exceeded, the quotas subsystem warns users when they exceed their allotted limit, but it allows some extra space for current work (that is, there is a hard limit and a soft limit).

For more information, see the `quotaon`(8), `quotacheck`(8), and `edquota`(8) Linux commands.

5.3.4 Associating Users with Projects

You can assign project names for users to submit jobs in order to determine project charges. Project names can be up to 80 characters long.

To associate users with project names, add the following line to their individual login scripts in their home directories:

`set_account` *a_project_name*

After accounts are set, users do not have to manually run the `set_account` command at each login.

If your users run batch jobs, they can set a project code; for example, when using PBS Professional, a user can set a project code with the `ENVIRONMENT` variable. This associates the project code with the job in the accounting database. For more information, see the documentation provided by your batch system vendor.

5.4 System-wide Default Modulefiles

The `Base-opts` modulefile loads two lists of module files: a default list and a site-specified local list.

The default list differs between the SMW and the Cray system. On the SMW, the file `/etc/opt/cray/modules/Base-opts.default.SMW` contains the list of the CLE module files to load by default. On the Cray system, the file `/etc/opt/cray/modules/Base-opts.default` contains the list of CLE module files to load by default.

Additionally, all the module files listed in the file `/etc/opt/cray/modules/Base-opts.default.local` are loaded. Edit this file to make your site-specific changes.

The `/etc/opt/cray/modules/Base-opts.default.local` file initially includes the `admin-modules` module file, which loads a full set of module files. You do not need to manually load the `admin-modules` module file, unless the you have removed it from the default list. The CLE installation process removes `admin-modules` module file from the default list on login nodes.

An example file, `/etc/opt/cray/modules/Base-opts.default.local.example`, is also provided. The example file is a copy of the `/etc/opt/cray/modules/Base-opts.default.local` file provided for an initial installation.

5.5 User Access to a Compiler Environment Using Modulefiles

The Modules software utility enables your users to modify their environment dynamically by using *modulefiles*; modulefiles are metafiles containing Tool Command Language (Tcl) code that is interpreted by the Modules software utility.

Each modulefile contains the information needed to configure the shell for an application. After the Modules software utility is initialized, users can modify the environment on a per-module basis using the `module` command, which interprets modulefiles. Typically, modulefiles instruct the `module` command to alter or set shell environment variables such as `PATH`, `MANPATH`, and others. The modulefile can be shared by many users on a system, and users can have their own collection to supplement or replace the shared modulefiles.

The Cray, PGI, GCC, PathScale, and Intel compilers are available to users through the `PrgEnv-cray`, `PrgEnv-pgi`, `PrgEnv-gnu`, `PrgEnv-pathscale`, and `PrgEnv-intel` modulefiles, respectively.

The modulefile, `Base-opts` loads the OS modules in a versioned set that is provided with the CLE release. A user can have only one environment loaded at a time; however, users can add and remove modulefiles from their current environments.

Before beginning to compile programs, the user must verify that the target architecture is set correctly. The target architecture is used by the compilers and linker in creating executables to run on compute nodes. (The target architecture is not necessarily the kernel currently running on compute nodes; as the system administrator, at boot time, you determine the compute node kernel that will run.)

The CNL target is defined automatically at login. If any compute node is running CNL, the target module `xtpe-target-cnl` is loaded and the `XTPE_COMPILE_TARGET` environment is set to `linux`.

To support customer-specific needs, you can create your own modulefiles for a product set for your users; for details, see Appendix F, Creating Modulefiles on page 355.

For more information about the Modules software package, see the `module`(1) and `modulefile`(4) man pages.

5.6 Maintaining `*rc.local` Scripts

The `prgenv` RPM adds a section to the `/etc/bash.bashrc.local` and `/etc/csh.cshrc.local` scripts, which set default modulefiles to be loaded. `##BEGIN` and `##END` tags delimit the contents of this section. These scripts have clearly delimited sections for operating system changes. A CLE upgrade modifies these sections in place, maintaining any local changes you have made outside of the delimited block and, more importantly, the order of the blocks within the file.

5.7 Using the `pam_listfile` Module in the Shared Root Environment

The Linux `pam_listfile` Pluggable Authentication Module (PAM) may be used to maintain a list of authorized users. Using the `pam_listfile` PAM may also help to reduce impacts on service nodes if users consume too many resources (see Caution in Login Nodes on page 40).

The `pam_listfile` PAM requires that the file specified with the `file=` parameter be a regular file. The usual approach of storing the file in the `/etc` directory does not work in the shared-root environment of Cray systems: files in the `/etc` directory are symbolic links, so the required file must be created in a directory other than the `/etc` directory. For example, you can place it in persistent `/var` or another directory that is not controlled by the shared root.

Example 55. Creating a `pam_listfile` list file

This example assumes you have created an empty `pam_listfile` called `/var/../pam_listfile_authorized_users_list`. It adds authorized users to it.

```
boot:~ # xtopview -x /etc/opt/cray/sdb/node_classes -c login
class/login/:# vi /var/../pam_listfile_authorized_users_list

user1
user2
...
```

Example 56. Adding a line to `/etc/pam.d/sshd` to enable `pam_listfile`

Edit the `pam.d/sshd` file to include an alternative path for `file=`.

```
class/login/:#  vi /etc/pam.d/sshd

auth required pam_listfile.so \
file=/var/.../pam_listfile_authorized_users_list
```

If you need nodes to have different `pam_listfile` list files, create the list files and specialize the PAM configuration files (such as `pam.d/sshd`) to point to them.

5.8 `ulimit` Stack Size Limit

The login environment defaults to the kernel default stack size limit. To set up the default user environment to have an unlimited stack size resource limit, add the following to `/etc/profile.local` in the shared root:

```
ulimit -Ss unlimited
```

5.9 Stopping a User's Job

This section describes how to stop a user's job.

5.9.1 Stopping a CNL Job Running in Interactive Mode

If the job is running on a CNL compute node in interactive mode (through `aprun`), perform the following procedure.

Procedure 22. Stopping a CNL job running in interactive mode

- Use the `apkill -`*signal apid* command to send a signal to all processes that are part of the specified application (*apid*); signal 15 (`SIGTERM`) is sent by default.

The signaled application must belong to the current user unless the user is a privileged user. For more information, see the `aprun`(1) and `apkill`(1) man pages.

5.9.2 Stopping a Job Running Under a Batch System

To stop a job that is running under a batch system, see the documentation provided by your batch system vendor.

Example 57. Stopping a job running under PBS Professional

If the job is running under PBS Professional, use the `qdel` command and name the job.

To terminate job 104, type:

```
% qdel 104
```

Modifying an Installed System [6]

6.1 PBS Professional Licensing Requirements for Cray Systems

The licensing scheme for PBS Professional is based on FLEXnet and uses a central license server to allow licenses to float between servers. The PBS server and scheduler are run on the service database (SDB) node, therefore, network connectivity must exist between the FLEXnet license server and the SDB node. For information about network configuration options for PBS, see Appendix G, PBS Professional Licensing for Cray Systems on page 359.

6.2 Disabling Secure Shell (SSH) on Compute Nodes

By default, the SSH daemon, `sshd`, is enabled on compute nodes. To disable `sshd` follow this procedure.

Procedure 23. Disabling SSH daemon (sshd) on compute nodes

1. Edit the `shell_bootimage_`*label*`.sh` script used to prepare boot images for the system set with the specified *label*; *label* the system set in `/etc/sysset.conf` where your CLE release is installed.

   ```
   smw:~ # vi /var/opt/cray/install/shell_bootimage_label.sh
   ```

2. Locate this section:

   ```
   # install rpms into service clone
   ```

   Add these lines immediately **before** the above comment line:

```
if [[ -f /opt/xt-images/${BOOTIMAGE}/compute/etc/init.d/rc3.d/S12sshd ]]; then
        rm  /opt/xt-images/${BOOTIMAGE}/compute/etc/init.d/rc3.d/S12sshd
        STATUS=$?
        test ${STATUS} != 0 && abort "Removing link for SSH on compute node"
fi
# install rpms into service clone
```

3. Run the `shell_bootimage_`*label*`.sh` script.

   ```
   smw:~ # /var/opt/cray/install/shell_bootimage_label.sh
   ```

4. Execute the `xtbootimg` and `xtcli boot_cfg` commands that are suggested by the script.

```
smw:~ # xtbootimg -L /opt/xt-images/xthostname-xtversion/compute/CNL0.load
-L /opt/xt-images/xthostname-xtversion/service/SNL0.load -c /raw1
smw:~ # xtcli boot_cfg update -i /raw1
```

6.3 Modifying SSH Keys for Compute Nodes

The `dropbear` RPM is provided with the CLE release. Using `dropbear` SSH software, you can supply and generate site-specific SSH keys for compute nodes in place of the keys provided by Cray.

Procedure 24. Using `dropbear` to generate site-specific SSH keys

Follow these steps to replace the RSA and DSA/DSS keys provided by the `CLEinstall` program.

1. Load the `dropbear` module.

   ```
   crayadm@smw:~> module load dropbear
   ```

2. Create a directory for the new keys on the SMW.

   ```
   crayadm@smw:~> mkdir dropbear_ssh_keys
   crayadm@smw:~> cd dropbear_ssh_keys
   ```

3. To generate a dropbear-compatible RSA Key, type:

```
crayadm@smw:~/dropbear_ssh_keys> dropbearkey -t rsa -f ssh_host_rsa_key.db
Will output 1024 bit rsa secret key to 'ssh_host_rsa_key.db'
Generating key, this may take a while...
Public key portion is:
ssh-rsa AAAAB3NzaC1yc2EAAAADAQABAAAAgwCQ9ohUgsrrBw5GNk7w2H5RcaBGajmUv8XN6fxg/YqrsL4t5
CIkNghI3DQDxoiuC/ZVIJCtdwZLQJe708eiZee/tg5y2g8JIb3stg+ol/9BLPDLMeX24FBhCweUpfGCO6Jfm4
Xg4wjKJIGrcmtDJAYoCRj0h9IrdDXXjpS7eI4M9XYZ
Fingerprint: md5 00:9f:8e:65:43:6d:7c:c3:f9:16:48:7d:d0:dd:40:b7
crayadm@smw:~/dropbear_ssh_keys>
```

   To generate a dropbear-compatible DSS Key, type:

```
crayadm@smw:~/dropbear_ssh_keys> dropbearkey -t dss -f ssh_host_dss_key.db
Will output 1024 bit dss secret key to 'ssh_host_dss_key.db'
Generating key, this may take a while...
Public key portion is:
ssh-dss AAAAB3NzaC1kc3MAAACBAMEkThlE9N8iczLpfg0wUtuPtPcpIs7Y4KbG3Wg1T4CAEXDnfMCKSyuCy
21TMAvVGCvYd80zPtL04yc1eUtD5RqEKy0h8jSBs0huEvhaJGHx9FzKfGhWi1ZOVX5vG3R+UCOXG+71wZp3LU
yOcv/U+GWhalTWpUDaRU81MPRLW7rnAAAAFQCEqnqW61bouSORQ52d+MRiwp27MwAAAIEAho69yAfGrNzxEI/
kjyDE5IaxjJpIBF262N9UsxleTX6F65OjNoL84fcKqlSL6NV5XJ5O00SKgTuVZjpXO913q9SEhkcI0Zy0vRQ8
H5x3osZZ+Bq20QWof+CtWTqCoWN2xvne0NtET4lg81qCt/KGRq1tY6WG+a01yrvunzQuafQAAACASXvs8h8AA
EK+3TEDj57rBRV4pz5JqWSlUaZStSQ2wJ3Oy1pIJIhKfqGWytv/nSoWnr8YbQbvH9k1BsyQU8sOc5IJyCFu7+
Exom1yrxq/oirfeSgg6xC2rodcs+jH/K8EKoVtTak3/jHQeZWijRok4xDxwHdZ7e3l2HgYbZLmA5Y=
Fingerprint: md5 cd:a0:0b:41:40:79:f9:4a:dd:f9:9b:71:3f:59:54:8b
crayadm@smw:~/dropbear_ssh_keys>
```

4. As root, copy the SSH keys to the boot image template.

   Note: To make these changes for a system partition, rather than for the entire system, replace `/opt/xt-images/templates` with `/opt/xt-images/templates-p`*N*, where *N* is the partition number.

   ```
   crayadm@smw:~/dropbear_ssh_keys> su root
   ```

For the RSA Key:

```
smw:/home/crayadm/dropbear_ssh_keys # cp -p ssh_host_rsa_key.db \
/opt/xt-images/templates/default/etc/ssh/ssh_host_rsa_key
```

For the DSA/DSS Key:

```
smw:/home/crayadm/dropbear_ssh_keys # cp -p ssh_host_dss_key.db \
/opt/xt-images/templates/default/etc/ssh/ssh_host_dss_key
```

5. Update the boot image to include these changes; follow the steps in Procedure 2 on page 68.

6.4 Configuring the System Environmental Data Collector (SEDC)

To configure the System Environmental Data Collector (SEDC), which collects data about internal cabinet temperatures, cooling system air pressures, critical voltages, etc., see *Using and Configuring System Environment Data Collections (SEDC)*.

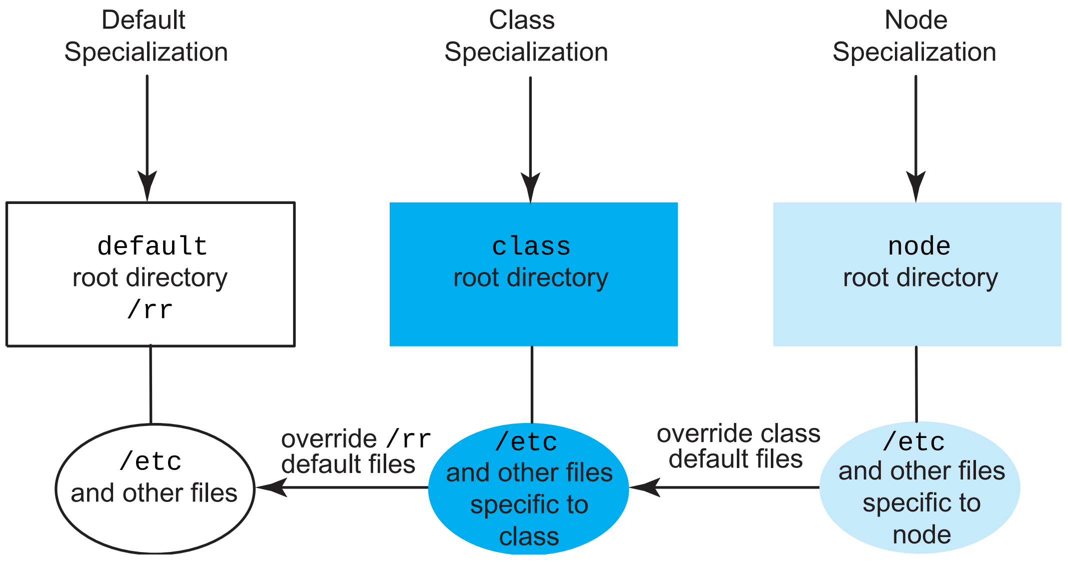
6.5 Configuring the Shared-root File System on Service Nodes

CLE implements a shared-root file system where `/` is exported from the boot node and is mounted as read-only on all service nodes. To overcome the restriction that all nodes must have the same shared-root file system, `/etc` directories can be symbolic links to unique directories that have the same structure as the default `/etc` directory but contain modified files. These node-specific files reside in subdirectories in the `/.shared/base` directory.

Specialization is the process of changing the link to a file in the `/etc` directory to point to a unique file for one, a few, or all nodes. You can specialize one or more files for an individual node or for a class (type) of nodes, such as login. You must be root user to configure the shared-root file system in this manner. You can specialize files when you install the system or at a later time.

The hierarchical structure of the specialized files is shown in Figure 2. Node specialization is more specific than class specialization. Class specialization is more specific than default specialization. Generally, about 98% of the service nodes use the default version of the shared root.

Figure 2. Types of Specialization


Default Specialization
Class Specialization
Node Specialization
default root directory /rr
class root directory
node root directory
/etc and other files
override /rr default files
/etc and other files specific to class
override class default files
/etc and other files specific to node

6.5.1 Specialization

You specialize files when you need to point to a unique version of a file in the `/etc` directory rather than to the standard version of the file that is shared on all nodes. For example, you might specialize files when differences exist in hardware, network configuration, or boot scripts or when there are services that run on a single node. You can also specialize files for a class of nodes that have a particular function, such as login.

Generally, files are specialized as part of the installation process, but the process can be done at any time. It is good practice to enter the `xtopview` shell (see Managing System Configuration with the `xtopview` Tool on page 129) and then specialize your files (see Specializing Files on page 132).

Table 4 lists files and directories that you can specialize by class and the reasons to do so. Table 5 lists files and directories that you can specialize by node and the reasons to do so. In these tables, `*` refers to "wildcard" characters that represent no characters or any number of characters.

Table 4. File Specialization by Class

File or Directory	Reason for Specialization
`/etc/auditd.conf`	Cray Audit configured on login nodes.
`/etc/audit.rules`	Cray Audit configured on login nodes.
`/etc/cron*`	Different classes need custom crontabs.
`/etc/fstab`	I/O nodes need to mount other file systems.
`/etc/hosts.{allow,deny}`	Must restrict logins on login nodes.

File or Directory	Reason for Specialization
`/etc/init.d/boot.d/*`	Different classes have different start-up scripts enabled.
`/etc/init.d/rc*/`	Different classes have different start-up scripts enabled.
`/etc/issue`	Different classes have different messages.
`/etc/modprobe.conf`	I/O and login nodes have different hardware.
`/etc/motd`	Different classes have different messages.
`/etc/pam*`	Authentication is class-specific.
`/etc/profile.d/*`	Login nodes have custom environments.
`/etc/resolv.conf`	Hosts that interact with external servers need special resolver configurations.
`/etc/security/*`	Authorization and system limits are class-specific.
`/etc/sysconfig/network/*`	I/O and login nodes need custom network configuration.

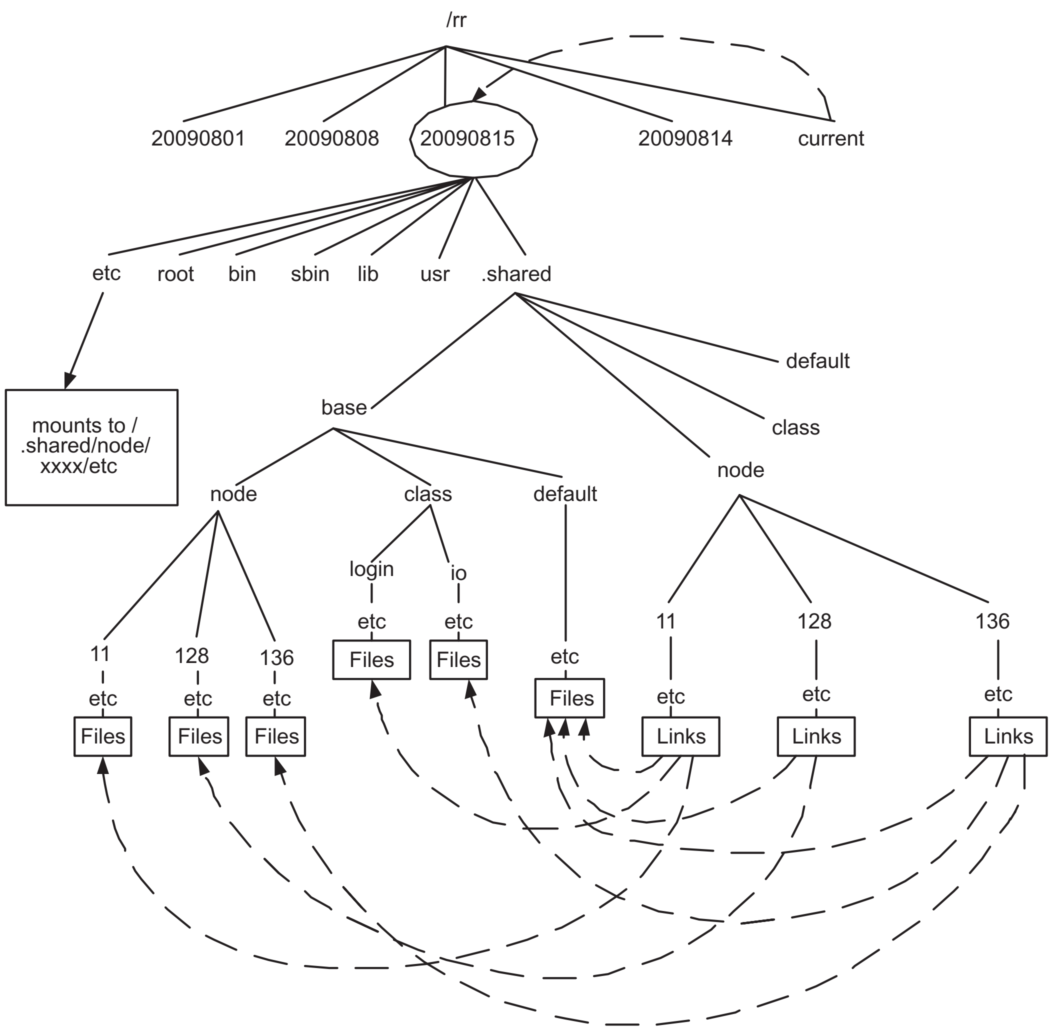
Table 5. File Specialization by Node

File or Directory	Reason for Specialization
`/etc/cron*`	Certain service nodes, such as `sdb` and `syslog`, need custom crontabs.
`/etc/ntp.conf`	A node that runs an NTP server needs a different configuration than NTP clients.
`/etc/sysconfig/network/*`	Each network node should have a different IP address.
`/etc/syslog-ng/syslog-ng.conf.in`	A node that runs a syslog server needs a different configuration than syslog clients.
`/etc/ssh/*key*`	Use when sharing keys across systems is unacceptable.

6.5.2 Visible Shared-root File System Layout

Figure 3 is a detailed illustration of shared-root directory structure. The directory `current` is a subdirectory of `/rr`. The `current` directory links to a time-stamped directory (in this example 20090815). The timestamp indicates the date of the software installation, not the date of the release.

Figure 3. Shared-root Implementation



Service nodes mount the `/rr/current` directory from the boot node as read-only for use as their root file system. The visible file layout, that is, how it appears from the node you are viewing it from, contains the following files:

`/`	Root file system
`/root`	Equivalent to directory of the same name in `/rr/current`
`/bin`	Equivalent to directory of the same name in `/rr/current`
`/lib`	Equivalent to directory of the same name in `/rr/current`
`/sbin`	Equivalent to directory of the same name in `/rr/current`
`/usr`	Equivalent to directory of the same name in `/rr/current`
`/etc`	Contains links to the shared-root files
`/home`	Link to `/ufs/home`, a customer-specific location
`/tmp`	Implemented through the `tmpfs` (in RAM)
`/var`	Directory in the `tmpfs` and RAMFS but populated with skeleton files if you do not have persistent `/var`
`/proc`	Per-node pseudo-file system
`/dev`	Per-node pseudo-file system implemented through the DEVFS
`/ufs`	Mount point for the `/ufs` file system to be mounted from the `ufs` node

6.5.3 How Specialization Is Implemented

The shared-root file system is implemented in the `/.shared` directory. Only the `/etc` directory has been set up for specialization. Files in `/etc` are symbolic links to files in `/.shared/base`. A specialized file is a unique version of the file in the `/.shared/base` directory.

The `/.shared` directory contains four subdirectories: `base`, `node`, `class`, and `default`. The `node`, `class`, and `default` directories are also known as `view` directories, because you can look at the file system (with the `xtopview` command) as if the view directory were `/`.

The `base` subdirectory also contains subdirectories called `node`, `class`, and `default`. These are referred to as `base` directories. They contain files that are specific to a certain node, specific to a class of nodes, or shared as the default among all nodes. Under each of the `base` directories is a rooted directory hierarchy where files are stored.

Example 58. Shared-root links

The path of the link shows the type of specialization for the file.

Default specialization:

```
default/: # ls -la /etc/hosts
lrwxrwxrwx 1 root root 31 Dec 8 17:12 /etc/hosts -> /.shared/base/default/etc/hosts
```

Class specialization:

```
class/login/: # ls -la /etc/security/access.conf
lrwxrwxrwx 1 root root 46 Dec 8 17:14 /etc/security/access.conf -> \
/.shared/base/class/login/etc/security/access.conf
```

Node specialization:

```
node/128/: # ls -la /etc/resolv.conf
lrwxrwxrwx 1 root root 36 Dec 8 17:15 /etc/resolv.conf -> \
/.shared/base/node/128/etc/resolv.conf
```

6.5.4 Working with the Shared-root File System

CLE commands shown in Table 6 control and monitor the shared-root file system. For more information, refer to the sections noted and the related man pages.

Table 6. Shared-root Commands

Command	Function
`xtopview`	View file layout from the specified node (see Managing System Configuration with the `xtopview` Tool on page 129).
`xtopcommit`	Record file specialization before leaving `xtopview` shell (see Updating Specialized Files from within the `xtopview` Shell on page 131).
`xtspec`	Specialize; create a directory structure that links files to non-default files (see Specializing Files on page 132).
`xthowspec`	Determine the type of specialization (see Determining which Files are Specialized on page 134).
`xtverifyshroot`	Verify that node-specialized and class-specialized files are linked correctly (see Checking Shared-root Configuration on page 136).

Command	Function
`xtverifyconfig`	Verify that start/stop links generated by tools such as `chkconfig` are consistent across all views of the shared root. You can configure `xtopview` to invoke `xtverifyconfig` automatically; this is the preferred usage. `xtverifyconfig` is not intended for direct use. (See Verifying the Coherency of `/etc/init.d` Files Across All Shared Root Views on page 136.)
`xtcloneshared`	Create a directory structure for a new node or class based on an existing node or class (see Cloning a Shared-root Hierarchy on page 136).
`xtnce`	Modify the class of a node or display the current class of a node (see Changing the Class of a Node on page 137).
`xtunspec`	Remove specialization (see Removing Specialization on page 137).
`xtoprlog`	Display RCS log information for shared root files (see Displaying RCS Log Information for Shared Root Files on page 138).
`xtopco`	Check out (restore) RCS versioned shared root files (see Checking Out an RCS Version of Shared Root Files on page 139).
`xtoprdump`	Print a list of file specifications that can be used as the list of files to operate on an archive of shared root file system files (see Listing Shared Root File Specification and Version Information on page 139).
`xtoparchive`	Perform operations on an archive of shared root configuration files (see Performing Archive Operations on Shared Root Files on page 140).

6.5.4.1 Managing System Configuration with the `xtopview` Tool

The `xtopview` tool manages the files in the shared-root file system. The command runs on the boot node. You specify the view of the system you want, such as from a particular node, when you invoke the command. The system appears as if you were logged in directly to the location you specify; that is, the files that are specialized for that node appear in the `/etc` directory. You can specify location by node ID or hostname.

Changes you make within `xtopview` are logged to a revision control system (RCS) file. When you exit the shell, you are prompted to type a message about each change you have made. Use the `c` command to comment the work you have done in `xtopview`. This information is saved in the Revision Control System (RCS) files.

Tip: Use the `-m msg` option when starting an `xtopview` session to make similar changes to multiple files.

The changed files and messages are then logged to create a history that is stored in the `/.shared/base` directory by its specialization (node, class, or default) and file name. For example, changes and messages relating to default-specialized file `/etc/spk` are stored in `/.shared/base/default/etc/RCS`. Use standard RCS tools, such as `rlog`, for retrieving information.

Warning: If you do not want the changes you have made in your `xtopview` session, you must invoke any necessary commands to undo them. There is no automatic way to back out.

Cray recommends that you configure the shared root from within the `xtopview` shell. Only operations that take place within the `xtopview` shell are logged. If you choose to use specialization commands outside of `xtopview`, they are not logged. Logs reside in the `/rr/current/.shared/log` path relative to the boot node.

New files that are created from within the `xtopview` shell automatically have the specialization that is associated with the view under which you are operating. You do not have to specialize them. If you want a file to be used by all service nodes, create the file in the default view.

Example 59. Starting the `xtopview` shell for a node

To start the `xtopview` shell for node 131, type:

```
boot:~ # xtopview -n 131
node/131/: #
```

Example 60. Starting the `xtopview` shell for a class of nodes

To start the `xtopview` shell for the login nodes, type:

```
boot:~ # xtopview -c login
class/login/: #
```

Note: If you are using the Emacs editor within the `xtopview` shell, you may see the following message:

```
Symbolic link to RCS-controlled source file; follow link [yes or no]?
```

The symbolic link points to a real file in the `/.shared` directory. If you choose `yes`, you edit the file directly. If you choose `no`, you replace the symbolic link with a real file, but when you exit the `xtopview` shell, the file is moved to the correct location and the link is recreated. The difference is that if you are editing the real file, modifications appear immediately in other views.

Example 61. Starting the `xtopview` shell for a directory other than `/rr/current`

To start the `xtopview` shell in a directory other than `/rr/current`, which is a link to the most current directory, type:

```
boot:~ # xtopview -r /rr/20050901
default/:/ #
```

Example 62. Sample `xtopview` session

```
boot:~ # xtopview -n 3
node/3:/ # vi etc/fstab
. . . (edited the file)
node/3:/ # exit
exit
***File /etc/fstab was MODIFIED
operation on file /etc/fstab? (h for help):c
enter description, terminated with single '.' or end of file:
>changed the fstab file to add support for xyz.
boot:~ #
```

Generally, the `xtopview` command obtains node and class information from the SDB. If the SDB is not running, you can direct `xtopview` to access the `/etc/opt/cray/sdb/node_classes` file by selecting the `-x` option.

Example 63. Starting `xtopview` using `node_classes` for information

For nodes:

```
boot:~ # xtopview -x /etc/opt/cray/sdb/node_classes -n 4
```

For classes:

```
boot:~ # xtopview -x /etc/opt/cray/sdb/node_classes -c login
```

For more information, see the `xtopview`(8) man page.

6.5.4.2 Updating Specialized Files from within the `xtopview` Shell

When you exit the `xtopview` shell (see Managing System Configuration with the `xtopview` Tool on page 129), changes you make are propagated to the shared-root file system. Use the `xtopcommit` command to immediately update the shared root with modifications you have made. You do not need to leave the `xtopview` shell.

Example 64. Updating a file within `xtopview` shell

```
boot:~ # xtopview -n 3
node/3:/ # vi /etc/fstab
node/3:/ # xtopcommit
***File /etc/fstab was MODIFIED
operation on file /etc/fstab? (h for help):h
c:check-in - record changes in RCS file
d:diff - diff between file and backup RCS file
h:help - print this help message
m:message - set message for later checkins
M:nomsg - clear previously set message
l:list - list file info (ls -l)
s:skip - check-in file with empty log message
q:quit - check-in ALL files without querying
```

6.5.4.3 Specializing Files

Specifying a view with the `xtopview` command does not automatically specialize existing files. To specialize existing files, you must use the specialization command `xtspec`. The command runs on the boot node and creates a copy of a file that is unique to a node or class. The `xtspec` command has the form:

`xtspec [`*options*`]` *file*

The command specializes the file at the location *file* and updates each node or class of nodes that contains the newly specialized file if the new file is the most specialized file in its view. For example, if a file is specialized by class `io`, for all nodes with class `io` the symbolic links associated with this file are updated to point to the new file unless they are already specialized by node (see Figure 2), which is a more restrictive class.

If you are not within `xtopview` (see Managing System Configuration with the `xtopview` Tool on page 129) when you specialize a file, you must specify the path of the shared root with the `-r` option. In addition, the RCS log of changes has a generic entry for each file.

> **Note:** The `xtspec` command can be used only to specify files or directories residing in or under the `/etc` directory. If you attempt to specify a file or directory outside of the `/etc` directory, the command fails and an error message is generated.

The `-V` option of the `xtspec` command specifies the location from which the file that is to be the specialized file is copied. If the `-V` option is specified, the newly specialized file is a duplicate of the file from the target's view. If the `-V` option is not specified, the newly specialized file is a duplicate of the file from the administrator's view.

If you do not specialize a file, the default specialization level is based on the current view if you are running in the `xtopview` shell (see Managing System Configuration with the `xtopview` Tool on page 129) or on the default view if you are operating outside the `xtopview` shell.

Classes are defined in the `node_classes` file (see Class Name on page 60).

Procedure 25. Specializing a file by class login

1. To specialize the file `/etc/dhcpd.conf` by the class of login nodes, enter the login shell.

   ```
   boot:~ # xtopview -c login
   ```

2. Specialize the selected file.

   ```
   class/login:~ # xtspec /etc/dhcpd.conf
   ```

3. Edit `/etc/dhcpd.conf` if it is the default copy of the file. If you have pointed to a unique copy of the file in the `xtspec` command, omit this step.

As a result of this procedure, each node in the class `login` links to the "new" `/etc/dhcpd.conf` file unless the node is already specialized by node. For example, node 23 might already be specialized and link to a different `/etc/dhcpd.conf` file.

Procedure 26. Specializing a file by node

1. To specialize the file `/etc/motd` for node `11`, enter the login shell.

   ```
   boot:~ # xtopview -n 11
   ```

2. Specialize the selected file.

   ```
   node/11/: # xtspec /etc/motd
   specializing motd from default to node/11
   ```

This procedure creates a node-specific copy of `/etc/motd`. That is, the directory entry in the `/etc` file associated with `node 11` is updated to point to the new version of `/etc/motd` and the activity is logged.

Procedure 27. Specializing a file by node without entering `xtopview`

- Specify the root path and view mode.

  ```
  boot:~ # xtspec -r /rr/current -V -n 11 /etc/motd
  ```

As a result of this procedure, the directory entry in the `/etc` file associated with `node 11` is updated to point to the new version of `/etc/motd` but the activity is not logged.

After you have specialized nodes, you can unspecialize them (see `xtunspec` command, Removing Specialization on page 137) or determine how they are specialized (see `xthowspec` command Determining which Files are Specialized on page 134). You can also view or change the class type of a particular node (see `xtnce` command, Changing the Class of a Node on page 137).

You can use specialization commands only from the boot node. You must be root user to use them. For more information, see the `shared_root`(5) and `xtspec`(8) man pages.

6.5.4.4 Determining which Files are Specialized

The CLE `xthowspec` command displays how the files in a specified path are specialized. For example, you might use this command to examine restrictions on login nodes.

The `xthowspec` command has the form:

`xthowspec [`*options*`]` *path*

You can display file specialization for all nodes or all classes, for a particular node or class, for the default view, or for a selection of parameters. Inside the `xtopview` shell, the `xthowspec` command acts on files in the current view by default.

Output has the form *TYPE*:*ITEM*:*FILE*:*SPEC*, where the fields are as follows:

TYPE	Node, class or default.
ITEM	The specific node or class type; this field is empty for the default view.
FILE	The file upon which the command is acting.
SPEC	The specialization level of the file in the view; for example, for default view this is default; for class view options are class or default.

Procedure 28. Finding files in `/etc` that are specialized by a node

Find all files specialized by node `11`.

1. Enter the `xtopview` shell for the node.

   ```
   boot:~ # xtopview -n 11
   ```

2. Use the `xthowspec` command for the node.

   ```
   node/11/: # xthowspec -t node /etc
   node:11:/etc/fstab.h:node
   node:11:/etc/hostname:node
   ```

Procedure 29. Finding files in `/etc` that are specialized by class on a node

Find all files specialized by class.

1. Enter the `xtopview` shell for class.

   ```
   boot:~ # xtopview -c login
   ```

2. Use the `xthowspec` command for the class and locate the node you are interested in.

   ```
   class/login:~ # xthowspec -t class /etc
   node:1:/etc/crontab:class
   node:11:/etc/crontab:class
   ...
   ```

Procedure 30. Finding specialization of a file on a node

Find the specialization of `/etc/dhcpd.conf` on node `11`.

1. Enter the `xtopview` shell for the node.

   ```
   boot:~ # xtopview -n 11
   ```

2. Use the `xthowspec` command for the file.

   ```
   node/11/: # xthowspec /etc/dhcpd.conf
   node:11:/etc/dhcpd.conf:default
   ```

Example 65. Finding nodes on which a file is specialized

To find the nodes that the `/etc/fstab` is specialized on, type:

```
boot:~ # xthowspec -H /etc/fstab
node:1/etc/fstab:default
node:33:/etc/fstab:node:
```

To examine specialization outside the `xtopview` shell, you must type the full path name.

Example 66. Finding specialization of a file on a node without invoking the `xtopview` shell

To find the specialization of `/etc/fstab` on node `102`, type:

```
boot:~ # xthowspec -r /rr/current -n 102 /etc/fstab
node:102:/etc/fstab:node
```

Example 67. Finding specialization of files by class without invoking the `xtopview` shell

To find all files that are specialized by class in `/etc` for all nodes, type:

```
boot:~ # xthowspec -r /rr/current -N -t class /etc
node:11:/etc/crontab:class
node:1:/etc/crontab:class
```

For more information, see the `xthowspec`(8) man page.

6.5.4.5 Checking Shared-root Configuration

You can check the configuration of the shared-root file system with the `xtverifyshroot` command:

`xtverifyshroot [`*options*`]` *path*

If there are node-specialized or class-specialized files, the command verifies that they are linked correctly. If a problem is detected with a file, it is reported but not corrected.

Note: You must be in the `xtopview` shell to use the `xtverifyshroot` command.

For more information, see the `xtverifyshroot`(8) man page.

6.5.4.6 Verifying the Coherency of `/etc/init.d` Files Across All Shared Root Views

The `xtopview` command can be configured to invoke the `xtverifyconfig` utility automatically to resolve potential inconsistencies in the mechanism used to configure various CLE software services on or off.

Note: This is the preferred usage; the `xtverifyconfig` utility is not intended for direct use.

When you use the `chkconfig` utility to configure services on or off, a collection of encoded symbolic links are generated to determine which system services are started or shut down and in what order. The `chkconfig` utility does not account for the multiple levels of specialization within the shared root when `xtopview` is used. As a result, `chkconfig` occasionally produces a startup or shutdown order that violates dependencies between services when all levels of specialization are taken into account. To resolve this problem, you can configure `xtopview` to invoke the `xtverifyconfig` verification utility upon exit. The `xtverifyconfig` utility will detect inconsistencies and may rename startup and shutdown links to maintain the proper dependency ordering. The `/.shared/log` log file in the shared root contains a log of modifications `xtverifyconfig` makes to the shared root.

The `xtopview` command will run `xtverifyconfig` upon exit if the `XTOPVIEW_VERIFY_INITD` environment variable is non-zero when `xtopview` is invoked, or if the `XTOPVIEW_VERIFY_INITD` variable is set to non-zero in the `/etc/sysconfig/xt` file on the boot node. By default, this parameter is not included in the configuration file and this feature is not enabled.

For more information, see the `xtverifyconfig`(8) man page.

6.5.4.7 Cloning a Shared-root Hierarchy

You can create a directory structure for a new node or class name in the shared-root hierarchy based on an existing node or class with the `xtcloneshared` command. For more information, see the `xtcloneshared`(8) man page.

6.5.4.8 Changing the Class of a Node

If you remove nodes, for example, you may need to change the class of the remaining nodes. If you add a login node, you must add it to class `login`. The `xtnce` command displays the current class of a node or modifies its class. The command has the form:

`xtnce [options]` *nodename*

Example 68. Finding the class of a node

To identify the class of node `132`, type:

```
crayadm@boot:~> xtnce 132
132:login
```

Example 69. Adding a node to a class

Use the `xtnce` command for the node and specify the class it should be:

```
crayadm@boot:~> xtnce -c login 104
```

You also need to change `/etc/opt/cray/sdb/node_classes` on the boot node so the data is preserved across a boot; this is because the `node_classes` file is used to initialize the SDB data on the next boot, and the boot node file cannot be updated from within `xtopview`.

For more information, see the `xtnce`(8) man page.

Note: The `xtnodeclasses2db` command inserts the node-class list into the database, but it does not make any changes to the shared root.

6.5.4.9 Removing Specialization

If you specialized a node or class of nodes and, for example, you want to remove unique start-up scripts from them, you can remove this specialization with the `xtunspec` command:

`xtunspec [`*options*`]` *path*

You can unspecialize files for all nodes and classes (default), for a specified class of nodes or for a particular node. Cray strongly recommends that you unspecialize files from within the `xtopview` shell; if you do not unspecialize your files from within the `xtopview` shell (see Managing System Configuration with the `xtopview` Tool on page 129), you must also specify the path for the shared root.

Note: You can only use `xtunspec` on the boot node.

Example 70. Removing node specialization

To remove all versions of `/etc/fstab` specialized by node, type:

```
boot:~ # xtopview
default/:/ # xtunspec -N /etc/fstab
```

Each node is updated so that it uses a version of `/etc/fstab` based on its class, or if that is not available, based on the default version of `/etc/fstab`.

Example 71. Removing class specialization

To remove all versions of `/etc/fstab` that are specialized by, for example, class I/O (`io`), type:

```
boot:~ # xtopview
default/:/ # xtunspec -c io /etc/fstab
```

I/O nodes that link to the class-specialized version of the file are changed to link to the default version of `/etc/fstab`. However, I/O nodes that already link to node-specialized versions of `/etc/fstab` are unchanged. To remove a file specialized by node, you must use the `xtunspec` command on the node (see Example 70).

For more information, see the `xtunspec`(8) man page.

6.5.4.10 Displaying RCS Log Information for Shared Root Files

The `xtoprlog` command displays Revision Control System (RCS) log information for shared root files. Specify the file name using the required *filename* command-line argument. Execute the `xtoprlog` command from any service node.

The scope of this tool is limited to identification and manipulation of `/etc` configuration data within the shared root. Configuration files on the boot root file system or on the SMW are not managed by this utility.

For more information, see the `xtoprlog`(8) man page.

Example 72. Printing the latest version of a file

Use the `xtoprlog --version` option to print the latest version (revision) number of a specified file:

```
crayadm@nid00004:~ xtoprlog --version /etc/fstab
1.7
```

Example 73. Printing the RCS log for `/etc/fstab` in the node 3 view

Use the `xtoprlog -n` option to specify the `/etc/fstab` node view RCS log to print:

```
crayadm@nid00004:~ xtoprlog -n 3 /etc/fstab
RCS file: /.shared/base/node/3/etc/RCS/fstab,v
Working file: /.shared/base/node/3/etc/fstab
head: 1.6
...
```

Example 74. Displaying differences between two versions of the `/etc/fstab` file

Use the `xtoprlog -x` option with the `xtoprlog -r` option to display the differences between the current version of `/etc/fstab` and version 1.3:

```
crayadm@nid00004:~ xtoprlog --x -r 1.3 /etc/fstab
===================================================================
RCS file: /.shared/base/default/etc/RCS/fstab,v
retrieving revision 1.3
diff -r1.3 /.shared/base/default/etc/fstab
1,3c1,4
< # Default view fstab file 1.3
---> # Default view fstab file 1.7
```

6.5.4.11 Checking Out an RCS Version of Shared Root Files

Use the `xtopco` command to check out a version of shared root files. The `xtopco` command should be run on the boot node using the `xtopview` utility in the default view.

The scope of this tool is limited to identification and manipulation of `/etc` configuration data within the shared root. Configuration files on the boot root file system or on the SMW are not managed by this utility.

Example 75. Checking out a version 1.2 copy of `/etc/fstab`

Use the `xtopco -r` option to specify the version of the file to check out:

```
boot:~ # xtopview
default/:/ # xtopco -r 1.2 /etc/fstab
```

Example 76. Recreating the file link for `/etc/fstab` to the current view's `/etc/fstab` file

To recreate the file link only, use the `xtopco --link` option:

```
boot:~ # xtopview
default/:/ # xtopco --link /etc/fstab
```

For more information, see the `xtopco`(8) man page.

6.5.4.12 Listing Shared Root File Specification and Version Information

Using RCS information, combined with the `xtopview` specialization information, `xtoprdump` prints a list of file specifications that can be used as the list of files to operate on an archive of shared root file system files. The `xtoprdump` command should be invoked using the `xtopview` utility unless the `--root` option is specified.

The scope of this tool is limited to identification and manipulation of `/etc` configuration data within the shared root. Configuration files on the boot root file system or on the SMW are not managed by this utility.

Example 77. Printing specifications for login class specialized files

Use the `xtoprdump -n` option to specify the node view; set to `all` for all nodes:

```
boot:~ # xtopview
default/:/ # xtoprdump -n all
```

Example 78. Printing specifications for files modified in the default view and include any warning messages

The following `xtoprdump` command prints specifications for modified files (`-m` option) in the default view (`-d` option), including warning messages (`-w` option):

```
boot:~ # xtopview
default/:/ # xtoprdump -m -d -w
```

For more information, see the `xtoprdump`(8) man page.

6.5.4.13 Performing Archive Operations on Shared Root Files

Use the `xtoparchive` command to perform operations on an archive of shared root configuration files. Run the `xtoparchive` command on the boot node using the `xtopview` utility in the default view. The archive is a text-based file similar to a tar file and is specified using the required `archivefile` command-line argument. The `xtoparchive` command is intended for configuration files only. Binary files will not be archived. If a binary file is contained within a specification file list, it will be skipped and a warning will be issued.

The scope of this tool is limited to identification and manipulation of `/etc` configuration data within the shared root. Configuration files on the boot root file system or on the SMW are not managed by this utility.

Example 79. Adding files specified by specifications listed in `specfile` to an archive file

Use the following `xtoparchive` command to add files specified by the specifications listed in `specfile` to the archive file `archive.042208`; create the archive file if it does not already exist:

```
boot:~ # xtopview
default/:/ # xtoparchive -a -f specfile archive.042208
```

Example 80. Listing specifications for files currently in the `archive.042208` archive file

Use the `xtoparchive -l` command to list specifications for files currently in the archive file `archive.042208`:

```
boot:~ # xtopview
default/:/ # xtoparchive -l archive.042208
```

For more information, see the `xtoparchive`(8) man page.

6.5.5 Logging Shared-root Activity

All specialization activity is logged in the log file `/.shared/log`, which tracks additions, deletions, and modifications of files. To view the details of your changes, you must access the RCS logs that were created during the `xtopview` session.

Note: If you have exited `xtopview` with `Ctrl-c`, you do not log the operations you performed within the shell, The changes to the system are present nonetheless. This means that if you want to back out of changes, it is not sufficient to exit `xtopview`. You must submit the commands to undo what you have done.

6.6 Configuring Optional RPMs in the CNL Boot Image

You can configure which optional RPMs are installed into the CNL boot image for your system in one of two ways. First, several parameters are available in the `CLEinstall.conf` file to control whether specific RPMs are included during installation or upgrade of your system software. When you edit `CLEinstall.conf` prior to running `CLEintall`, set the `CNL_` parameters to either **`yes`** or **`no`** to indicate which optional RPMs should be included in your CNL compute node boot images. For example, to include all optional RPMs, change the following lines.

```
CNL_audit=yes
CNL_csa=yes
CNL_dvs=yes
CNL_ntpclient=yes
CNL_rsip=yes
CNL_cpr=yes
```

The second method is to add or remove specific RPMs by editing the `/var/opt/cray/install/shell_bootimage_`*label*`.sh` command used when preparing boot images for CNL compute nodes. Change the settings for these parameters to **`y`** or **`n`** to indicate which optional RPMs should be included. For example, to include the optional Cray Audit, CSA, DVS, and RSIP RPMs, change the following lines.

```
CNL_AUDIT=y
CNL_CSA=y
CNL_DVS=y
CNL_RSIP=y
```

6.7 Configuring Cray Enhanced Linux Security Features

This section describes Cray extensions to Linux security auditing utilities and the `cray_pam` PAM module for logging failed login attempts.

6.7.1 Security Auditing and Cray Audit Extensions

Cray Audit is a set of Cray specific extensions to standard Linux security auditing. When the Cray Audit is configured, separate logs are generated for each audited node on the Cray system. Cray specific utilities simplify administration of auditing options and log files across a large number of nodes. For more information about standard Linux security auditing, see the following website: http://www.novell.com/linux.

Cray Audit includes the following components:

- **Cluster option to enable Cray Audit.** The `/etc/auditd.conf` includes a Cray specific option called `cluster` which, when configured on, will enable Cray Audit extensions. The standard Linux `auditd` daemon has been enhanced to implement this configuration option. The clustered configuration provides a mechanism to collect audit data on many nodes and store the data in a central location. The configuration script creates a separate directory for each node and names and manages the auditing log file in the same way as on a single-node system. This includes tracking log size, responding to size-related events, and rotating log files.

  Caution: If you run Linux security auditing on a Cray system without Cray Audit extensions, auditing data from the various nodes collide and generate a corrupt audit log. Because of this, Cray Audit extensions are enabled by default when Linux auditing is configured on.

  Note: The cluster option should **not** be used when auditing a boot node.

- `xtauditctl` **command.** The `xtauditctl` command distributes `auditctl` administrative commands to compute nodes on the system. This command traverses a list of all running compute nodes and invokes commands that deliver a signal to the audit daemons on each node. This utility allows an administrator to apply configuration changes without having to restart every node in the system. For more information see the `xtauditctl`(8) and `auditctl`(8) man pages.

- `xtaumerge` **command.** The `xtaumerge` command merges clustered audit logs into a single log file. When you use this tool to generate a single audit file, you can also use Linux audit tools to report on and analyze system-wide audit data. An additional benefit is that `xtaumerge` maintains compatibility with the Linux audit tools; you can move audit data to another Linux platform for analysis. For more information see the `xtaumerge`(8) man page.

  Note: When you run `xtaumerge`, the resulting merged data stream loses one potentially useful piece of information: the node name of the node on which the event originated. In order to maintain compatibility with standard Linux utilities, the merged audit log does not include this information. Use Linux audit utilities directly on the per-node log files to find a specific record if you require that level of information.

- **ALPS interface to security auditing.** For Cray systems with CNL compute nodes, the Application Level Placement Scheduler (ALPS) supports security auditing functionality. ALPS instantiates an application on behalf of the user on specific compute nodes. After instantiating the application, the ALPS interface calls the auditing system to begin auditing the application. At job start and end, auditing system utilities write the audit record to the audit log.

By default, Cray Audit extensions are enabled but will have no impact until Linux security auditing is configured on. Linux security auditing is configured off by default. Follow Procedure 31 on page 144 to configure Cray Audit and Linux security auditing to audit boot, login and compute nodes. This procedure will direct you to edit the `/etc/auditd.conf` and `/etc/audit.rules` files and define your audit configuration based on site-specific requirements. The file `/usr/share/doc/packages/audit/sample.rules` describes a sample rule set. Once you have established these configuration files, you can make temporary changes to your audit configuration using `xtauditctl` and standard Linux `auditctl` command options. For more information see the `xtauditctl`(8) and `auditctl`(8) man pages.

Cray recommends that you configure auditing to use a Lustre file system to hold the audit log files. Follow Procedure 31 on page 144, to specify the Lustre file system by setting `log_file =` *lustre_pathname*. For more information on specific Lustre file system requirements to run Cray Audit, see Lustre File System Requirements for Cray Audit on page 146.

Procedure 31. Configuring Cray Audit

By default, Linux security auditing is disabled and Cray Audit extensions are enabled. Follow these steps to define your site-specific auditing rules and enable standard Linux auditing.

Note: To make these changes for a system partition, rather than for the entire system, replace `/opt/xt-images/templates` with `/opt/xt-images/templates-p`*N*, where *N* is the partition number. Also, replace `/opt/xt-images/`*xthostname*`-`*XT_version* with `/opt/xt-images/`*xthostname*`-`*XT_version*`-p`*N*.

1. Follow these steps to edit the auditing configuration files in the compute node image and enable auditing on CNL compute nodes.

   a. Copy the `auditd.conf` and `audit.rules` configuration files to the template directory so that modifications are retained when new boot images are created in the future.

```
smw:~# cp /opt/xt-images/xthostname-XT_version/compute/etc/auditd.conf \
/opt/xt-images/templates/default/etc/auditd.conf
smw:~# cp /opt/xt-images/xthostname-XT_version/compute/etc/audit.rules \
/opt/xt-images/templates/default/etc/audit.rules
```

   b. Edit `/opt/xt-images/templates/default/etc/auditd.conf` on the SMW and set the `log_file` parameter. For example, if the mount point for your Lustre file system is `mylusmnt` and you want to place audit logs in a directory called `auditdir`, type the following commands.

```
smw:~# vi /opt/xt-images/templates/default/etc/auditd.conf
log_file = /mylusmnt/auditdir/audit.log
```

Warning: If you run auditing on compute nodes without configuring the audit directory, audit records that are written to the local ram-disk could cause the ram-disk to fill.

   c. Edit `/opt/xt-images/templates/default/etc/audit.rules` on the SMW. Change this file to set site-specific auditing rules for the compute nodes. At a minimum, you should set the `-e` option to 1.

```
smw:~# vi /opt/xt-images/templates/default/etc/audit.rules
```

   Make your changes after the following line; for example:

```
# Feel free to add below this line.  See auditctl man page
-e 1
```

   d. Create the following symbolic link.

```
smw:~# mkdir -p -m 755 /opt/xt-images/templates/default/etc/init.d/rc3.d
smw:~# cd /opt/xt-images/templates/default/etc/init.d/rc3.d
smw:/opt/xt-images/templates/default/etc/init.d/rc3.d # ln -s ../auditd S12auditd
```

   e. If you set `CNL_audit=`*yes* in `CLEinstall.conf` before you ran the `CLEinstall` program, update the boot image by following the steps in Procedure 2 on page 68.

      Otherwise, you must first edit the `/var/opt/cray/install/shell_bootimage_`*label*`.sh` script and set `CNL_AUDIT=`**`y`** and then update the boot image following the steps in Procedure 2 on page 68.

2. Follow these steps to enable and configure auditing on login nodes.

   a. Log on to the boot node and use the `xtopview` command to access all login nodes by class.

```
smw:~# ssh root@boot
boot:~ # xtopview -c login -m "configuring audit files"
```

   b. Edit `/etc/auditd.conf` and set the `log_file` parameter. For example, if your Lustre file system is called `mylustrefs` and you want to place audit logs in a directory called `auditdir`, type the following commands.

```
class/login/:# vi /etc/auditd.conf
log_file = /mylustrefs/auditdir/audit.log
```

   c. Edit the `/etc/audit.rules` file to set site-specific auditing rules for the login nodes. At a minimum, you should set the `-e` option to 1.

```
class/login/:# vi /etc/audit.rules
```

      Make your changes after the following line; for example:

```
# Feel free to add below this line.  See auditctl man page
-e 1
```

   d. Specialize these files to the `login` class.

```
class/login/:# xtspec -c login /etc/auditd.conf
class/login/:# xtspec -c login /etc/audit.rules
```

   e. Exit `xtopview`.

```
class/login/:# exit
```

3. You must configure auditing on the boot node to use standard Linux auditing. Follow these steps to turn off Cray audit extensions for the boot node. Configure the boot node to use the default `log_file` parameter in the `auditd.conf` file and set the `cluster` entry to `no`.

   a. While logged on to the boot node, edit the `/etc/auditd.conf` file.

```
boot:~ # vi /etc/auditd.conf
log_file = /var/log/audit/audit.log
cluster = no
```

b. Edit the `/etc/audit.rules` file to set site-specific auditing rules for the boot node. At a minimum, you should set the `-e` option to 1.

```
boot:~ # vi /etc/audit.rules
```

Make your changes after the following line; for example:

```
# Feel free to add below this line.  See auditctl man page
-e 1
```

c. Configure the audit daemon to start on the boot node.

```
boot:~ # chkconfig --force auditd on
```

4. Create the log file directory. Log into a node that has the Lustre file system mounted and type the following commands:

```
login:~# mkdir -p /mylustrefs/auditdir
login:~# chmod 700 /mylustrefs/auditdir
```

5. Edit the boot automation file to configure your system to start the Cray audit daemon on login nodes by invoking `/etc/init.d/auditd start` on each login node.

6.7.1.1 Lustre File System Requirements for Cray Audit

The audit system stores audit data in a directory tree structure that uses a naming scheme based on the directory name provided by the `log_file` parameter. For example, if you set `log_file` to */lus/audit/audit.log*, the auditing system stores audit data in files named `/lus/audit/`*node_specific_path*`/audit.log`, where *node_specific_path* is a directory structure generated by Cray Audit.

Warning: If you run auditing on compute nodes without configuring the audit directory, audit records are written to the local ram-disk which may consume all your resources and cause data loss.

With the exception of the boot node, each audited node in the system must have access to the Lustre file system that contains the audit directory. Because each node has its own audit log file, sufficient space must be made available to store audit data. You configure the log size in the `/etc/auditd.conf` file. The file system should be large enough to hold at least twice the maximum configured log size, multiplied by the number of log files retained and the number of audited nodes, plus enough space to avoid triggering out of space recovery actions. The following formula can be used to estimate a reasonable file system size:

```
(2 * num_logs * max_log_file * nnodes) + space_left
```

Where:

`num_logs` is the number of log files kept in rotation.

`max_log_file` is the maximum size of a log file in megabytes.

nnodes is the number of audited nodes

`space_left` is the amount of space in megabytes required to avoid out of space recovery actions.

The `num_logs`, `max_log_file`, and `space_left` parameters are set in the `/etc/auditd.conf` file. The default `/etc/auditd.conf` file is shown in Example 81.

> **Note:** This formula assumes that you use the default destination for the output of `xtaumerge`, placing the merged log file and the per-node log files on the same file system. This roughly doubles the size of the disk space needed to hold the audit trail.

Example 81. Default `/etc/auditd.conf` File

```
#
# This file controls the configuration of the audit daemon
#

log_file = /var/log/audit/audit.log
cluster = yes
log_format = RAW
priority_boost = 3
flush = INCREMENTAL
freq = 20
num_logs = 4
#dispatcher = /usr/sbin/audispd
disp_qos = lossy
max_log_file = 5
max_log_file_action = ROTATE
space_left = 75
space_left_action = SYSLOG
action_mail_acct = root
admin_space_left = 50
admin_space_left_action = SUSPEND
disk_full_action = SUSPEND
disk_error_action = SUSPEND
```

6.7.1.2 System Performance Considerations for Cray Audit

With auditing turned off there is no performance impact from this feature. With auditing turned on, system performance is impacted. The performance costs for running Linux audit and the associated Cray extensions vary greatly, depending on the site-defined audit event selection criteria. Auditing of judiciously chosen events, for example login or `su` attempts, do not impact overall system performance. However, auditing of frequently used system calls has a negative impact on system performance because each occurrence of an audited system call triggers a file system write operation to the audit log.

It is the responsibility of the administrator or auditor to design the site security policy and configure auditing to minimize this impact.

6.7.2 Using the `cray_pam` PAM to Log Failed Login Attempts

The `cray_pam` module is a Pluggable Authentication Module (PAM) that, when configured, provides information to the user at login time about any failed login attempts since their last successful login. The module provides:

- Date and time of last successful login
- Date and time of last unsuccessful login
- Total number of unsuccessful logins since the user's last successful login

Cray recommends that you configure login failure logging on all service nodes. The RPMs are installed by default on the boot root and shared root file systems.

To use this feature, you must configure the `pam_tally` and `cray_pam` PAM modules. The PAM configuration files provided with the CLE software allow you to manipulate a common set of configuration files that will be active for all services.

The `cray_pam` module requires an entry in the PAM `common-auth` and `common-session` files or an entry in the PAM `auth` section and an entry in the PAM `session` section of any PAM application configuration file. Use of the common files is typically preferable so that other applications such as `su` also report failed login information; for example:

```
crayadm@boot:~> su -
2 failed login attempts since last login.
Last failure Thu May  8 11:41:20 2008 from smw.
boot:~ #
```

For each log in attempt, a per-user counter is updated. When a successful log in occurs, the statistics are displayed and the counter is cleared. The default location of the `pam_tally` counter file is `/var/log/faillog`. Additionally, `cray_pam` uses a temporary directory, by default, `/var/opt/cray/faillog`, to store information about the users. Change these defaults by editing `/etc/opt/cray/pam/faillog.conf` and by using the `file=` option for each `pam_tally` and `cray_pam` entry. You can find an example `faillog.conf` file in `/opt/cray/pam/`*xtrelease-xtversion*`/etc`.

You can configure a number of nodes to share information by modifying the default location for these directories to use a common set of directories, writable to all nodes. Edit `/etc/opt/cray/pam/faillog.conf` to reflect an alternate, root-writable directory. Configure `pam_tally` to save tally information in an alternate location using the `file=` option; each entry for `cray_pam` must also include the `file=` option to specify the alternate location.

Limitations:

- If a login attempt fails, `cray_pam` in the `auth` section creates a temporary file; but because the login attempt failed, the `session` section is not called and, as a result, the temporary file is not removed. This is harmless because the file will be overwritten at the next login attempt and removed at the next successful login.
- Logins that occur outside of the PAM infrastructure will not be noted.
- Host names are truncated after 12 characters. This is a limitation in the underlying `faillog` recording.
- The `cray_pam` module requires `pam_tally` to be configured.

Note: For additional information on using the `cray_pam` PAM module, see the `pam`(8) and `pam_tally`(8) man pages.

Procedure 32. Configuring `cray_pam` to log failed login attempts

1. Edit the `/etc/pam.d/common-auth`, `/etc/pam.d/common-account`, and `/etc/pam.d/common-session` files on the boot node.

   Note: In these examples, the `pam_faillog.so` and `pam.tally.so` entries can include an optional `file=`*/path/to/pam_tally/counter/file* argument to specify an alternate location for the tally file.

   Example 82 shows these files after they have been modified to report failed login using an alternate location for the tally file.

   a. Edit the `/etc/pam.d/common-auth` file and add the following lines as the first and last entries:

   ```
   boot:~ # vi /etc/pam.d/common-auth
   auth required pam_faillog.so [file=alternatepath] (as the FIRST entry)
   auth required pam_tally.so [file=alternatepath] (as the LAST entry)
   ```

Your modified `/etc/pam.d/common-auth` file should look like this:

```
#%PAM-1.0
#
# This file is autogenerated by pam-config. All changes
# will be overwritten.
#
# Authentication-related modules common to all services
#
# This file is included from other service-specific PAM config files,
# and should contain a list of the authentication modules that define
# the central authentication scheme for use on the system
# (e.g., /etc/shadow, LDAP, Kerberos, etc.). The default is to use the
# traditional Unix authentication mechanisms.
#
auth    required        pam_faillog.so
auth    required        pam_env.so
auth    required        pam_unix2.so
auth    required        pam_tally.so
```

b. Edit the `/etc/pam.d/common-account` file and add the following line as the last entry:

```
boot:~ # vi /etc/pam.d/common-account
account required pam_tally.so [file=alternatepath]
```

Your modified `/etc/pam.d/common-account` file should look like this:

```
#%PAM-1.0
#
# This file is autogenerated by pam-config. All changes
# will be overwritten.
#
# Account-related modules common to all services
#
# This file is included from other service-specific PAM config files,
# and should contain a list of the authorization modules that define
# the central access policy for use on the system.  The default is to
# only deny service to users whose accounts are expired.
#
account required        pam_unix2.so
account required        pam_tally.so
```

c. Edit the `/etc/pam.d/common-session` file and add the following line as the last entry:

```
boot:~ # vi /etc/pam.d/common-session
session optional pam_faillog.so [file=alternatepath]
```

Your modified `/etc/pam.d/common-session` file should look like this:

```
#%PAM-1.0
#
# This file is autogenerated by pam-config. All changes
# will be overwritten.
#
# Session-related modules common to all services

#
# This file is included from other service-specific PAM config files,
# and should contain a list of modules that define tasks to be performed
# at the start and end of sessions of *any* kind (both interactive and
# non-interactive).  The default is pam_unix2.
#
session required        pam_limits.so
session required        pam_unix2.so
session optional        pam_umask.so
session optional        pam_faillog.so
```

2. Copy the edited files to the shared root by using `xtopview` in the default view.

```
boot:~ # cp -p /etc/pam.d/common-auth /rr/current/software
boot:~ # cp -p /etc/pam.d/common-account /rr/current/software
boot:~ # cp -p /etc/pam.d/common-session /rr/current/software
boot:~ # xtopview -m "configure login failure logging PAM"
default/:/ # cp -p /software/common-auth /etc/pam.d/common-auth
default/:/ # cp -p /software/common-account /etc/pam.d/common-account
default/:/ # cp -p /software/common-session /etc/pam.d/common-session
```

3. Exit `xtopview`.

```
default/:/ # exit
boot:~ #
```

Example 82. Modified PAM configuration files configured to report failed login by using an alternate path

If you configure `pam_tally` to save tally information in an alternate location by using the `file=` option, each entry for `cray_pam` must also include the `file=` option to specify the alternate location.

Your modified `/etc/pam.d/common-auth` file should look like this:

```
#
# /etc/pam.d/common-auth - authentication settings common to all services
#
# This file is included from other service-specific PAM config files,
# and should contain a list of the authentication modules that define
# the central authentication scheme for use on the system
# (e.g., /etc/shadow, LDAP, Kerberos, etc.).  The default is to use the
# traditional Unix authentication mechanisms.
#
auth    required        pam_faillog.so file=/ufs/logs/tally.log
auth    required        pam_env.so
auth    required        pam_unix2.so
auth    required        pam_tally.so file=/ufs/logs/tally.log
```

Your modified `/etc/pam.d/common-account` file should look like this:

```
#
# /etc/pam.d/common-account - authorization settings common to all services
#
# This file is included from other service-specific PAM config files,
# and should contain a list of the authorization modules that define
# the central access policy for use on the system.  The default is to
# only deny service to users whose accounts are expired.
#
account required        pam_unix2.so
account required        pam_tally.so file=/ufs/logs/tally.log
```

Your modified `/etc/pam.d/common-session` file should look like this:

```
#
# /etc/pam.d/common-session - session-related modules common to all services
#
# This file is included from other service-specific PAM config files,
# and should contain a list of modules that define tasks to be performed
# at the start and end of sessions of *any* kind (both interactive and
# non-interactive).  The default is pam_unix2.
#
session required        pam_limits.so
session required        pam_unix2.so
session optional        pam_faillog.so file=/ufs/logs/tally.log
```

6.8 Configuring `cron` Services

Optional: Configuring `cron` services is optional on CLE systems.

The `cron` daemon is disabled, by default, on the shared root file system and the boot root. It is enabled, by default, on the SMW. Use standard Linux procedures to enable `cron` on the boot root, following Procedure 33 on page 153.

On the shared root, how you configure `cron` for CLE depends on whether you have set up persistent `/var`. If you have persistent `/var` follow Procedure 34 on page 153; if you have not set up persistent `/var`, follow Procedure 35 on page 154.

The `/etc/cron.*` directories include a large number of cron scripts. On a new CLE system, the `CLEinstall` program disables these scripts and you must manually enable any scripts you want to use.

Procedure 33. Configuring `cron` for the SMW and the boot node

Note: By default, the `cron` daemon on the SMW is enabled and this procedure is required only on the boot node.

1. Log on to the target node as root and determine the current configuration status for `cron`.

   On the on the SMW:

   ```
   smw:~# chkconfig cron
   cron on
   ```

   On the boot node:

   ```
   boot:~ # chkconfig cron
   cron off
   ```

2. Use the `chkconfig` command to configure the `cron` daemon to start. For example, to enable `cron` on the boot node, type the following command:

   ```
   boot:~ # chkconfig --force cron on
   ```

The `cron` scripts shipped with the Cray customized version of SLES are located under `/etc/cron.hourly`, `/etc/cron.daily`, `/etc/cron.weekly`, and `/etc/cron.monthly`. The system administrator can enable these scripts by using the `chkconfig` command. However, if you do not have a persistent `/var`, Cray recommends that you follow Procedure 35.

Procedure 34. Configuring `cron` for the shared root with persistent `/var`

Use this procedure for service nodes by using the shared root on systems that are set up with a persistent `/var` file system.

1. Invoke the command in the default view to enable the `cron` daemon.

   ```
   boot:~ # xtopview -m "configuring cron"
   default/:/ # chkconfig --force cron on
   ```

2. Examine the `/etc/cron.hourly`, `/etc/cron.daily`, `/etc/cron.weekly`, and `/etc/cron.monthly` directories and change the file access permissions to enable or disable distributed cron scripts to meet your needs. To enable a script, invoke `chmod ug+x` to make the script executable. By default, `CLEinstall` removes the execute permission bit to disable all distributed cron scripts.

   ⚠ **Caution:** Some distributed scripts impact performance negatively on a CLE system. To ensure that all scripts are disabled, type the following:

   ```
   default/:/ # find /etc/cron.hourly /etc/cron.daily \
   /etc/cron.weekly /etc/cron.monthly \
   -type f -follow -exec chmod ugo-x {} \;
   ```

3. Exit `xtopview`.

   ```
   default/:/ # exit
   boot:~ #
   ```

Procedure 35. Configuring `cron` for the shared root without persistent `/var`

Because CLE has a shared root, the standard `cron` initialization script `/etc/init.d/cron` activates the `cron` daemon on all service nodes. Therefore, the `cron` daemon is disabled by default and you must turn it on with the `xtservconfig` command to specify which nodes you want the daemon to run on.

1. Edit the `/etc/group` file in the default view to add users who do not have root permission to the "trusted" group. The operating system requires that all `cron` users who do not have root permission be in the "trusted" group.

   ```
   boot:~ # xtopview
   default/:/ # vi /etc/group
   default/:/ # exit
   ```

2. Create a `/var/spool/cron` directory in the `/ufs` file system on the `ufs` node which is shared among all the nodes of class `login`.

   ```
   boot:~ # ssh root@ufs
   ufs:~# mkdir /ufs/cron
   ufs:~# cp -a /var/spool/cron /ufs
   ufs:~# exit
   ```

3. Designate a single login node on which to run the scripts in this directory. Configure this node to start `cron` with the `xtservconfig` command rather than the `/etc/init.d/cron` script. This enables users, including root, to submit `cron` jobs from any node of class `login`. These jobs are executed only on the specified login node.

   a. Create or edit the following entry in the `/etc/sysconfig/xt` file in the shared root file system in the default view.

      ```
      boot:~ # xtopview
      default/:/ # vi /etc/sysconfig/xt
      CRON_SPOOL_BASE_DIR=/ufs/cron
      default/:/ # exit
      ```

b. Start an `xtopview` shell to access all login nodes by class and configure the spool directory to be shared among all nodes of class `login`.

```
boot:~ # xtopview -c login
class/login/:/ #
```

c. Edit the `/etc/init.d/boot.xt-local` file to add the following lines.

```
class/login/:/ # vi /etc/init.d/boot.xt-local
MYCLASS=`xtuname -C | tr -d [:space:]`
CRONSPOOL=`xtgetconfig CRON_SPOOL_BASE_DIR`
if [ "$MYCLASS" = "login" -a -n "$CRONSPOOL" ];then
  mv /var/spool/cron /var/spool/cron.$$
  ln -sf $CRONSPOOL /var/spool/cron
fi
```

d. Examine the `/etc/cron.hourly`, `/etc/cron.daily`, `/etc/cron.weekly`, and `/etc/cron.monthly` directories and change the file access permissions to enable or disable distributed cron scripts to meet your needs. To enable a script, invoke `chmod ug+x` to make the file executable. By default, `CLEinstall` removes the execute permission bit to disable all distributed cron scripts.

Caution: Some distributed scripts impact performance negatively on a CLE system. To ensure that all scripts are disabled, type the following:

```
class/login/:/ # find /etc/cron.hourly /etc/cron.daily \
/etc/cron.weekly /etc/cron.monthly \
-type f -follow -exec chmod ugo-x {} \;
```

e. Exit from the login class view.

```
class/login/:/ # exit
boot:~ #
```

f. Use the `xtservconfig` command to enable the `cron` service on a single login node; in this example, node 4.

```
boot:~ # xtopview -n 4
node/4/:/ # xtservconfig -n 4 add CRON
node/4/:/ # exit
```

The `cron` configuration becomes active on the next reboot. For more information, see the `xtservconfig`(8) man page.

6.9 Configuring the Load Balancer

Optional: The load balancer service is optional on systems that run CLE.

The load balancer can distribute user logins to multiple login nodes, allowing users to connect by using the same Cray host name, for example *xthostname*.

Two main components are required to implement the load balancer, the `lbnamed` service (on the SMW and Cray login nodes) and the site-specific domain name service (DNS).

When an external system tries to resolve *xthostname*, a query is sent to the site-specific DNS. The DNS server recognizes *xthostname* as being part of the Cray domain and shuttles the request to `lbnamed` on the SMW. The `lbnamed` service returns the IP address of the least-loaded login node to the requesting client. The client connects to the Cray system login node by using that IP address.

The CLE software installation process installs `lbnamed` in `/opt/cray-xt-lbnamed` on the SMW and in `/opt/cray/lbcd` on all service nodes. Configure `lbnamed` by using the `lbnamed.conf` and `poller.conf` configuration files on the SMW. For more information about configuring `lbnamed`, see the `lbnamed.conf`(5) man page.

Procedure 36. Configuring `lbnamed` on the SMW

1. Edit the `lbnamed.conf` file on the SMW to define the `lbnamed` host name, domain name, and polling frequency.

   ```
   smw:~# vi /etc/opt/cray-xt-lbnamed/lbnamed.conf
   ```

   For example, if `lbnamed` is running on the host name `smw.mysite.com`, set the login node domain to the same domain specified for the `$hostname`. The Cray system *xthostname* is resolved within the domain specified as `$login_node_domain`.

   ```
   $poller_sleep = 30;
   $hostname = "mycray-rsms.mysite.com";
   $lbnamed_domain = "mycray-lb.mysite.com";
   $login_node_domain = "mysite.com";
   $hostmaster = "rootmail.mysite.com";
   ```

2. Edit the `poller.conf` file on the SMW to configure the login node names.

   ```
   smw:~# vi /etc/opt/cray-xt-lbnamed/poller.conf
   #
   # groups
   # ------------------------
   # login     mycray1-mycray3

   mycray1 1 login
   mycray2 1 login
   mycray3 1 login
   ```

   Note: Because `lbnamed` runs on the SMW, `eth0` on the SMW must be connected to the same network from which users log on to the login nodes. Do not put the SMW on the public network.

Procedure 37. Installing the load balancer on an external "white box" server

> **Optional:** Install `lbnamed` on an external "white box" server as an alternative to installing it on the SMW. **Cray does not test or support this configuration.**

A "white box" server is any workstation or server that supports the `lbnamed` service.

1. Shut down and disable `lbnamed`.

   ```
   smw:~# /etc/init.d/lbnamed stop
   smw:~# chkconfig lbnamed off
   ```

2. Locate the `cray-xt-lbnamed` RPM on the `Cray CLE 3.1.UP`*nn* `Software` media and install this RPM on the "white box." Do **not** install the `lbcd` RPM.

3. Follow the instructions in the `lbnamed.conf`(5) man page to configure `lbnamed`, taking care to substitute the name of the external server wherever `SMW` is indicated, then enable the service.

6.10 Configuring Node Health Checker (NHC)

For an overview of NHC (sometimes referred to as *NodeKARE*), see the `intro_NHC`(8) man page. For additional information about ALPS and how ALPS cooperates with NHC to perform application cleanup, see Chapter 8, Using the Application Level Placement Scheduler (ALPS) on page 235.

6.10.1 `/etc/opt/cray/nodehealth/nodehealth.conf` Configuration File

The NHC configuration file, `/etc/opt/cray/nodehealth/nodehealth.conf`, is located in the shared root. The CLE installation and upgrade processes automatically install and enable NHC software; there is no need for you to change any installation configuration parameters or issue any commands. However, you may edit the `/etc/opt/cray/nodehealth/nodehealth.conf` file to specify which NHC tests are to be run and to alter the behavior of NHC tests (including time-out values and actions for tests when they fail); configure time-out values for Suspect Mode and disable/enable Suspect Mode; or disable or enable NHC.

> **Note:** After you modify the `/etc/opt/cray/nodehealth/nodehealth.conf` file, the changes are reflected immediately the next time NHC runs.

Each CLE release package also includes an example NHC configuration file, `/opt/cray/nodehealth/default/etc/nodehealth.conf.example`. The `nodehealth.conf.example` file is a copy of the `/etc/opt/cray/nodehealth/nodehealth.conf` file provided for an initial installation.

Important: The `/etc/opt/cray/nodehealth/nodehealth.conf` file is not overwritten during a CLE upgrade if the file already exists. This preserves your site-specific modifications previously made to the file. However, you should compare your `/etc/opt/cray/nodehealth/nodehealth.conf` file content with the `/opt/cray/nodehealth/default/etc/nodehealth.conf.example` file provided with each release to identify any changes, and then update your `/etc/opt/cray/nodehealth/nodehealth.conf` file accordingly. If the `/etc/opt/cray/nodehealth/nodehealth.conf` file does **not** exist, then the `/opt/cray/nodehealth/default/etc/nodehealth.conf.example` file is copied to the `/etc/opt/cray/nodehealth/nodehealth.conf` file.

To use an alternate NHC configuration file, use the `xtcleanup_after -f` *alt_NHCconfigurationfile* option to specify which NHC configuration file to use with the `xtcleanup_after` script. For additional information, see the `xtcleanup_after`(8) man page.

6.10.2 Configuring Node Health Checker Tests

Edit the `/etc/opt/cray/nodehealth/nodehealth.conf` file to configure the NHC tests that will test compute node functionality. All tests that are enabled will run when NHC is in either Normal Mode or in Suspect Mode. Tests run in parallel, independently of each other, except for the `Free Memory Check` test, which requires that the `Application Exited Check` test passes before the `Free Memory Check` test begins.

The `xtcheckhealth` binary runs the NHC tests; for information about the `xtcheckhealth` binary, see the `intro_NHC`(8) and `xtcheckhealth`(8) man pages.

The NHC tests are listed below. In the default NHC configuration file, each test that is enabled starts with an action of `admindown`, except for the `Free Memory Check`, which starts with an action of `log`.

Important: Also read important test usage information in Guidance About NHC Tests on page 160.

- `Application Exited Check`, which verifies that any remaining processes from the most recent application have terminated.

  The `Application Exited Check` test checks locally on the compute node to see if there are processes running under the ID of the application (APID). If there are processes running, then NHC waits a period of time (set in the configuration file) to determine if the application processes exit properly. If the process does not exit within that time, then this test fails.

The `Application Exited Check` test is enabled in the default NHC configuration file.

- `Apinit Ping`, which verifies that the ALPS daemon is running on the compute node and is responsive.

  The `Apinit Ping` test queries the status of the `apinit` daemon locally on each compute node; if the `apinit` daemon does not respond to the query, then this test fails.

  The `Apinit Ping` test is enabled in the default NHC configuration file.

- `Free Memory Check`, which examines how much memory is consumed on a compute node while applications are not running. The `Application Exited Check` test must complete before the `Free Memory Check` test begins, ensuring that the application has exited the compute node and is not inflating the memory usage.

  The `Free Memory Check` test is enabled in the default NHC configuration file; however, its action is `log` only.

- `Filesystem`, which ensures that the compute node is able to perform simple I/O to the specified file system. For a file system that is mounted read-write, the test performs a series of operations on the file system to verify the I/O. A file is created, written, flushed, synced, and deleted. If a mount point is not explicitly specified, the mount point(s) from the compute node `/etc/fstabs` file will be used and a `Filesystem` test will be created for each mount point found in the file. If a mount point is explicitly specified, then only that file system will be checked. You can specify multiple `FileSystem` tests by placing multiple `Filesystem` lines in the configuration file. One line could specify the implicit `Filesystem` test. The next line could specify a specific file system that does not appear in `/etc/fstab`. This could continue for any and all file systems.

  If you enable the `Filesystem` test, you can place an optional line (such as, Excluding: `FileSystem-foo`) in the `/etc/opt/cray/nodehealth/nodehealth.conf` configuration file that allows you to list mount points that should **not** be tested by the `Filesystem` test. This allows you to intentionally exclude specific mount points even though they appear in the `fstab` file. This action prevents NHC from setting nodes to `admindown` because of errors on relatively benign file systems. Explicitly specified mount points cannot be excluded in this fashion; if they should not be checked, then they should simply not be specified.

  The `Filesystem` test is enabled in the default NHC configuration file.

- `Plugin`, which allows scripts and executables not built into NHC to be run, provided they are accessible on the compute node. No plugins are configured by default and the `Plugin` test is disabled in the default NHC configuration file so that local configuration settings may be used.

For information about writing a plugin test, see *Writing a Node Health Checker (NHC) Plugin Test*.

Individual tests may appear multiple times in the `/etc/opt/cray/nodehealth/nodehealth.conf` file, with different variable values. Every time a test is specified in the `/etc/opt/cray/nodehealth/nodehealth.conf` file, NHC will run that test. This means if the same line is specified five times, NHC will try to run that same test five times. This functionality is mainly used in the case of the `Plugin` test, allowing you to specify as many additional tests as you want to write, or the `Filesystem` test, allowing you to specify as many additional file systems as you want. However, any test can be specified to run any number of times. Different parameters and test actions can be set for each test. For example, this could be used so that you can set up hard limits and soft limits for the `Free Memory Check` test. Two `Free Memory Check` tests could be specified in the configuration file; the first test configured to only warn about small amounts of non-free memory, and the second test configured to `admindown` a node that has large amounts of non-free memory. See the `/etc/opt/cray/nodehealth/nodehealth.conf` file for configuration information.

6.10.2.1 Guidance About NHC Tests

Guidance about the `Application Exited Check` and `Apinit Ping` tests: These two tests must be enabled and both tests must have their action set as `admindown` or `die`; otherwise, NHC runs the risk of allowing ALPS to enter a live-lock. ALPS must guarantee the following two things about the nodes in a reservation before releasing that reservation: 1) ALPS must guarantee that ALPS is functioning on the nodes, and 2) ALPS must guarantee that the previous application has exited from the nodes. Either those two things are guaranteed or the nodes must be set to some state other than `up`. When either ALPS has guaranteed the two things about the nodes or the nodes have been set to some state other than `up`, then ALPS can release the reservation. These two NHC tests guarantee those two things: 1) the `Apinit_ping` test guarantees that ALPS is functioning on the nodes, and 2) the `Application_Exited_Check` test guarantees that the previous application has exited from the nodes. If either test fails, then NHC sets the nodes to `suspect` state (if Suspect Mode is enabled; otherwise, NHC sets the nodes to `admindown`). In the end, either the nodes pass those tests, or the nodes are no longer in the `up` state. In either case, ALPS is free to release the reservation and the live-lock is avoided. However, this only happens if the two tests are enabled and their action is set as `admindown` or `die`. The `log` action does not suffice because it does not change the state of the nodes. If either test is disabled or has an action of `log`, then ALPS may live-lock. In this live-lock, ALPS will call NHC endlessly.

Guidance about the `Filesystem` test: The NHC `Filesystem` test can take an explicit argument – the mount point of the file system – or no argument. If an argument is provided, then the `Filesystem` test is referred to as an explicit `Filesystem` test. If no argument is given, the `Filesystem` test is referred to as an implicit `Filesystem` test.

The explicit `Filesystem` test will test the file system located at the specified mount point.

The implicit `Filesystem` test will test each file system listed in the `/etc/fstab` file on each compute node. The implicit `Filesystem` test is enabled by default in the NHC configuration file.

The `Filesystem` test will determine whether a file system is mounted read-only or read-write. If the file system is mounted read-write, then NHC will attempt to write to it. If it is mounted read-only, then NHC will attempt to read the directory entities "." and ".." in the file system to guarantee, at a minimum, that the file system is readable.

Some file systems are mounted on the compute nodes as read-write file systems, while their underlying permissions are read-only. As an example, for an auto-mounted file system, the base mount-point may have read-only permissions; however, it could be mounted as read-write. It would be mounted as read-write, so that the auto-mounted sub-mount-points could be mounted as read-write. The read-only permissions prevent tampering with the base mount-point. In a case such as this, the `Filesystem` test would see that the base mount-point had been mounted as a read-write file system. The `Filesystem` test would try to write to this file system, but the write would fail due to the read-only permissions. Because the write fails, then the `Filesystem` test would fail, and NHC would incorrectly decide that the compute node is unhealthy because it could not write to this file system. For this reason, file systems that are mounted on compute nodes as read-write file systems, but are in reality read-only file systems, should be excluded from the implicit `Filesystem` test.

You can exclude tests by adding an "Excluding: *file system mount point*" line in the NHC configuration file. See the NHC configuration file for further details and an example.

A file system is deemed a critical file system if it is needed to run applications. All systems will likely need at least one shared file system for reading and writing input and output data. Such a file system would be a critical file system. File systems that are not needed to run applications or read and write data would be deemed as noncritical file systems. You need to determine the criticality of each file system.

Cray recommends the following:

- Excluding noncritical file systems from the implicit `Filesystem` test. See the NHC configuration file for further details and an example.
- If there are critical file systems that do not appear in the `/etc/fstab` file on the compute nodes (such file systems would not be tested by the implicit `Filesystem` test), these critical file systems should be checked via explicit `Filesystem` tests. You can add explicit `Filesystem` tests to the NHC configuration file by providing the mount point of the file system as the final argument to the `Filesystem` test. See the NHC configuration file for further details and an example.
- If you have a file system that is mounted as read-write but it has read-only permissions, you should exclude it from the implicit `Filesystem` test. NHC does not support such file systems.

Guidance about the NHC `Lustre` file system test: The Lustre file system has its own hard time-out value that determines the maximum time that a Lustre recovery will last. This time-out value is called `RECOVERY_TIME_HARD`, and it is located in the file system's `fs_defs` file. The default value for the `RECOVERY_TIME_HARD` is fifteen minutes.

> **Important:** The time-out value for the NHC `Lustre` file system test should be **twice** the `RECOVERY_TIME_HARD` value.
> The default in the NHC configuration file is thirty minutes, which is twice the default `RECOVERY_TIME_HARD`. If you change the value of `RECOVERY_TIME_HARD`, you must also correspondingly change the time-out value of the NHC `Lustre` file system test.

The NHC time-out value is specified on this line in the NHC configuration file:

```
# Lustre: <warning time-out> <test time-out> <restart delay>
Lustre: 900 1800 60
```

If you change the `RECOVERY_TIME_HARD` value, you must change the `1800` seconds (thirty minutes) to reflect your new `RECOVERY_TIME_HARD` multiplied by two.

Further, the overall time-out value of NHC's Suspect Mode is based on the maximum time-out value for all of the NHC tests. Invariably, the NHC `Lustre` file system test has the longest time-out value of all the NHC tests.

Important: If you change the NHC `Lustre` file system test time-out value, then you must also change the time-out value for Suspect Mode. The time-out value for Suspect Mode is set by the `suspectend` variable in the NHC configuration file. The guidance for setting the value of `suspectend` is that it should be the maximum time-out value, plus an additional buffer. In the default case, `suspectend` was set to thirty-five minutes – thirty minutes for the Lustre test, plus an additional five-minute buffer. For more information about the `suspectend` variable, see Suspect Mode on page 165.

6.10.2.2 Global Configuration Variables That Affect All NHC Tests

The following global configuration variables may be set in the `/etc/opt/cray/nodehealth/nodehealth.conf` file to alter the behavior of all NHC tests. The global configuration variables are case-insensitive.

`Runtests:` *Frequency*

Determines how frequently NHC tests are run on the compute nodes. *Frequency* may be either `errors` or `always`. When the value `errors` is specified, the NHC tests are run only when an application terminates with a non-zero error code or terminates abnormally. When the value `always` is specified, the NHC tests are run after every application termination. If you do not specify the `Runtests` global variable, the implicit default is `errors`.

`Connecttime:` *TimeoutSeconds*

Specifies the amount of time, in seconds, that NHC waits for a node to respond to requests for the TCP connection to be established. If Suspect Mode is disabled and a particular node does not respond after `connecttime` has elapsed, then the node is marked `admindown`. If Suspect Mode is enabled and a particular node does not respond after `connecttime` has elapsed, then the node is marked `suspect`. Then, NHC will attempt to contact the node with a frequency established by the `recheckfreq` variable. (For information about Suspect Mode and the `recheckfreq` variable, see Suspect Mode on page 165.)

If you do not specify the `Connecttime` global variable, then the implicit default TCP time-out value is used. NHC will not enforce time-out on the connections if none is specified. The `Connecttime`: *TimeoutSeconds* value provided in the default NHC configuration file is `60` seconds.

6.10.2.3 Standard Variables That Affect Individual NHC Tests

The following four variables are used with each NHC test; set each variable for each test. All variables are case-insensitive. Each NHC test has values supplied for these variables in the default NHC configuration file.

> **Note:** Specific NHC tests require additional variables, which are defined in the `nodehealth` configuration file.

action

Specifies the action to perform if the compute node fails the given NHC test. *action* may have one of the following values:

- `log` — Logs the failure to the system console log; the `log` action will not cause a compute node's state to be set to `admindown`.

  > **Important:** Tests that have an action of `Log` do **not** run in Suspect Mode. If you use plugin scripts with an action of `Log`, the script will only be run once, in Normal Mode; this makes log collecting and various other maintenance tasks easier to code.

- `admindown` — Sets the compute node's state to `admindown` (no more applications will be scheduled on that node) and logs the failure to the system console log.

  If Suspect Mode is enabled, the node will first be set to `suspect` state, and if the test continues to fail, the node will be set to `admindown` at the end of Suspect Mode.

- `die` — Halts the compute node so that no processes can run on it, sets the compute node's state to `admindown`, and logs the failure to the system console log. (The `die` action is the equivalent of a kernel panic.)

  > **Note:** This action is good for catching bugs because the state of the processes is preserved and can be dumped at a later time.

Each subsequent action includes the actions that preceded it; for example, the `die` action encompasses the `admindown` and `log` actions.

> **Note:** If NHC is running in Normal Mode and cannot contact a compute node, and if Suspect Mode is not enabled, NHC will set the compute node's state to `admindown`.

warntime

Specifies the amount of test time, in seconds, that should elapse before `xtcheckhealth` logs a warning message to the console file. This allows an administrator to take corrective action, if necessary, before the *testtime* is reached.

testtime
: Specifies the total time, in seconds, that a test should run before an error is returned by `xtcheckhealth` and the specified *action* is taken.

restart_delay
: Valid only when NHC is running in Suspect Mode. Specifies how long NHC will wait, in seconds, to restart the test after the test fails.

6.10.3 Suspect Mode

Upon entry into Suspect Mode, NHC immediately allows healthy nodes to be returned to the resource pool. Suspect Mode allows the remaining nodes, which are all in `suspect` state, an opportunity to return to healthiness. If the nodes do not return to healthiness by the end of the Suspect Mode (determined by the `suspectend` global variable; see below), their states are set to `admindown`. For more information about how Suspect Mode functions, see the `intro_NHC`(8) man page.

Important: Suspect Mode is enabled in the default `/etc/opt/cray/nodehealth/nodehealth.conf` configuration file. Cray Inc. recommends that you run NHC with Suspect Mode enabled.

If enabled, the default NHC configuration file provided from Cray Inc. uses the following Suspect Mode variables:

`suspectenable:`
: Enables Suspect Mode; valid values are `y` and `n`. The `/etc/opt/cray/nodehealth/nodehealth.conf` configuration file provided from Cray Inc. has this variable set as `suspectenable: y`.

`suspectbegin:`
: Sets the Suspect Mode timer. Suspect Mode starts after the number of seconds indicated by `suspectbegin` have expired. The `/etc/opt/cray/nodehealth/nodehealth.conf` configuration file provided from Cray Inc. has this variable set as `suspectbegin: 180`.

`suspectend:`
: Suspect Mode ends after the number of seconds indicated by `suspectend` have expired. This timer only starts after NHC has entered Suspect Mode. The `/etc/opt/cray/nodehealth/nodehealth.conf` configuration file provided from Cray Inc. has this variable set as `suspectend: 2100`.

Considerations when evaluating shortening the length of Suspect Mode:

- You can shorten the length of Suspect Mode if you do not have external file systems, such as Lustre, that NHC would be checking.
- The length of Suspect Mode should be at least a few seconds longer than the longest time-out value for any of the NHC tests. For example, if the `Filesystem` test had the longest time-out value at 900 seconds, then the length of Suspect Mode should be at least 905 seconds.
- The longer Suspect Mode is, the longer nodes have to recover from any unhealthy situations. Setting the length of Suspect Mode too short reduces this recovery time and increases the likelihood of the nodes being marked `admindown` prematurely.

`recheckfreq:`

Suspect Mode rechecks the health of the nodes in `suspect` state at a frequency specified by `recheckfreq`. This value is in seconds. The `/etc/opt/cray/nodehealth/nodehealth.conf` configuration file provided from Cray Inc. has this variable set as `recheckfreq: 300`. (For a detailed description about NHC actions during the recheck process, see the `intro_NHC`(8) man page.)

6.10.4 NHC Messages

NHC messages are sent though the `ec_console_log` event with `'<node_health:`*M*`.`*m*`>'` in the message, where *M* is the major and *m* is the minor NHC revision number. All NHC messages are visible in the console file.

NHC prints a summary message per node at the end of Normal Mode and Suspect Mode when at least one test has failed on a node. For example:

```
<node_health:3.1> APID:100 (xtnhc) FAILURES: The following tests have failed in normal mode:
<node_health:3.1> APID:100 (xtnhc) FAILURES: (Admindown) Apinit_Ping
<node_health:3.1> APID:100 (xtnhc) FAILURES: (Admindown) Plugin /example/plugin
<node_health:3.1> APID:100 (xtnhc) FAILURES: (Log Only ) Filesystem_Test on /mydir
<node_health:3.1> APID:100 (xtnhc) FAILURES: (Admindown) Free_Memory_Check
<node_health:3.1> APID:100 (xtnhc) FAILURES: End of list of 5 failed test(s)
```

The `xtcheckhealth` error and warning messages include node IDs and application IDs and are written to the console file on the SMW; for example:

```
[2010-04-05 23:07:09][c1-0c2s0n0]<node_health:3.0> APID:2773749
(check_apid) WARNING: Failure: File /dev/cpuset/2773749/tasks exists and is not empty. \
The following processes are running under expired APID
2773749:
[2010-04-05 23:07:09][c1-0c2s0n1]<node_health:3.0> APID:2773749
(check_apid) WARNING: Pid:   300 Name:           (marys_program) State: D
```

The `xtcleanup_after` script writes its normal launch information to the `/var/log/xtcheckhealth_log` file, which resides on the login nodes. The `xtcleanup_after` launch information includes the time that `xtcleanup_after` was launched and the `xtcleanup_after`'s call to `xtcheckhealth`.

The `xtcleanup_after` script writes error output (launch failure information) to the `/var/log/xtcheckhealth_log` file, to the console file on the SMW, and to the syslog.

Example `xtcleanup_after` output follows:

```
Thu Apr 22 17:48:18 CDT 2010 <node_health> (xtcleanup_after) \
/opt/cray/nodehealth/3.0-1.0000.20840.30.8.ss/bin/xtcheckhealth -a 10515 \
-e 1 /tmp/apsysLVNqO9 /etc/opt/cray/nodehealth/nodehealth.conf
```

6.10.5 What if a Login Node Crashes While `xtcheckhealth` Binaries are Monitoring Nodes?

If a login node crashes while some `xtcheckhealth` binaries on that login node are monitoring compute nodes that are in `suspect` state, those `xtcheckhealth` binaries will die when the login node crashes. When the login node that crashed is rebooted, a recovery action takes place. When the login node boots, the `node_health_recovery` binary starts up. This script checks for all compute nodes that are in `suspect` state and were last set to `suspect` state by this login node. The script then determines the APID of the application that was running on each of these compute nodes at the time of the crash. The script then launches an `xtcheckhealth` binary to monitor each of these compute nodes. One `xtcheckhealth` binary is launched per compute node monitored.

`xtcheckhealth` will be launched with this APID, so it can test for any processes that may have been left behind by that application. This testing only takes place if the `Application_Exited_Check` test is enabled in the configuration file. (The `Application_Exited_Check` test is enabled in the default NHC configuration file.) If the `Application_Exited_Check` test is not enabled, when the recovery action takes place, NHC does not run the `Application_Exited_Check` test and will not check for leftover processes. However, it will run any other NHC tests that are enabled in the configuration file.

Nodes will be changed from `suspect` state to `up` or `admindown`, depending upon whether they fail any health checks. No system administrator intervention should be necessary.

NHC automatically recovers the nodes in `suspect` state when the crashed login node is rebooted because the recovery feature runs on the rebooted login node. If the crashed login node is not rebooted, then manual intervention is required to rescue the nodes from `suspect` state. This manual recovery can commence as soon as the login node has crashed. To recover from a login node crash during the case in which a login node will not be rebooted, the `nhc_recovery` binary is provided to help you release the compute nodes owned by the crashed login node; see Procedure 38 on page 168. Also, see the `nhc_recovery`(8) man page for a description of the `nhc_recovery` binary usage.

Procedure 38. Recovering from a login node crash when a login node will not be rebooted

1. Create a *nodelistfile* that contains a list of the nodes in the system that are currently in Suspect Mode. The file must be a list of NIDs, one per line; do not include a blank line at the end of the file.

2. To list all of the `suspect` nodes in the system and which login nodes own those nodes, execute the following command; use the *nodelistfile* you created in step 1.

   `nhc_recovery -d` *nodelistfile*

3. Parse the `nhc_recovery` output for the NID of the login node that crashed. The file (for example, name it `nodelistfile_computenodes`) of this parsed list should contain all of the compute nodes owned by the crashed login node.

4. If you plan to recover the `suspect` nodes by using option 6 a below, then complete this step; otherwise, skip this step.

   Note: This recovery method is recommended.

   From the list you created in step 3, create *nodelistfile*s containing nodes that share the same APID to determine the nodes from the crashed login node. For example, your *nodelistfile*s can be named `nodelistfile-APID1`, `nodelistfile-APID2`, `nodelistfile-APID3`, and so on.

5. Using the file you created in step 3, release all of the `suspect` compute nodes owned by the crashed login node. Execute the following command:

   `nhc_recovery -r` *nodelistfile_computenodes*

6. All of these compute nodes have been released in the database. However, they are all still in `suspect` state. Determine what to do with these `suspect` nodes from the following three options:

   a. (Cray recommends this option) Rerun NHC on a non-crashed login node to recover the nodes listed in step 4. Invoke NHC for each *nodelistfile*. Supply as the APID argument the APID that corresponds to the *nodelistfile*; an iteration count of `0` (zero), which is the value normally supplied to NHC by ALPS; and an application exit code of `1` (one). An exit code of `1` ensures that NHC will run regardless of the value of the `runtests` variable (`always` or `errors`) in the NHC configuration file. For example:

   ```
   xtcleanup_after -s nodelistfile-APID1  APID1  0  1
   xtcleanup_after -s nodelistfile-APID2  APID2  0  1
   xtcleanup_after -s nodelistfile-APID3  APID3  0  1
   .
   .
   .
   ```

   b. These `suspect` nodes can be set to `admindown` and their fate determined by further analysis.

   c. These `suspect` nodes can be set back to `up`, but they were in Suspect Mode for a reason.

6.10.6 Disabling NHC

To disable NHC entirely, set the value of the *nhcon* global variable in the `/etc/opt/cray/nodehealth/nodehealth.conf` file to `off` (the default value in the file provided from Cray Inc. is `on`).

6.10.7 `nodehealth` Modulefile

To gain access to the NHC functions, the `nodehealth` module must be loaded. The `admin-modules` module file loads the `nodehealth` module, or you can load the `nodehealth` module by executing the following command:

```
module load nodehealth
```

The `Base-opts.default.local` file includes the `admin-modules` module file. For additional information about the `Base-opts.default.local` file, see System-wide Default Modulefiles on page 116.

6.10.8 Configuring the Node Health Checker to Use SSL

If your site requires authentication and authorization to protect access to compute nodes, you can configure compute nodes to perform node health checking by using the `openssl` utility and secure sockets layer (SSL) protocol. SSL provides optional security functionality for NHC.

To enable the use of SSL the following files must be setup in the `.nodehealth` directory within the home directory of the root user on both the login node(s) and compute nodes:

- `rsa_key`
- `servercsr`
- `rsa_cert`

The files and the `.nodehealth` directory must have their permissions set to `0700` for maximum security. The same files must be used on both the login and compute nodes. If the files are not identical on both the login and compute nodes, the node health infrastructure will not run and a message similar to the following will be displayed:

```
server authentication failed
node health configuration error
```

Procedure 39. Configuring the Node Health Checker (NHC) to use SSL

Follow these steps to configure NHC to use SSL.

Caution: This process should be performed with all compute nodes down.

Note: The shared root and compute image changes must both be made to ensure they both assume SSL is being used.

1. Create the SSL configuration in the shared root.
2. As user `root`, create SSL key information in the shared root and modify the correct permissions and ownership groups.

```
boot:~ # xtopview
boot:~ # mkdir /root/.nodehealth
boot:~ # chmod 700 /root/.nodehealth
boot:~ # openssl genrsa -out /root/.nodehealth/rsa_key 1024
boot:~ # openssl req -new -key /root/.nodehealth/rsa_key \
-out /root/.nodehealth/servercsr
    (answer the questions as appropriate - defaults work fine)
boot:~ # openssl x509 -req -days 365 -in /root/.nodehealth/servercsr \
-signkey /root/.nodehealth/rsa_key -out /root/.nodehealth/rsa_cert
    (the certificate expiration time is not used)
boot:~ # chown 700 /root/.nodehealth/*
boot:~ # exit
```

3. As `root` and on the SMW, update the compute node image with the required libraries. These libraries are `/usr/lib64/libssl.so` and `/usr/lib64/libcrypto.so`. Link and file name structures must be maintained exactly as they exist (note the version number (e.g. `0.9.8`) may be different).

```
lrwxrwxrwx 1 root root     15 Feb 14  2008 /usr/lib64/libssl.so -> libssl.so.0.9.8
-r-xr-xr-x 1 root root 290728 Oct 17  2007 /usr/lib64/libssl.so.0.9.8

lrwxrwxrwx 1 root root      18 Feb 14  2008 /usr/lib64/libcrypto.so -> libcrypto.so.0.9.8
-r-xr-xr-x 1 root root 1464704 Oct 17  2007 /usr/lib64/libcrypto.so.0.9.8
```

   For example, if the compute node image was located in the directory `compute`, on the SMW you would do:

```
smw:~ # cd compute/lib64
smw:~ # cp /usr/lib64/libssl.so.0.9.8 .
smw:~ # ln -s libssl.so.0.9.8 libssl.so
smw:~ # cp /usr/lib64/libcrypto.so.0.9.8 .
smw:~ # ln -s libcrypto.so.0.9.8 libcrypto.so
```

4. As `root` and on the SMW, move the SSL key data to the compute node image by copying the files `/root/.nodehealth/rsa_key` and `/root/.nodehealth/rsa_cert` that you created in step 2 to the `/opt/xtimages/templates/default/root/.nodehealth` directory.

   For example, if the compute node image was located in the directory `compute`, you would do:

```
smw:~ # cd compute/root
smw:~ # mkdir .nodehealth
smw:~ # chmod 700 .nodehealth
smw:~ # scp root@boot: /rr/current/root/.nodehealth/rsa_key .nodehealth
smw:~ # scp root@boot: /rr/current/root/.nodehealth/rsa_cert .nodehealth
```

5. Create a new `cpio` file of the compute node image.

6. Reboot the compute nodes.

6.11 Activating Process Accounting for Service Nodes

The GNU 6.4 accounting package uses Berkeley Software Design (BSD) type process accounting. The GNU 6.4 process accounting is enabled for the Cray system's service nodes. The package name is `acct`; it can be activated using the `acct` boot script. To enable the `acct` boot script, execute the following command on the boot node root and/or shared root:

```
boot:~ # chkconfig acct on
```

The GNU 6.4 process accounting utilities process V2 and V3 format records seamlessly, even if the data is written to the same file. Output goes to an accounting file, which by default is `/var/account/pacct`. The accounting utilities provided for administration use are: `ac`, `lastcomm`, `accton`, and `sa`. The related man pages are accessible by using the `man` command.

6.12 Configuring Failover for Boot and SDB Nodes

The boot node is integral to the operation of a Cray system. Critical services like the Application Level Placement Scheduler (ALPS) and Lustre rely on the SDB and will fail if the SDB node is unavailable. The CLE release provides functionality to create standby boot and SDB nodes that automatically act as a backup in the event of primary node failure. Failover allows the system to keep running without an interrupt to the system or system services.

Note: The boot-node and SDB node failover features do not provide a failback capability.

A virtual network is configured for the boot and SDB nodes to support failover for these nodes. The virtual network is configured by default, regardless of the boot or SDB node failover configuration on your system.

The `CLEinstall` program provides the capability to change the default virtual network configuration, however, the default values are acceptable is most cases. For more information, see *Installing and Configuring Cray Linux Environment (CLE) Software* or the `CLEinstall.conf`(5) man page.

6.12.1 Configuring Boot-node Failover

When you configure a secondary (backup) boot node, boot-node failover occurs automatically when the primary boot node fails.

The following services run on the boot node:

- NFS shared root (read-only)
- NFS persistent `/var` (read-write)
- Boot node daemon, `bnd`
- Hardware supervisory system (HSS) and system database (SDB) synchronization daemon, `xtdbsyncd`
- ALPS daemons `apbridge`, `apres`, and `apwatch` (for information about configuring ALPS, see Chapter 8, Using the Application Level Placement Scheduler (ALPS) on page 235)

When the primary boot node is booted, the backup boot node also begins to boot. However, the backup boot node makes a call to the `rca-helper` utility before it mounts its root file system, causing the backup boot node to be suspended until a primary boot-node failure event is detected.

The `rca-helper` daemon running on the backup boot node waits for a primary boot-node failure event, `ec_node_failed`. When the heartbeat of the primary boot node stops, the L0 begins the heartbeat checking algorithm to determine if the primary boot node has failed. When the L0 determines that the primary boot node has failed, it sends an `ec_heartbeat_stop` event to set the alert flag for the primary node. The primary boot node is halted through STONITH. Setting the `alert` flag on the node triggers the HSS state manager on the SMW to send out the `ec_node_failed event`.

When the `rca-helper` daemon running on the backup boot node receives an `ec_node_failed` event alerting it that the primary boot node has failed, it allows the boot process of the backup boot node to continue. Any remaining boot actions occur on the backup boot node. Booting of the backup boot node takes approximately two minutes.

Each service node runs a failover manager daemon (`fomd`). When each service node's `fomd` receives the `ec_node_failed` event, it takes appropriate action. The `fomd` process updates the arp cache entry for the boot node virtual IP address to reference the backup boot node.

The purpose of this implementation of boot-node failover is to ensure that the system continues running, not to guarantee that every job will continue running. Therefore, note the following:

- During the time the primary boot node has failed, any service node that tries to access its root file system will be I/O blocked until the backup boot node is online, at which time the request will be satisfied and the operation will resume. In general, this means if an application is running on a service node, it can continue to run if the application is in memory and does not need to access disk. If it attempts to access disk for any reason, it will be blocked until the backup boot node is online.

- Applications running on compute nodes are affected only if they cause a service node to access its root file system, in which case the service node function would be blocked until the backup boot node is online.

The following is a list of requirements for configuring your system for boot-node failover:

- The backup boot node must have a Fibre Channel card connected to the boot RAID.

  Note: You must configure the backup boot node in the same zone as the primary boot node.

- You must ensure that the boot RAID host port can see the desired LUNs; for DDN, use the host port mapping; for LSI (Engenio), use SANshare in the SANtricity Storage Manager.
- The backup boot node also requires a Gigabit Ethernet card connected via a Gigabit Ethernet switch to the same port on the SMW as the primary boot node (typically port 4 of the SMW quad Ethernet card).
- You must enable the STONITH capability on the blade or module of the primary boot node in order to use the boot node failover feature. STONITH is a per blade setting and not a per node setting. Ensure that your primary boot node is located on a separate blade from services with conflicting STONITH requirements, such as Lustre.

Procedure 40. Configuring boot-node failover

Note: If you configured boot-node failover during your CLE software installation or upgrade (as documented in the *Installing and Configuring Cray Linux Environment (CLE) Software*), this procedure is not needed.

1. Halt the primary and alternate boot nodes.

   Warning: Verify that your system is shut down before you invoke the `xtcli halt` command.

   ```
   smw:~# xtcli halt primary_id, backup_id
   ```

2. Update the default boot configuration used by the boot manager to boot nodes by using the `xtcli` command:

```
crayadm@smw:~> xtcli boot_cfg update -b primary_id, backup_id -i /tmp/boot/kernel.cpio
```

OR

If you are using `/raw0`, use the following command:

```
crayadm@smw:~> xtcli boot_cfg update -i /raw0
```

If you are using partitions, use the following command to designate the primary boot node and the backup boot node:

```
crayadm@smw:~> xtcli part_cfg update pN -b primary_id,backup_id -i /tmp/boot/kernel.cpio
```

OR

If you are using `/raw0`, use the following command:

```
crayadm@smw:~> xtcli part_cfg update pN -i /raw0
```

3. Update the `CLEinstall.conf` file to designate the primary and backup boot nodes so the file has the correct settings when you do your next upgrade.

4. Boot the boot node.

5. The STONITH capability must be enabled on the blade of the primary boot node in order to use the boot-node failover feature.

   Caution: STONITH is a per blade setting, not a per node setting. You must ensure that your primary boot node is not assigned to a blade that hosts services with conflicting STONITH requirements, such as Lustre.

   a. Use the `xtdaemonconfig` command to determine the current STONITH setting on your primary boot node. For example, if the primary boot node is `c0-0c0s0n1` located on blade `c0-0c0s0`, type this command:

      Note: If you have a partitioned system, invoke these commands with the `--partition p`*n* option.

      ```
      crayadm@smw:~> xtdaemonconfig c0-0c0s0 | grep stonith
      c0-0c0s0: stonith=false
      ```

   b. To enable STONITH on your primary boot node, execute the following command:

      ```
      crayadm@smw:~> xtdaemonconfig c0-0c0s0 stonith=true
      c0-0c0s0: stonith=true
      The expected response was received.
      ```

   c. The STONITH setting does not survive a power cycle. You can maintain the STONITH setting for the primary boot node by adding the following line to your boot automation file:

```
# boot bootnode:
lappend actions {crms_exec "xtdaemonconfig c0-0c0s0 stonith=true"}
```

6. Boot the system.

Procedure 41. Disabling boot-node failover

- To disable boot-node failover, type these commands; in this example procedure, the primary boot node is `c0-0c0s0n1` and the backup boot node is `c0-0c0s3n1`.

  ```
  crayadm@smw:~> xtcli halt c0-0c0s0n1,c0-0c0s3n1
  crayadm@smw:~> xtcli boot_cfg update -b c0-0c0s0n1,c0-0c0s0n1
  crayadm@smw:~> xtdaemonconfig c0-0c0s0 stonith=false
  ```

6.12.2 Configuring SDB Node Failover

When you configure a secondary (backup) SDB node, SDB node failover occurs automatically when the primary SDB node fails.

The CLE implementation of SDB node failover includes installation configuration parameters that facilitate automatic configuration, a `chkconfig` service called `sdbfailover`, and a `sdbfailover.conf` configuration file for defining site-specific commands to invoke on the backup SDB node.

The backup SDB node uses `/etc` files that are class or node specialized for the primary SDB node and not for the backup node itself; the `/etc` files for the backup node will be identical to those that existed on the primary SDB node.

The following list summarizes requirements to implement SDB node failover on your Cray system.

- Designate a service node to be the alternate or backup SDB node. The backup SDB node requires a QLogic Host Bus Adapter (HBA) card to communicate with the RAID. This backup node is dedicated and cannot be used for other service I/O functions.

- Enable the STONITH capability on the blade or module of the primary SDB node in order to use the SDB node failover feature. STONITH is a per blade setting and not a per node setting. Ensure that your primary SDB node is located on a separate blade from services with conflicting STONITH requirements, such as Lustre.

- Enable SDB node failover by setting the `sdbnode_failover` parameter to **`yes`** in the `CLEinstall.conf` file prior to running the `CLEinstall` program.

  When this parameter is used to configure SDB node failover, the `CLEinstall` program will verify and turn on `chkconfig` services and associated configuration files for `sdbfailover`.

- Specify the primary and backup SDB nodes in the boot configuration by using the `xtcli` command with the `boot_cfg update -d` options. For more information, see the `xtcli`(8) man page.

- **(Optional)** Populate `/etc/opt/cray/sdb/sdbfailover.conf` with site-specific commands.

  When a failover occurs, the backup SDB node invokes all commands listed in the `/etc/opt/cray/sdb/sdbfailover.conf` file. Include commands in this file that are normally invoked during system start-up via boot automation scripts. In a SDB node failover situation, these commands must be invoked on the new (backup) SDB node. For example, you may include commands to start batch system software (if not started via `chkconfig`) or commands to add a route to an external license server.

If at any time you reconfigure your system to use a different primary SDB node, you must enable STONITH for the new SDB node and disable STONITH for the previous node.

For procedures to configure SDB node failover during a CLE software installation, see *Installing and Configuring Cray Linux Environment (CLE) Software*.

6.12.3 Compute Node Failover Manager

The compute node failover manager daemon (`cnfomd`) facilitates communication from the compute nodes to the backup boot or SDB node in the event of a primary boot or SDB node failure. When a node failed event from the primary boot or SDB node is detected, `cnfomd` updates the ARP cache entries for the boot or SDB node virtual IP address to point to the backup node. The daemon runs on the compute nodes and is similar to the failover manager daemon (`fomd`) on the service nodes. If both boot and SDB node failover are disabled, the `cnfomd` process exits immediately after start up.

This functionality is included in the `cray-rca-compute` RPM and is installed by default.

6.13 Creating Logical Machines

Logical Machines on page 63, introduces logical machines. Configure a logical machine (sometimes known as a *system partition*) with the `xtcli part_cfg` command.

Partition IDs are predefined as `p0` to `p31`. The default partition `p0` is reserved for the complete system.

6.13.1 Creating Routable Logical Machines

A routable logical machine is generally one that is logically a cube. The topology class of the system indicates how the system is physically cabled together, which in turn, determines the logical structure of the system. It is easiest to describe the routing based on physical location. Because it is impossible to route around some types of failures without a torus in the z-dimension, do not divide the system in a way that breaks the z-dimension torus.

6.13.1.1 Topology Class 0

These are the smallest systems. A topology class 0 system can contain one to nine chassis in up to three cabinets. Each chassis has its y- and z-dimensions looped back on itself. The chassis are connected in the x-dimension.

To partition the system, you break up the configuration in the x-dimension by grouping a number of chassis together. Thus, you need to know the order in which the chassis are cabled together to define your partitions. Table 7 shows the order of the chassis. The last chassis in the list is cabled back to the first chassis in the list to complete the torus.

Table 7. Topology 0 Chassis Layout

Number of Chassis	Order of Chassis in x-Dimension
1	c0-0c0
2	c0-0c0,c0-0c1
3	c0-0c0,c0-0c1,c0-0c2
4	c0-0c0,c0-0c1,c0-0c2,c1-0c1
5	c0-0c0,c0-0c1,c0-0c2,c1-0c1,c1-0c0
6	c0-0c0,c0-0c1,c0-0c2,c1-0c2,c1-0c1,c1-0c0
7	c0-0c0,c0-0c1,c0-0c2,c1-0c2,c1-0c1,c2-0c0,c1-0c0
8	c0-0c0,c0-0c1,c0-0c2,c1-0c2,c1-0c1,c2-0c1,c2-0c0,c1-0c0
9	c0-0c0,c0-0c1,c0-0c2,c1-0c2,c1-0c1,c2-0c2,c2-0c1,c2-0c0,c1-0c0

To partition the system on a cabinet basis, you must take your particular configuration and the logical chassis ordering shown in Table 7 into account. For example, if you have a three-cabinet (nine-chassis) topology class 0 system, you can partition your system on a cabinet basis as follows:

```
c0-0,c1-0 and c2-0
```

OR

```
c0-0 and c1-0,c2-0
```

Cabinet `c1-0` cannot be a partition on its own because the three chassis are not all directly connected together. Cabinets `c0-0` and `c2-0` can each be independent partitions because all three chassis for each of these cabinets are directly connected together.

6.13.1.2 Topology Class 1

Class 1 topology systems contain a single row of cabinets. Generally, systems have 4 to 15 cabinets. The three chassis in each cabinet are cabled together in the y-dimension. The z-dimension is looped back on itself within the chassis. The cabinets are then cabled together in the x-dimension.

To create a torus in the x-dimension, the cabinets are cabled in an interleaved fashion. This means that cabinet 0 in the row is cabled to cabinet 2, which is cabled to 4, and so on to the end of the row. At this point, the highest-numbered even cabinet is cabled to the highest-numbered odd cabinet. Then the odd cabinets are cabled together, coming back down the row to cabinet 1. To complete the torus, cabinet 1 is cabled to cabinet 0.

To partition this system, you can:

- Group together a consecutive number of even (or odd) cabinets. For example, you can create two logical machines, one with all the even cabinets and another with the odd cabinets.
- Group together consecutive cabinets on each end of the row. For example, you can partition a 12-cabinet system with cabinets 0-5 in one partition and cabinets 6-11 in another.
- Group a combination of cabinets, For example, for a 12-cabinet system, you can define three logical machines containing cabinets 0-5; 6,8,10; and 7,9,11, respectively.

6.13.1.3 Topology Class 2

Topology class 2 systems are configured with two equal-sized rows of cabinets. The chassis within the cabinet are cabled together in the y-dimension. Corresponding cabinets in each row are cabled together in the z-dimension. That is, they are cabled together by pairing up chassis within the cabinets, and then cabling them together. The chassis are paired chassis0-chassis2, chassis1-chassis1, and chassis2-chassis0. The x-dimension within each row is cabled the same interleaved fashion as is topology class 1.

To partition a topology class 2 system, keep pairs of corresponding cabinets together so you do not break the z-dimension. Thus, topology class 2 can be partitioned in the same way as topology class 1. The logical machine includes the cabinets from both rows.

6.13.1.4 Topology Class 3

Topology class 3 systems contain multiple equal-sized rows of cabinets. These can be cabled in two ways:

- The y-dimension is a torus.

  There must be an even number of rows in this configuration.

- The y-dimension is a mesh.

  This configuration can have any number of rows, typically three or more. The y-dimension is cabled between the rows. The z-dimension cables the three chassis within a cabinet together. The x-dimension is cabled down each row, in the same configuration as topology classes 1 and 2.

There are many ways to create a logical machine for a topology class 3 system. Make sure that all partitions are rectangular with respect to the cabinets. You must also account for x-dimension cabinet interleaving. Rows are more complicated to divide when the y-dimension is a torus, especially for systems with row counts greater than four. You can take a subset of the number of rows to make a partition. Taking corresponding cabinets from all rows leaves the y-dimension torus intact, which in general helps performance.

6.13.2 Configuring a Logical Machine

The logical machine can have one of three states:

- Empty — not configured
- Disabled — configured but not activated
- Enabled — configured and activated

When a partition is defined, its state changes to `DISABLED`. Undefined partitions are `EMPTY` by default.

Procedure 42. Configuring a logical machine

- Use the `xtcli part_cfg` command with the *part_cmd* option (`add` in the following example) to identify the operation to be performed and the *part_option* (`-m`, `-b`, `-d` and `-i`) to specify the characteristics of the logical machine. The boot image may be a raw device, such as `/raw0`, or a file.

Example 83. Creating a logical machine with a boot node and SDB node specifying the boot image path

```
crayadm@smw:~> xtcli part_cfg add p2 -m c0-0,c0-1,c0-2,c0-3 \
-b c0-0c0s0n0 -d c0-0c1s0n0 -i /bootimagedir/bootimage
```

Note: When using a file for the boot image, the same file must be on both the SMW and the `bootroot` at the same path.

For the logical machine to be bootable, you must specify boot node and SDB node IDs.

For instructions on booting a logical machine, see Booting a Logical Machine on page 181.

For information about configuring boot-node failover, see Configuring Boot-node Failover on page 172.

To watch HSS events on the specified partition, execute the `xtconsumer -p` *partition_name* command.

To display the console text of the specified partition, execute the `xtconsole -p` *partition_name* command.

For more information, see the `xtcli_part`(8), `xtconsole`(8), and `xtconsumer`(8) man pages.

6.13.3 Booting a Logical Machine

The `xtbootsys --part` *partition_name* option enables you to indicate which logical machine (partition) to boot. If you do not specify a partition name, the default partition `p0` (component name for the entire system) is booted. Alternatively, if you do not specify a partition name and you use the `CRMS_PARTITION` environment variable, this variable is used as the default partition name. Valid values are in the form `p#`, where # ranges from `0` to `31`.

Each file in `/opt/craylog/bootlogs` has a partition name suffix.

To boot a partition, see Booting the System on page 72.

6.14 Updating Boot Configuration

The HSS `xtcli boot_cfg` command allow you to specify the primary and backup boot nodes and the primary and backup SDB nodes.

Example 84. Updating boot configuration

Update the boot configuration using the boot image `/bootimagedir/bootimage`, primary boot node `c0-0c1s0n0`, backup boot node `c0-1c0s0n0`, primary SDB node `c0-0c0s0n0`, and the backup SDB node `c0-1c1s0n0`:

```
crayadm@smw:~> xtcli boot_cfg update -b c0-0c1s0n0,c0-1c0s0n0 \
-d c0-0c0s0n0,c0-1c1s0n0 -i /bootimagedir/bootimage
```

For more information, see the `xtcli_boot`(8) man page.

For information about configuring failover, see Configuring Failover for Boot and SDB Nodes on page 172.

6.15 Modifying Boot Automation Files

Your boot automation files should be located in `/opt/cray/etc`. There are several automation files; for example, `auto.generic.cnl` and `auto.min.cnl`.

For boot automation scripts, when running CNL on compute nodes, the Lustre file system should start up before the compute nodes.

> **Note:** You can also boot the system or shut down the system using both user-defined and built-in procedures in the `auto.xtshutdown` file. For related procedures, see *Installing and Configuring Cray Linux Environment (CLE) Software*.

If you use boot automation files, see the `xtbootsys`(8) man page, which provides detailed information about boot automation files, including descriptions of using the `xtbootsys crms_boot_loadfile` and `xtbootsys crms_boot_sdb_loadfile` automation file procedures.

6.16 Callout to `rc.local` During Boot

The file `/etc/init.d/rc.local` is available for local customization of the boot process. If this file/script is present, it is executed during the compute node boot. This script is executed after `/init`, before any of the scripts in `/etc/init.d/rc3.d` and before `/etc/fstab` is processed.

6.17 Changing the System Software Version to Be Booted

Release switching enables you to change between versions and releases of the CLE software that are installed concurrently on the system.

You must boot the operating system to switch CLE releases on your Cray system. You cannot change a release while the mainframe is running. You must reboot each time you change versions; however, you do not need to reboot the SMW.

Minor release switching allows you to select one of the CLE software versions that are installed within a single system set and have the same base operating system release (for example, switching from 2.2.45, back to 2.2.44). Switching is achieved by modifying sets of symbolic links in the file system to refer to the requested release.

Major release switching requires that you have a separate set of disk partitions for each major operating system (for example, switching from 3.0.17, to 3.1.25). Each system set provides a complete set of all file system and boot images, thus making it possible to switch easily between two or more different versions of your CLE system software. Each system set can be an alternative location for an installation or upgrade of your Cray system. System sets are defined in the `/etc/sysset.conf` file on the SMW.

If multiple versions of the software are installed and no version is chosen, the most recently installed is used.

6.17.1 Minor Release Switching within a System Set

The `xtrelswitch` command performs release switching by manipulating symbolic links in the file system and by setting the default version of module files that are loaded at login. `xtrelswitch` uses a release version that is provided either in the `/etc/opt/cray/release/xtrelease` file or by the `xtrel=` boot parameter. If the latter is not provided, the former is used. The `xtrelswitch` command is not intended to be invoked interactively; rather it is called by other scripts as part of the boot sequence. Specifically, when the boot node is booted, this command is invoked to switch the components in the boot node and shared root file systems.

To accomplish minor release switching, you must set the `bootimage_xtrel` parameter to `yes` in your `CLEinstall.conf` installation configuration file. This will include the release version in your boot image parameters file. If you routinely switch between minor levels, you may find it more convenient to use a *cpio_path* in `/tmp` (the boot image must be in the same path for both the SMW and the boot root), instead of the updating the `BOOT_IMAGE` partition.

Note: The `xtrelswitch` command does not support switching between major release levels, for example from CLE 3.0 to CLE 2.2.

For additional information, see the `xtrelswitch`(8) man page.

6.17.2 Major Release Switching using Separate System Sets

When you use system sets to change the Cray software booted on your Cray system, you boot an entirely different file system. The switched components include:

- The boot node root file system
- The shared-root file system
- The disk partition containing the SDB
- The `syslog`, `ufs`, and persistent `/var` file systems

Booting a system set requires:

- The `/etc/sysset.conf` file that describes the available system sets.
- Choosing which boot image will be used for the next boot. Each system set label has at least one `BOOT_IMAGE`.
- Activating a boot image for the chosen system set label.

The `CLEinstall` program installs or upgrades a system set to a set of disk partitions on the Boot RAID. For more information about the `CLEinstall` program and the `/etc/sysset.conf` file, see the *Installing and Configuring Cray Linux Environment (CLE) Software* and the `sysset.conf`(5) man page.

Procedure 43. Booting a system set

1. Choose which system set in the `/etc/sysset.conf` file should be used for the boot. For example:

   ```
   LABEL:BLUE
   DESCRIPTION:BLUE system with production
   ```

2. For the chosen system set, there is at least one `BOOT_IMAGE` in the `/etc/sysset.conf` file. Look at the `/etc/sysset.conf` file to determine which boot image is associated with which raw device. For example, to get the `SMWdevice` entry for `BOOT_IMAGE0` for the chosen system set:

```
# function    SMWdevice   host   hostdevice  mountpoint  shared
 BOOT_IMAGE0 /dev/disk/by-id/scsi-3600a0b800026e1400000192c4b66eb70-part2 boot \
              /dev/disk/by-id/scsi-3600a0b800026e1400000192c4b66eb70-part2 /raw0 no
```

3. Set the next boot to use the boot image `BOOT_IMAGE0` from the `BLUE` system set, which is the `/dev/disk/by-id/scsi-3600a0b800026e1400000192c4b66eb70-part2` disk partition. There will be a link from `/raw0` to `/dev/disk/by-id/scsi-3600a0b800026e1400000192c4b66eb70-part2`.

   ```
   smw:~ # xtcli boot_cfg update -i /raw0
   ```

6.18 Changing the Service Database (SDB)

The SDB, which is a MySQL database, contains the XTAdmin system database. The XTAdmin database contains both persistent and nonpersistent tables. The `processor` and `service_processor` tables are nonpersistent and are created from the HSS data at boot time. The XTAdmin database tables track system configuration information. The SDB makes the system configuration information available to the Application Level Placement Scheduler (ALPS), which interacts with individual compute nodes running CNL.

Cray provides commands (see Updating Database Tables on page 186) that enable you to examine values in the SDB tables and update them when your system configuration changes.

⚠ **Caution:** Do not use MySQL commands to change table values directly. Doing so can leave the database in an inconsistent state.

Accounts that access MySQL by default contain a `.my.cnf` file in their home directories.

6.18.1 Service Database Tables

Table 8 describes the SDB tables, which belong to the XTAdmin database.

Table 8. Service Database Tables

Table Name	Function
`attributes`	Stores compute node attribute information
`lustre_failover`	Updates the database when a node's Lustre failover configuration changes
`lustre_service`	Updates the database when a node's Lustre service configuration changes
`filesystem`	Updates the database when a Lustre file system's configuration changes
`processor`	Stores master list of processing elements and their status
`segment`	For nodes with multiple NUMA nodes, stores attribute information about the compute node and its associated NUMA nodes
`service_cmd`	Stores characteristics of a service
`service_config`	Stores processing element services that the resiliency communication agent (RCA) starts
`service_processor`	Stores nodes and classes (boot, login, server, I/O, or network)
`textfiles`	Stores text
`version`	Stores the database schema version

6.18.2 Database Security

Access to MySQL databases requires a user name and password. The MySQL accounts and privileges are shown in Table 9. For security purposes, Cray recommends changing the account passwords on a regular basis. Default MySQL account passwords and an example of how to change them are documented in *Installing and Configuring Cray Linux Environment (CLE) Software*. To change the default MySQL passwords, also see Changing Default MySQL Passwords on the SDB on page 109.

Table 9. Database Privileges

Account	Privilege
MySQL basic	Read access to most tables; most applications use this account.
MySQL sys_mgmt	Most privileged; access to all information and commands.

6.18.3 Updating Database Tables

The CLE command pairs shown in Table 10 enable you to update tables in the SDB. One command converts the data into an ASCII text file that you can edit; the other writes the data back into the database file.

Table 10. Service Database Update Commands

Get Command	Put Command	Table Accessed	Reason to Use	Default File
`xtdb2proc`	`xtproc2db`	`processor`	Updates the database when a node is taken out of service	`./processor`
`xtdb2attr`	`xtattr2db`	`attributes`	Updates the database when node attributes change (see Setting and Viewing Node Attributes on page 191)	`./attribute`
`xtdb2nodeclasses`	`xtnodeclasses2db`	`service_processor`	Updates the database when a node's class changes (see Changing Nodes and Classes on page 188)	`./node_classes`
`xtdb2segment`	`xtsegment2db`	`segment`	For nodes with multiple NUMA nodes, updates the database when attribute information about node changes (see Using the XTAdmin Database `segment` Table on page 196)	`./segment`
`xtdb2servcmd`	`xtservcmd2db`	`service_cmd`	Updates the database when characteristics of a service changes	`./serv_cmd`

Get Command	Put Command	Table Accessed	Reason to Use	Default File
`xtdb2servconfig`	`xtservconfig2db`	`service_config`	Updates the database when services change (see Changing Services on page 188)	`./serv_config`
`xtdb2etchosts`	none	`processor`	Manages IP mapping for service nodes	none
`xtdb2lustrefailover`	`xtlustrefailover2db`	`lustre_failover`	Updates the database when a node's Lustre failover state changes	`./lustre_failover`
`xtdb2lustreserv`	`xtlustreserv2db`	`lustre_service`	Updates the database when a file system's failover process is changed	`./lustre_serv`
`xtdb2filesys`	`xtfilesys2db`	`filesystem`	Updates the database when a file system's status changes	`./filesys`
`xtprocadmin`	none	`processor`	Displays or sets the current value of processor flags and node attributes in the service database (SDB). The batch scheduler and ALPS are impacted by changes to these flags and attributes.	none

Get Command	Put Command	Table Accessed	Reason to Use	Default File
`xtservconfig`	none	`service_config`	Adds, removes, or modifies service configuration in the SDB `service_config` table see Changing Services on page 188)	none

6.18.3.1 Changing Nodes and Classes

The `service_processor` table tracks node IDs (NIDs) and their classes (see Class Name on page 60). The table is populated from the `/etc/opt/cray/sdb/node_classes` file on the boot node every time the system boots. Change this file to update the database when the classes of nodes change, for example, when you are adding login nodes.

Note: The `xtnodeclasses2db` command inserts the node-class list into the database. It does not make any changes to the shared root. To change the shared root, invoke the `xtnce` command (see Changing the Class of a Node on page 137).

For more information, see the `xtdb2nodeclasses`(8) and `xtnodeclasses2db`(8) man pages.

6.18.3.2 Changing Services

The `service_config` table of the SDB maintains a list of the services to be configured on service nodes. Update this table when services are changed, for example, when you are adding the `PBS-MOM` service.

Use the `xtservconfig` command to determine the services that are available in the `service_config` table. The `xtservconfig` command can be executed from any service node but is normally run from the boot node.

Example 85. Identifying services in the `service_config` table

```
boot:~ # xtservconfig avail
 SERVICE-COMMAND START                          STOP
 SERVICE-COMMAND START                          STOP
NTP             /opt/cray/rca/default/etc/fom+ /opt/cray/rca/default/etc/fom+
PBS-MOM         /opt/cray/rca/default/etc/fom+ /opt/cray/rca/default/etc/fom+
PBS-SCHED       /opt/cray/rca/default/etc/fom+ /opt/cray/rca/default/etc/fom+
PBS-SERV        /opt/cray/rca/default/etc/fom+ /opt/cray/rca/default/etc/fom+
```

Procedure 44. Updating the `service_config` table when services change

1. Use the `xtservconfig` command to modify the services that run on each node. The `xtservconfig` command can be executed from any service node but is normally run from the boot node. You must be user `root` to make a change using the `xtservconfig` command. For example, to add the `PBS-MOM` service, type the following command:

   ```
   boot:~ # xtservconfig -n 012 add PBS-MOM
   ```

2. Reboot the node or send a `SIGHUP` signal on the affected node to activate the change:

   a. Log on to the affected node as root user.

      ```
      boot:~ # ssh root@nid00012
      ```

   b. Type:

      ```
      nid00012:~ # killall -HUP fomd
      ```

   This causes the failover manager to read the database.

   For example, to effect the change for node 012, type:

   ```
   nid00012:~ # pdsh -w 012 "killall -HUP fomd"
   ```

For more information, see the `xtservconfig`(8) man page.

For information about providing SSH keys for computes nodes, see Modifying SSH Keys for Compute Nodes on page 122.

6.19 Viewing the Service Database Contents with MySQL Commands

The service database is configured as part of the system installation (see the *Installing and Configuring Cray Linux Environment (CLE) Software*).

Caution: Use MySQL commands to examine tables, but do not use them to change table values directly. Doing so can leave the database in an inconsistent state.

Procedure 45. Examining the service databases with MySQL commands

1. As user `crayadm`, on the SDB node, enter the MySQL shell.

   ```
   crayadm@sdb:~> mysql -u basic -p
   Enter password: ***********
   mysql> show databases;
   +-----------+
   | Database  |
   +-----------+
   | XTAdmin   |
   1-----------+
   1 row in set (0.04 sec)
   ```

2. Select the `XTAdmin` database.

```
mysql> use XTAdmin;
Database changed
```

3. Display the tables in the `XTAdmin` database.

```
mysql> show tables;
+-------------------+
| Tables_in_XTAdmin |
+-------------------+
| attributes        |
| filesystem        |
| lustre_failover   |
| lustre_service    |
| processor         |
| segment           |
| service_cmd       |
| service_config    |
| service_processor |
| version           |
+-------------------+
10 rows in set (0.00 sec)
```

4. Display the format of the `service_processor` table.

```
mysql> describe service_processor;
+------------+-----------------+------+-----+--------+
 Field       | Type           |Null|Key|Default| Extra|
+--------------+-----------------+------+-----+------+
|processor_id|int(10) unsigned|    |PRI|0      |      |
|service_type|varchar(64)     |YES |   |NULL   |      |
+--------------+-----------------+------+-----+------+
2 rows in set (0.00 sec)
```

5. Display the contents of all fields in the `service_processor` table.

```
mysql> select * from XTAdmin.service_processor;
+--------------+-------------+
| processor_id | service_type |
+--------------+-------------+
|            0 | service      |
|            3 | service      |
|            4 | service      |
|            7 | service      |
|            8 | service      |
|           11 | service      |
|           12 | service      |
|           15 | service      |
|           16 | service      |
|           19 | service      |
|           20 | service      |
|           23 | service      |
|           24 | service      |
|           27 | service      |
+--------------+-------------+
14 rows in set (0.00 sec)
```

6. Display `processor_id` values from the `processor` table.

```
mysql> select processor_id from processor;
+--------------+
| processor_id |
+--------------+
|            0 |
|            3 |
|            4 |
|            7 |
|            8 |
|          103 |
|          104 |
|          107 |

    ...

|          192 |
|          195 |
+--------------+
162 rows in set (0.00 sec)
```

6.20 Configuring the Lustre File System

For a description of the Lustre file system and how to configure it, see *Managing Lustre for the Cray Linux Environment (CLE)*.

6.21 Configuring Cray Data Virtualization Service (Cray DVS)

For a description of the Cray DVS parallel I/O forwarding service and how to configure it, see *Introduction to Cray Data Virtualization Service*.

6.22 Enabling File-locking for Lustre Clients

To enable file-locking for all Linux clients when mounting the Lustre file system on service nodes or on CNL compute nodes, you must use the `flock` option for `mount`.

6.23 Setting and Viewing Node Attributes

Users can control the selection of the compute nodes on which to run their applications and can select nodes on the basis of desired characteristics (*node attributes*). This allows a placement scheduler to schedule jobs based on the node attributes.

A user invokes the `cnselect` command to specify node-selection criteria. The `cnselect` script uses these selection criteria to query the table of node attributes in the SDB and returns a node list to the user based on the results of the query.

When launching the application, the user includes the node list using the `aprun -L` *node_list* option as described on the `aprun`(1) man page. The ALPS placement scheduler allocates nodes based on this list.

> **Note:** To meet specific user needs, you can modify the `cnselect` script. For additional information about the `cnselect` script, see the `cnselect`(1) man page.

6.23.1 Setting Node Attributes Using the `/etc/opt/cray/sdb/attr.xthwinv` and `/etc/opt/cray/sdb/attr.defaults` Files

In order for users to select desired node attributes, you must first set the characteristics of individual compute nodes. Node attribute information is written to the `/etc/opt/cray/sdb/attributes` data file and loaded into the `attributes` table in the SDB when the SDB is booted.

6.23.1.1 Enabling Node Attributes during Boot Process

Enable node attributes by instructing the boot process to generate the `/etc/opt/cray/sdb/attributes` data file when the boot node is booted and to load it into the SDB when the SDB node is booted.

On the boot node, to instruct the boot process to generate the `/etc/opt/cray/sdb/attributes` file, modify the `/etc/sysconfig/xt` file to include the line:

```
boot:~ # vi /etc/sysconfig/xt
SDBATTR=/etc/opt/cray/sdb/attributes
```

If you do not include the `SDBATTR=/etc/opt/cray/sdb/attributes` line and you instruct the boot process to generate the `/etc/opt/cray/sdb/attributes` file, you get a nonfatal warning message to alert you to the fact that there is no `SDBATTR` value defined in the installed `/etc/sysconfig/xt` file and no node attribute data is being generated.

On the shared root in the default view, to instruct the boot process to load the `/etc/opt/cray/sdb/attributes` file into the SDB, enter the `xtopview` shell and add the following line to the `/etc/sysconfig/xt` shared root file:

```
boot:~ # xtopview
default/:/ # vi /etc/sysconfig/xt
SDBATTR=/etc/opt/cray/sdb/attributes
```

6.23.1.2 Generating the `/etc/opt/cray/sdb/attributes` File

Data for the `/etc/opt/cray/sdb/attributes` file comes from two other files: the `/etc/opt/cray/sdb/attr.xthwinv` file, which contains information to generate the hardware attributes for each node, and the `/etc/opt/cray/sdb/attr.defaults` file, which contains default values for additional attributes not generated from the `attr.xthwinv` file. The `xtprocadmin`(8) man page includes a description of the attributes fields used by these two files.

- The `/etc/opt/cray/sdb/attr.xthwinv` file contains information to generate the hardware attributes for each node. The hardware attributes listed in the `attr.xthwinv` file apply to all nodes and include:

`clockmhz`	The processor clock speed in megahertz.
`availmem`	The amount of physical memory on the node.
`coremask`	A bit mask that shows which cores are available on a node. For a single-core processor, the value is `1`. For a dual-core processor where both cores are available, the value is `3`. For a quad-core processor where all cores are available, the value is `15`.

  To generate the `/etc/opt/cray/sdb/attr.xthwinv` file, invoke the `xthwinv` command on the System Management Workstation (SMW), redirecting the output to the `/etc/opt/cray/sdb/attr.xthwinv` file on the boot node, which is run from the boot node; for example:

  ```
  boot:~ # ssh smw 'xthwinv s0' > /etc/opt/cray/sdb/attr.xthwinv
  ```

  For additional information about the `xthwinv` command, see the `xthwinv`(8) man page.

  Note: If you have blades powered down when you want to upgrade your software, see the `CLEinstall`(8) man page for which `xthwinv` file to use during your upgrade process.

- The `/etc/opt/cray/sdb/attr.defaults` file contains default values for additional attributes not generated from the `attr.xthwinv` file.

  In addition to hardware characteristics, you can specify additional attributes in the `/etc/opt/cray/sdb/attr.defaults` file. This file can contain attribute settings for attributes in the following list. The attributes can be applied to all nodes or to a given set of nodes.

  Note: Do **not** set hardware attributes (memory size, clock speed, and cores) in the `attr.defaults` file because the values will be overwritten by those already specified in the `/etc/opt/cray/sdb/attr.xthwinv` file.

`archtype`	The architecture type: Cray XE and Cray XT=`2`; default=`2`.
`osclass`	The compute node's operating system: CNL=`2`; default=`2`. This setting does not impact the booting process; the compute node operating system to boot must still be specified at boot time.
`pageszl2`	The log base 2 of the page size. For example, if `pageszl2` is 12, the page size is 4K (2^{12} = 4096, or 4K). Default=`12`

`label0`	
`label1`	
`label2`	
`label3`	Each label is a string of up to 32 characters; the string cannot contain any spaces or shell-sensitive characters.

To create the `attr.defaults` file, copy the example file provided in `/opt/xt-boot/default/etc/opt/cray/sdb/attr.defaults.example` and then edit the file to modify the existing attribute settings and to create site-specific attributes as needed.

In addition to the attributes in the `/etc/opt/cray/sdb/attr.defaults` file, there are two keywords that allow you to describe the node or set of nodes to which attributes are assigned. For global default-attribute values that apply to the entire system, the line that specifies an attribute must begin with the `DEFAULT:` keyword. For example:

```
DEFAULT:  osclass=2
```

The `nodeid` keyword assigns attributes to a specific node or set of nodes and overrides a default setting. For values that apply only to certain nodes, the line that specifies the attributes must begin with `nodeid=[`*RANGE*`]`, where *RANGE* is a comma-separated list of nodes and ranges that have the form *m-n*.

> **Note:** Spaces are **not** allowed between the comma-separated list of nodes and ranges. When listing multiple attributes for a set of nodes, separate the attributes by a single space, for example, `nodeid=234,245-248 archtype=2 osclass=2`.

Example 86. Using node attribute labels to assign nodes to user groups

The following example uses labels to assign groups of compute nodes to specific user groups without the need to partition the system:

```
nodeid=101-500 label0=physicsdept
nodeid=501-1000 label1=csdept
nodeid=50-100,1001 label2=biologydept
```

6.23.2 SDB `attributes` Table

When the SDB boots, it reads the `/etc/opt/cray/sdb/attributes` file and loads it into the SDB `attributes` table.

To display the format of the `attributes` SDB table, use the `mysql describe` command:

```
mysql> describe attributes;
+----------+-----------------+------+-----+---------+-------+
| Field    | Type            | Null | Key | Default | Extra |
+----------+-----------------+------+-----+---------+-------+
| nodeid   | int(32) unsigned |      | PRI | 0       |       |
| archtype | int(4) unsigned  |      |     | 2       |       |
| osclass  | int(4) unsigned  |      |     | 2       |       |
| coremask | int(4) unsigned  |      |     | 1       |       |
| availmem | int(32) unsigned |      |     | 0       |       |
| pageszl2 | int(32) unsigned |      |     | 12      |       |
| clockmhz | int(32) unsigned | YES  |     | NULL    |       |
| label0   | varchar(32)      | YES  |     | NULL    |       |
| label1   | varchar(32)      | YES  |     | NULL    |       |
| label2   | varchar(32)      | YES  |     | NULL    |       |
| label3   | varchar(32)      | YES  |     | NULL    |       |
+----------+-----------------+------+-----+---------+-------+
```

The service database command pair `xtdb2attr` and `xtattr2db` enables you to update the `attributes` table in the SDB. For additional information about updating SDB tables using command pairs, see Updating Database Tables on page 186.

6.23.3 Setting Attributes Using the `xtprocadmin` Command

You can use the `xtprocadmin -a` *attr*=*value* command to temporarily set certain site-specific attributes. Using the `xtprocadmin -a` *attr*=*value* command to set certain site-specific attributes is **not** persistent across reboots. Attribute settings that are intended to be persistent across reboots must be specified in the `attr.defaults` file.

Note: For CNL nodes, `xtprocadmin` changes to attributes requires that you restart the `apbridge` daemon on the boot node in order for ALPS to detect changes that the `xtprocadmin` command has made to the SDB. Restarting the other ALPS components (for example, on the SDB node or on the login node if they are separate nodes) is not necessary. To restart `apbridge`, log into the boot node as root and execute the following command:

```
boot:~ # /etc/init.d/alps restart
```

For example, the following command creates a new `label1` attribute value for the compute node whose NID is 350; you must be user `root` and execute the `xtprocadmin` command from a service node, and the SDB must be running:

```
boot:~ # xtprocadmin -n 350 -a label1=eedept
```

The output is:

```
Connected
NID    (HEX)    NODENAME    TYPE     LABEL1
350    0x15e    c2-0c2s7n2  compute  eedept
```

Then restart the `apbridge` daemon on the boot node in order for ALPS to detect changes that the `xtprocadmin` command has made to the SDB.

```
boot:~ # /etc/init.d/alps restart
```

6.23.4 Viewing Node Attributes

Use the `xtprocadmin` command to view current node attributes. The `xtprocadmin -A` option lists all attributes of selected nodes. The `xtprocadmin -a` *attr1*`,`*attr2* option lists selected attributes of selected nodes.

6.24 Using the XTAdmin Database `segment` Table

The XTAdmin database contains a `segment` table that supports the memory affinity optimization tools for Cray XT5 applications and CPU affinity options for all Cray compute nodes with two or more NUMA nodes. The CPU affinity options apply to all Cray multicore compute nodes. The `segment` table is only supported by Cray systems running CNL.

The `segment` table is similar to the `attributes` table but differs in that a node may have multiple segments associated with it; the `attributes` table provides summary information for each node.

In order to address the application launch and placement requirements for compute nodes with two or more NUMA nodes, the Application Level Placement Scheduler (ALPS) requires additional information that characterizes the intranode topology of the system. This data is stored in the `segment` table of the XTAdmin database and acquired by `apbridge` when ALPS is started, in much the same way that node attribute data is acquired. (For more information about XTAdmin database tables, see Changing the Service Database (SDB) on page 184.)

The `segment` table contains the following fields:

- `node_id` is the node identifier that maps to the `nodeid` field of the `attributes` table and `processor_id` field of the `processor` table.
- `socket_id` contains a unique ordinal for each processor socket.
- `die_id` contains a unique ordinal for each processor die; with this release, `die_id` is `0` in the segment table and is otherwise unused (reserved for future use).
- `coremask` is the processor core mask. The coremask has a bit set for each core of a CPU. Quad core CPUs will have a value of 15 (binary 01111, hex 0xF).
- `mempgs` represents the amount of memory available, in Megabytes, to a single segment.

The `/etc/sysconfig/xt` file contains `SDBSEG` field, which specifies the location of the `segment` table file; by default, `SDBSEG=/etc/opt/cray/sdb/segment`.

When you change the hardware on the machine, at the next system boot, you must invoke the SMW `xthwinv` utility to populate the `attribute` and `segment` tables. The `/etc/opt/cray/sdb/attr.xthwinv` file, which contains information to generate the hardware attributes for each node, populates the `segment` table. Like the `attributes` table, you must reinitialize the `segment` table at boot. Any changes that you make manually to the table do not persist at reboot. For additional information about using the `xthwinv` command, see Generating the `/etc/opt/cray/sdb/attributes` File on page 192 and the `xthwinv`(8) man page.

To update the `segment` table, use the following service database commands:

- `xtdb2segment`, which converts the data into an ASCII text file that can be edited
- `xtsegment2db`, which writes the data back into the database file

For more information, see the `xtdb2segment`(8) and `xtsegment2db`(8) man pages.

After manually updating the `segment` table, you can log on to any login node or the SDB node as root and execute the `apmgr resync` command to request ALPS to reevaluate the configuration node segment information and update its information.

Note: If ALPS or any portion of the feature fails in relation to segment scheduling, ALPS reverts to the standard scheduling procedure.

6.25 Configuring Networking Services

6.25.1 Changing the High-speed Network (HSN)

To change your system interconnection network (HSN) address ranges, see *Installing and Configuring Cray Linux Environment (CLE) Software*.

6.25.2 Network File System (NFS)

The Network File System (NFS) version 4 distributed file system protocol is supported. NFS is enabled on service nodes but is not enabled on compute nodes. Support for NFSv4 is included as part of the SLES software.

The CLE installation tool supports NFS tuning via `/etc/sysconfig/nfs` and `/etc/init.d/nfsserver` on the boot node. The `nfs_mountd_num_threads` parameter in the `CLEinstall.conf` installation configuration file controls an NFS `mountd` tuning parameter that is added to `/etc/sysconfig/nfs` and used by `/etc/init.d/nfsserver` to configure the number of `mountd` threads on the boot node. By default, NFS `mountd` behavior is a single thread. If you have a larger Cray system (greater than 50 service I/O nodes), contact your Cray service representative for assistance changing the default setting.

6.25.3 Configuring Ethernet Link Aggregation (Bonding, Channel Bonding)

Linux Ethernet link aggregation is generally used to increase aggregate bandwidth by combining multiple Ethernet channels into a single virtual channel. Bonding can also be used to increase the availability of a link by utilizing other interfaces in the bond when one of the links in that bond fails.

Instructions for setting up Ethernet link aggregation are provided in the Linux documentation file `/usr/src/linux/Documentation/networking/bonding.txt`, installed on your system.

6.25.4 Cray Systems with SeaStar System Interconnection Network: Configuring the Virtual Channel (VC)

Note: This section applies only to Cray systems with the Cray SeaStar based system interconnection network (Cray XT series).

There are two virtual channel classes present within the SeaStar network, virtual channel 0 (VC0) and virtual channel 2 (VC2).

The SMW `xtbounce` `portals_algorithm` initialization file variable is a numeric value used to indicate which algorithm the Portals firmware is to use. Algorithm 0 indicates that the Portals firmware should use virtual channel 0 (VC0) exclusively. Algorithm 1 indicates that the Portals firmware should utilize virtual channel 0 (VC0) and virtual channel 2 (VC2).

Because Cray XT systems with multi-core processors that are operating under a heavy communication load have seen improved performance when using both VC0 and VC2, the default virtual channel setting is algorithm 1 (`xtbounce portals_algorithm=1`).

Important: The `xtspider` and `xtnxn2` tests should be run before starting to use VC2.

On the SMW, the output from running the `xtfwstat` command indicates the state of virtual channel 2 (VC2) usage within the firmware. This information is displayed as a diagnostic and a site-administration aid to confirm that VC2 is configured correctly.

For additional information, see the `xtbounce`(8) and `xtfwstat`(8) man pages.

6.25.5 Increasing Size of ARP Tables

To increase the size of ARP tables, change the `ARP_OVERHEAD` parameter in the `/etc/sysconfig/xt` file. `ARP_OVERHEAD` should be set to a value greater than the number of hosts in all locally attached external networks. The default is 1024 entries.

6.25.6 Configuring Native IP (SSIP)

Service nodes on the system interconnection network have IP addresses. The address is of the standard form *aaa.bbb.ccc.ddd*, where *aaa.bbb* is defined in the `/etc/sysconfig/xt` file and *ccc.ddd* is a function of the node's 15-bit NID.

Native IP (`ssip`) is a network driver that provides IP services through SeaStar hardware, which enables standard UNIX networking programs and protocols, such as `ssh`, to work between service nodes over the system interconnection network.

SSIP is implemented as a Linux loadable kernel module and is enabled on the service and compute nodes during the boot process; the `ssip` driver is part of the `portals` module that is already loaded, and it configures the `ss` IP interface with a default IP address derived from the node ID. (Node IDs are described in Node ID (NID) for Cray XT Systems on page 59 and in Node ID (NID) for Cray XE Systems on page 60.)

Cray defaults for *aaa.bbb* are `192` and `168`. You can modify the settings by changing the parameters `IPPO_BYTE1` and `IPPO_BYTE2` in `/etc/sysconfig/xt`. For example, you must change these parameters if the `IPPO_BYTE1` and `IPPO_BYTE2` IP addresses are already in use at your site.

The low-order bytes are set with the following algorithm:

```
ccc=NID div 254
ddd=(NID mod 254) + 1
```

The internal *IMAGEDIR*`/compute/etc/opt/cray/configuration/nids` file maps the IP address to the NID. Only the lowest-order bits are used by the Cray system. (The *IMAGEDIR*`/compute/etc/opt/cray/configuration/nids` file is created at boot time by the `xtcdr2proc` utility.)

ARP is not supported under SSIP. Each node's ARP cache is populated with the IP to NID mapping of any node it needs to communicate with through SSIP. CNL nodes use the `/init` script and `/sbin/rca-helper -s` to populate the ARP cache on CNL nodes. Service nodes use the `/etc/init.d/ippo` script to create ARP cache entries by reading the *IMAGEDIR*`/compute/etc/opt/cray/configuration/nids` file that was created at boot time.

The following example illustrates an *IMAGEDIR*`/compute/etc/opt/cray/configuration/nids` file defining NIDs 0, 3, 4, and 7.

Example 87. *IMAGEDIR*`/compute/etc/opt/cray/configuration/nids` file defining NIDs

```
#IP address Hardware address
192.168.0.1 00:00:00:00
192.168.0.4 00:00:00:03
192.168.0.5 00:00:00:04
192.168.0.8 00:00:00:07
```

Note: If you enable IP forwarding on a service node and want ICMP error returns, you must remove the `IFF_NOARP` parameter on the high-speed network interface. This can be done by issuing the `ifconfig ss arp` command in a start-up script, such as `/etc/rc.local`.

6.25.7 Configuring Realm-Specific IP Addressing (RSIP)

Realm-Specific Internet Protocol (RSIP) enables internal client nodes, such as compute nodes, to reach external IP networking resources. Support for RSIP is available with CLE on systems with CNL compute nodes.

Note: RSIP for IPv4 TCP and User Datagram Protocol (UDP) transport protocols are supported. Internet Protocol Security (IPSec) and IPv6 protocols are not supported.

RSIP is composed of two main components: RSIP clients and RSIP servers or gateways. You configure RSIP and select servers using RSIP parameters in `CLEinstall.conf`. By default, when RSIP is enabled, all CNL compute nodes are configured to be RSIP clients.

On your Cray system, RSIP servers must be service nodes with an external IP interface such as a 10-GbE network interface card (NIC). You can configure multiple RSIP servers using multiple service nodes, however only one RSIP daemon (`rsipd`) and one external interface is allowed per service node. Cray requires that you configure RSIP servers as dedicated network nodes.

Warning: Do not configure login nodes or service nodes that provide Lustre or batch services as RSIP servers. Failure to set up an RSIP server as a dedicated network node will disrupt network functionality.

The performance impact of configuring RSIP is negligible; very little noise is generated by the RSIP client. RSIP clients will issue a lease refresh message request/response pair once an hour, staggered by the startup window of 120 seconds, but otherwise are largely silent.

To configure RSIP for your Cray system, first determine which service nodes and associated Ethernet devices will be used to provide RSIP services. Optionally, determine if you will configure service nodes with no external IP interfaces (isolated service nodes) to act as RSIP clients. After selecting RSIP servers based on your machine-specific networking hardware configuration, follow Procedure 46 on page 202 to complete a default RSIP configuration and setup.

Enhancements to the default RSIP configuration require a detailed analysis of specific site configuration and requirements. Contact your Cray representative for assistance in changing the default RSIP configuration.

6.25.7.1 Using the `CLEinstall` Program to Install and Configure RSIP

The `CLEinstall` program can be configured to automatically install RSIP either during a system software upgrade or as a separate event. In either case, you will need to update the CNL boot image and restart your Cray system before RSIP is functional.

When you set the following RSIP-specific parameters in the `CLEinstall.conf` file, `CLEinstall` will load the RSIP RPM, modify `rsipd.conf` and invoke the appropriate `xtrsipcfg` commands to configure RSIP for your system.

`CNL_rsip=`**`yes`**

Enables the RSIP client on CNL compute nodes. Optionally, you can edit the `/var/opt/cray/install/shell_bootimage_`*label*`.sh` script and set `CNL_RSIP=`**`y`**.

`rsip_nodes=`

Specifies the RSIP servers. Populate with the node IDs of the nodes you have identified as RSIP servers.

`rsip_interfaces=`

Specifies the IP interface for each RSIP server node. List the interfaces in the same order specified by the `rsip_nodes` parameter.

If you are configuring RSIP for the first time during an installation or upgrade of your CLE system software, follow RSIP-specific instructions in the *Installing and Configuring Cray Linux Environment (CLE) Software*. If you are configuring RSIP as a separate event, follow Procedure 46 on page 202. If you already configured RSIP and want to add isolated service nodes as RSIP clients, follow Procedure 47 on page 205.

Note: You cannot configure service nodes to be RSIP clients using the `CLEinstall` command and the steps described in *Installing and Configuring Cray Linux Environment (CLE) Software*.

For additional information about configuring RSIP, see the `xtrsipcfg`(8) and `rsipd.conf`(5) man pages.

Procedure 46. Installing, configuring, and starting RSIP clients and servers

1. Edit `CLEinstall.conf` for your RSIP configuration. For example, to configure nodes 16 and 20 as RSIP servers with an external interface named `eth0` and node 64 as an RSIP server with an external interface named `eth1`, make these changes.

   ```
   smw:~ # vi /home/crayadm/install.xtrelease/CLEinstall.conf
   CNL_rsip=yes
   rsip_nodes=16 20 64
   rsip_interfaces=eth0 eth0 eth1
   ```

2. Invoke the `CLEinstall` program on the SMW; you **must** specify the *xtrelease* that is currently installed on the system set you are using.

   Warning: If `--XTrelease` does not match the release version that is currently installed, this command will perform an upgrade and will modify other CLE system software for the specified system set. **Do not use this procedure to perform an upgrade.** Follow *Installing and Configuring Cray Linux Environment (CLE) Software* to upgrade to a different *xtrelease*.

```
smw:~ # /home/crayadm/install.xtrelease/CLEinstall --upgrade --debug \
--label=system_set_label --XTrelease=xtrelease \
--configfile=/home/crayadm/install.xtrelease/CLEinstall.conf \
--CLEmedia=/home/crayadm/install.xtrelease
```

3. Type `y` and press the `Enter` key to proceed when prompted to update the boot root and again for the shared root.

   ```
   *** Do you wish to continue? (y/n) --> y
   ```

   Upon completion, `CLEinstall` lists suggested commands to finish the installation. Those commands are also described here. For more information about running the `CLEinstall` program, see *Installing and Configuring Cray Linux Environment (CLE) Software*.

4. Rebuild the boot image using `/var/opt/cray/install/shell_bootimage_`*label*`.sh`, `xtbootimg` and `xtcli` commands. Suggested commands are included in output from `CLEinstall` and `shell_bootimage_`*label*`.sh`. For more information about creating boot images, follow Procedure 2 on page 68.

5. **(Optional)** Follow these steps to configure an isolated service node as an RSIP client. Otherwise, skip to step 6.

   Caution: Only service nodes without external network connections should be configured as RSIP clients. Configuring a network node as an RSIP client will disrupt network functionality; Service nodes with external network connections will route all non-local traffic into the RSIP tunnel and IP may not function as desired.

   a. Select one of your RSIP servers to provide access for the isolated service node. In this example, we have chosen the RSIP server `node00016`, with the physical ID `c0-0c0s4n0`.

   b. Log on to the boot node and invoke `xtopview` in the node view for the RSIP server you have selected; for example:

   ```
   boot:~ # xtopview -n c0-0c0s4n0
   node/c0-0c0s4n0:/ #
   ```

   c. Modify `max_clients` in the `rsipd.conf` file to add an additional client for each isolated service node you are configuring. For example, if you configured 300 RSIP clients (compute nodes), change 300 to 301.

   ```
   node/c0-0c0s4n0:/ # vi /etc/opt/cray/rsipd/rsipd.conf
   max_clients 301
   ```

6. Unmount the boot root and shared root file systems. For example, if you use the default settings, type these commands.

   ```
   smw:~ # umount /bootroot0/rr
   smw:~ # umount /bootroot0
   ```

7. Shut down the system using your site-specific procedures; for example:

   ```
   crayadm@smw:~> xtbootsys -s last -a auto.xtshutdown
   ```

8. Edit the boot automation file to configure your system to start the RSIP daemon on RSIP servers. For example, if you have defined `nid00016` and `nid00020` as RSIP servers, add the following lines to the `/opt/cray/etc/auto.`*xthostname* file on the SMW.

```
yadm@smw:~> vi /opt/cray/etc/auto.xthostname
# RSIP server startup
lappend actions { crms_exec_via_bootnode "nid00016" \
"root" "/etc/init.d/rsipd start" }
lappend actions { crms_exec_via_bootnode "nid00020" \
"root" "/etc/init.d/rsipd start" }
```

> **Note:** As part of system boot, the RSIP clients on the compute nodes make connections to the RSIP server(s). Initiation of these connections is staggered over a two minute window; during that time, connectivity over RSIP tunnels will be unreliable. Avoid using RSIP services for three to four minutes following a system boot.

For information about options available when starting the `rsipd` server, see the `rsipd`(8) man page.

9. If you completed step 5 to configure one or more service nodes as an RSIP client, edit the boot automation file to start the RSIP client. On the isolated service node, invoke a `modprobe` of the `krsip` module with an IP argument pointing to the HSN IP address of the RSIP server node you selected in step 5. For example, if the IP address of the RSIP server is `192.168.0.29` and the isolated service node is `nid00023`, make these changes.

```
crayadm@smw:~> vi /opt/cray/etc/auto.xthostname
After the line or lines that start the RSIP servers add:
# RSIP client startup
lappend actions { crms_exec_via_bootnode "nid00023" "root" "modprobe krsip ip=192.168.0.29" }
```

10. Boot your Cray system; for example:

```
crayadm@smw:~> xtbootsys -a auto.xthostname
```

> **Note:** RSIP clients on the compute nodes make connections to the RSIP server(s) during system boot. Initiation of these connections is staggered over a two minute window; during that time, connectivity over RSIP tunnels will be unreliable. Avoid using RSIP services for three to four minutes following a system boot.

11. Test RSIP functionality. From a login node, log on to an RSIP client node (compute node) and ping the IP address of the SMW or other host external to your Cray system. For example, if *nid00024* is a compute node and *172.30.14.55* is a valid external IP address, type these commands.

```
crayadm@login:~> ssh root@nid00024
root@nid00024's password:
Welcome to the initramfs
# ping 172.30.14.55
172.30.14.55 is alive!
#
```

Procedure 47. Adding isolated service nodes as RSIP clients

You can configure service nodes that are isolated from the network as RSIP clients. This procedure assumes that RSIP is already configured and functional on your Cray system. If you have not installed and configured RSIP on your system, follow Procedure 46 on page 202, which includes an optional step to configure isolated service nodes as RSIP clients.

Warning: Do not configure service nodes with external network connections as RSIP clients. Configuring a network node as an RSIP client will disrupt network functionality; Service nodes with external network connections will route all non-local traffic into the RSIP tunnel and IP may not function as desired.

1. Select one of your RSIP servers to provide access for the isolated service node. In this example, we have chosen the RSIP server `node00016`, with the physical ID `c0-0c0s4n0`.

2. Log on to the boot node and invoke `xtopview` in the node view for the RSIP server you have selected; for example:

   ```
   boot:~ # xtopview -n c0-0c0s4n0
   node/c0-0c0s4n0:/ #
   ```

   Modify `max_clients` in the `rsipd.conf` file to add an additional client for each isolated service node you are configuring. For example, if you configured 300 RSIP clients (compute nodes), change 300 to 301.

   ```
   node/c0-0c0s4n0:/ # vi /etc/opt/cray/rsipd/rsipd.conf
   max_clients 301
   ```

3. Load the RSIP client on the node. On the isolated service node, invoke a `modprobe` of the `krsip` module with an IP argument pointing to the HSN IP address of the RSIP server node you selected in step 1. For example, if the IP address of the RSIP server is `192.168.0.29` and the isolated service node is `nid00023`, type these commands.

   ```
   boot:~ # ssh nid00023
   nid00023:~ #  modprobe krsip ip=192.168.0.29
   ```

4. Edit the boot automation file to start the RSIP client. Using the example from the previous steps, make these changes.

```
crayadm@smw:~> vi /opt/cray/etc/auto.xthostname
```
After the line or lines that start the RSIP servers add:
```
# RSIP client startup
lappend actions { crms_exec_via_bootnode "nid00023" "root" "modprobe
krsip ip=192.168.0.29" }
```

6.25.8 IP Routes for CNL Nodes in the `/etc/routes` File

You can edit the `/etc/routes` file in the CNL template image on the SMW to provide route entries for CNL nodes. This provides a simple mechanism for you to configure routing access from CNL compute nodes to login and network nodes using external IP destinations without having to traverse RSIP tunnels. This mechanism is not intended to be used for general-purpose routing of internal HSN IP traffic. It is intended only to provide IP routes for CNL nodes that need to reach external IP addresses or external networks. A new `/etc/routes` file is created in the CNL images and is examined during startup. Non-comment, non-blank lines are passed to the `route add` command. The empty template file provided contains comments describing the syntax.

6.26 Updating the System Configuration After A Hardware Change

When hardware is added to or removed from a Cray system, there are several steps that need to be done to update the configuration of the system. Possible scenarios are:

- Adding new cabinets
- Removing old cabinets
- Adding a blade
- Removing a blade
- Changing the routing topology

Note: If you have blades powered down when you want to upgrade your software, see the `CLEinstall`(8) man page for which `xthwinv` file to use during your upgrade process.

Procedure 48. Adding or removing cabinets or chassis within cabinets

1. Run the `xtdiscover` command to update the system configuration to reflect the changed hardware configuration. This example shows the display when you add two cabinets.

```
smw:~ # xtdiscover
Using ini file '/opt/cray/etc/xtdiscover.ini'

xtdiscover is about to discover new hardware.
This operation may significantly modify the system database.

Please enter 'c' to continue, or 'a' or 'q' to abort [c]: c


Please enter network type (s=SeaStar, g=Gemini, q=quit): g

Is this system a Single-Slot Tester? y/n, q=quit [n]: n

Setting system type to Gemini
Discovering Gemini-based system...

Enter maximum X cabinet size [1-64], q=quit: 5
Enter maximum Y cabinet size [1-16], q=quit:
```

```
discover_hosts: ERROR: Y value must be in the range [1-16]
Enter maximum Y cabinet size [1-16], q=quit: 1
Adding hosts and routes for 5 cabinets...done.

Enter your system's network topology class [0]: 0
Setting topology class to 0

Suspending State Manager for discovery phase 1...
Suspend successful.
Saving current configuration...done.

Discovering cabinets:
[2 out of 5]
Finished waiting for cabinet heartbeats; found 2 out of 5
The following cabinets were not detected by heartbeat:

c2-0   c3-0   c4-0


Found 2 cabinets.

xtdiscover will create a single system partition (p0)
containing all discovered cabinets. If you need to create
additional partitions, use 'xtcli part_cfg add'.

Enter the boot node name [c0-0c0s0n1]:
Enter the SDB node name [c0-0c0s0n3]:
Enter the absolute pathname to the default boot image [/raw0]: /tmp/boot/crayA-3.1.18blue.cpio

Gathering base cabinet attributes:
[2 out of 2]
Finished gathering cabinet attributes.

Clearing database...done.
Verifying phase 1 configuration...done.
Storing base cabinet data...done.
Resuming State Manager for power-up and bounce...Resume successful.

Discovery Phase 1 of 3 complete.

xtdiscover is about to power on the cabinets.
*** IF YOU NEED TO DISABLE BLADES TO AVOID THEM
*** BEING POWERED ON, PLEASE DO SO NOW USING 'xtcli disable'

Please enter 'c' to continue, or 'a' or 'q' to abort [c]:

Suspending State Manager for discovery phase 2...
Suspend successful.

Loading base component data for discovery phase 2...done.

Powering on cabinets...
2 cabinets will be powered on:
[2 out of 2]
Cabinets powered on.

Discovering component phase 2 (blade) state:
[32 out of 32]
Finished discovering component phase 2 (blade) state.

Discovering component phase 2 (blade) attributes:
[32 out of 32]
Finished discovering component phase 2 (blade) attributes.
Verifying phase 2 configuration...done.
```

```
Summary of blades discovered:
Total:    48    Service:     6  Empty:    16    Disabled:     0

Storing attribute data...done.

Discovery Phase 2 of 3 complete.

Resuming State Manager for bounce...Resume successful.

3 blades should be bounced using the command
in file /opt/cray/etc/xtdiscover-bounce-cmd

In a separate window, please bounce the system now to continue discovery.

After bounce completes, enter 'c' to complete discovery
or 'q' or 'a' to abort [c]:

Suspending State Manager for discovery phase 3...
Suspend successful.

Discovering component phase 3 (blade/node) attributes:
[32 out of 32]
Finished discovering component phase 3 attributes.
Verifying configuration...
INFO: 4 newly discovered components were added.
INFO: 836 components in previous configuration were deleted.
INFO: Added the following hardware:
    1 cabinet
            3 slots
INFO: Removed the following hardware:
    1 cabinet
            3 slots
                            832 cores
INFO: Configuration change details are in /opt/cray/etc/xtdiscover-config-changes.diff
done.
Storing component attribute data...done.
Updating component location history...done.

Restarting RSMS daemons for normal operation:
Stopping RSMS services: cm sedc_manager bm dm rm pm nm sm erd        done
Starting RSMS services: erd sm nm pm rm dm bm sedc_manager cm
Flushing and installing cabinet routes...done.
                                                                     done
Done.

Discovery complete
*********** xtdiscover finished ***********
```

2. Update the SDB database to provide ALPS with the new configuration at the next boot.

   a. Mount the boot root file system on the SMW. Although `sdc1` is used in this step, it may be different for your system.

      Note: Ensure the boot root is not also mounted on the boot node.

      ```
      smw:~ # fsck /dev/sdc1
      smw:~ # mkdir -p /bootroot0
      smw:~ # mount /dev/sdc1 /bootroot0
      ```

b. Save the old copy of the `/etc/opt/cray/sdb/attr.xthwinv` file on the boot root.

```
smw:~ # cp -p /bootroot0/etc/opt/cray/sdb/attr.xthwinv \
/bootroot0/etc/opt/cray/sdb/attr.xthwinv.date
```

c. Capture system configuration into the `/etc/opt/cray/sdb/attr.xthwinv` file on the boot root.

For the entire system, `s0`:

```
smw:~ # xthwinv s0 > /bootroot0/etc/opt/cray/sdb/attr.xthwinv
```

If the system set is used to boot a partition and not the entire machine then `xthwinv s0` should be `xthwinv p`*N* for the partition `p`*N*.

```
smw:~ # xthwinv pN > /bootroot0/etc/opt/cray/sdb/attr.xthwinv
```

Procedure 49. Adding or removing a service node

Some actions need to be done regardless of the function of the service node. At a minimum, the boot node and the SDB node should be booted when doing these steps. If reconfiguring RSIP servers, then all service nodes should be up.

1. Update the `/etc/opt/cray/sdb/node_classes` file on the boot root to add entries for new service nodes and classes or remove old service nodes and classes.

2. Update SMW boot automation files if new service nodes have been added or removed that are providing services (such as ALPS on login nodes) that are explicitly started by `hostname` in the boot automation file.

3. After adding a new service node, prepare the node view for it:

   a. Run the `xtcloneshared` command on the boot node in the shared root default view to copy an existing service node that is of similar type.

   ```
   default/:/ # xtcloneshared -n from_node to_node
   ```

   b. If the new service node will be in a new class, copy an existing service class. Run the `xtcloneshared` command on the boot node in the shared root default view to copy an existing service class.

   ```
   default/:/ # xtcloneshared -c from_class to_class
   ```

4. After removing a service node from a certain class, run the `xtcloneshared` command on the boot node in the shared root default view to reset to generic default:

   ```
   default/:/ # xtcloneshared -n to_node
   ```

5. If Lustre service nodes are added or removed, the Lustre configuration will need to be modified. For more information about Lustre configuration, see *Managing Lustre for the Cray Linux Environment (CLE)*.

6. If using RSIP and the new service node will be an RSIP server, then run `CLEinstall` to reconfigure RSIP. For more information, see Configuring Realm-Specific IP Addressing (RSIP) on page 200.

   The boot image will need to be rebuilt in step 8.

7. Update the `/etc/hosts` file on the boot root, the shared root default view, and the CNL image. When the boot node is booted, the `bnd` daemon will update the boot root `/etc/hosts` file and copy it to the shared root default view. This file should be copied from the boot root to the templates directory on the SMW and the boot image should be rebuilt. If using partitions, the template directory will be `/opt/xt-images/templates/default-p`*N*, where `p`*N* is the partition number.

```
smw:~ # cp -p /opt/xt-images/templates/default/etc/hosts /opt/xt-images/templates \
/default/etc/hosts.save
smw:~ # scp -p boot:/etc/hosts /opt/xt-images/templates/default/etc/hosts
```

   The boot image will need to be rebuilt in step 8.

8. Rebuild the boot image and reboot. Make sure you rerun the `shell_bootimage_BLUE.sh` script to re-clone the boot image and to pick up a change to the templates.

9. Update the `CLEinstall.conf` file with the service node changes before the next CLE software update so that it matches the new configuration of the machine.

   a. Update the `node_class`[*X*] variables. These variables are only used during an installation, not an update, but the `CLEinstall.conf` file should be kept current with the system configuration.

   b. If using RSIP, update `rsip_nodes` and `rsip_interfaces` variables if the new service node will be an RSIP server.

   c. If any of the new service nodes will be the primary or backup boot node, primary login node, ufs node, or syslog node, then update those variables. These variables are only used during an installation, not an update, but the `CLEinstall.conf` file should be kept current with the system configuration.

6.27 Changing the Location to Log `syslog-ng` Information

CLE uses the Linux `syslog-ng` daemon and associated `syslog-ng.conf` configuration file to log system messages. For more information see the `syslog-ng`(8) and `syslog-ng.conf`(5) man pages. You can modify the `/etc/syslog-ng/syslog-ng-conf` file to change where the log information is saved.

Procedure 50. Configuring `syslog-ng` system message logs

Follow these steps to modify the default `syslog-ng` configuration.

1. Log on to the boot node and edit the `syslog-ng.conf` configuration file.

   ```
   smw:~# ssh root@boot
   boot:~ # vi /etc/syslog-ng/syslog-ng.conf
   ```

2. Restart the `syslog-ng` daemon on the boot node.

   ```
   boot:~ # /etc/init.d/syslog restart
   ```

3. Edit the configuration file on the syslog node and make the desired changes.

   ```
   boot:~ # xtopview -n syslog
   node/syslog:/ # vi /etc/syslog-ng/syslog-ng.conf
   node/syslog:/ # exit
   ```

4. Restart the `syslog-ng` daemon on the syslog node.

   ```
   boot:~ # ssh syslog /etc/init.d/syslog restart
   ```

5. Edit the configuration file on other service nodes by using `xtopview` in the default view and make the desired changes.

   ```
   boot:~ # xtopview
   default/:/ # vi /etc/syslog-ng/syslog-ng.conf
   default/:/ # exit
   ```

6. Restart the `syslog-ng` daemon on the remaining service nodes. For each service node, type the following command.

   ```
   boot:~ # ssh nodename /etc/init.d/syslog restart
   ```

Managing Services [7]

This chapter describes how to manage Cray system services to best use the system or to modify a service.

For a list of administrator accounts that enable you to access these functions, see Administering Accounts on page 113.

7.1 Configuring the SMW to Synchronize to a Site NTP Server

The components of the Cray system synchronize time with the System Management Workstation (SMW) via Network Time Protocol (NTP). By default, the NTP configuration of the SMW is configured to stand alone; however, the SMW can optionally be configured to synchronize with a site NTP server. Use the following procedure to configure the SMW to synchronize to a site NTP server.

Procedure 51. Configuring the SMW to synchronize to a site NTP server

1. Stop the NTP server by issuing the `/etc/init.d/ntp stop` command; this command must be executed as user `root`:

   ```
   smw:~ # /etc/init.d/ntp stop
   ```

2. Edit the `/etc/ntp.conf` file on the SMW to point to the new server.

3. Restart the NTP server by issuing the `/etc/init.d/ntp restart` command:

   ```
   smw:~ # /etc/init.d/ntp start
   ```

The SMW can continue to update the rest of the system by proxy. By default, the SMW qualifies as a stratum 3 (local) NTP server. For more information about NTP, refer to the Linux documentation.

7.2 Synchronizing Time of Day on Compute Node Clocks with the Clock on the Boot Node

A network time protocol (NTP) client, `ntpclient`, is available to install on compute nodes. By default, `ntpclient` is not installed. When installed, the time of day on compute node clocks is synchronized with the clock on the boot node.

Without this feature, compute node clocks will drift apart over time, as much as 18 seconds a day. When `ntpclient` is installed on the compute nodes, the clocks drift apart for a four-hour calibration period and then slowly converge on the time reported by the boot node.

> **Note:** The standard Cray system configuration includes an NTP daemon (`ntpd`) on the boot node that synchronizes with the clock on the SMW. Additionally, the service nodes run `ntpd` to synchronize with the boot node.

To install the `ntpclient` RPM in the compute node boot image, edit the `shell_bootimage_`*label*`.sh` script and specify `CNL_NTPCLIENT=`**`y`**, and then update the CNL boot image. Optionally, you can enable this feature as part of a CLE software upgrade by setting `CNL_ntpclient=`**`yes`** in the `CLEinstall.conf` file before the `CLEinstall` program is run.

On compute nodes, the computational overhead for `ntpclient` is negligible and a small increase (800K) to the memory footprint will be incurred. Minimal network overhead for the boot node is required to process NTP requests. For each compute node on the system, the boot node will send and receive one packet every 15 minutes. Even on very large Cray systems, the boot node will process fewer than 25 transactions a second to support `ntpclient` requests.

7.3 Adding and Starting a Service Using Standard Linux Mechanisms

Services can be added to the service nodes by using standard Linux mechanisms, such as executing the `chkconfig` command while in the `xtopview` utility on the boot node or executing `/etc/init.d/`*servicename* `start|stop|restart` (which starts, stops, or restarts a service immediately on the service node). This is the recommended approach for most services.

7.4 Adding and Starting a Service Using RCA

Services may also be added by using the Resiliency Communication Agent (RCA). Configuration with RCA is indicated if a service requires extra resiliency. The RCA monitors the service and restarts it in case of failure.

7.4.1 Adding a Service to List of Services Available under RCA

Before a service can be attributed to a node or nodes, it must first be made available in the SDB database.

Procedure 52. Adding a service to list of services available under RCA

1. Modify the `service_cmd` table of the Service database (SDB) to include new service information (see Changing Services on page 188).
2. Send a `SIGHUP` signal to the failover manager to reread the database.

7.4.2 Indicating Nodes on Which the Service Will Be Started

Use the `xtservconfig` command to indicate the node or nodes on which the service will be started. The `xtservconfig` command can be executed from any service node but is normally run from the boot node. You must be user `root` to make a change using the `xtservconfig` command.

Example 88. Adding the `PBS-MOM` service for a specific node

To add the `PBS-MOM` service for node 5, type:

```
boot:~ # xtservconfig -n 5 add PBS-MOM
```

After you configure a new service, reboot the node or send a `SIGHUP` signal to the service (in this example, `PBS-MOM`) on the affected node.

Example 89. Force the `fomd` to update its configuration information about a new or updated service on a node

Log on to the affected node as user `root` and type:

```
# killall -HUP fomd
```

The `killall -HUP fomd` command causes the failover manager to read the database.

Example 90. Effect a change for a new or updated service on a group of nodes

To effect a change for login nodes 001 through 009, type:

```
boot:~ # pdsh -w login[001-009] "killall -HUP fomd"
```

7.5 Creating a Snapshot of `/var`

The `/var` directory on a Cray system can be configured either as persistent (see *Installing and Configuring Cray Linux Environment (CLE) Software*) or nonpersistent. In the latter case, the `/var` directory is volatile, and its initial contents are rebuilt at boot time from a skeleton archive, `/.shared/var-skel.tgz`.

The advantage of using a nonpersistent `/var` directory is ease of management. Each time the system is rebooted, the `/var` directory is freshly re-created from the central skeleton file, so accumulation of files and potential corruption of files with the `/var` directory is much less of a concern. However, because the contents of `/var` are not saved, if there is a need to update the initial contents of the `/var` directory (for example, when a new package requires a directory), the skeleton archive must be updated.

The `xtpkgvar` command creates a compressed tar file with a skeleton snapshot of the `/var` directory. To add files to the directory, make changes in the `xtopview` shell to the `/var` directory and take a snapshot of it with the `xtpkgvar` command.

Caution: Use the `xtpkgvar` command only when you are configuring the shared-root file system. The `xtpkgvar` command is used by the `CLEinstall` utility.

For more information, see the `xtpkgvar`(8) man page.

7.6 Setting Soft and Hard Limits to Prevent Login Node Hangs

A login node can be caused to hang or become nearly unresponsive by having all available processes on the node in use. A hang of this type can be identified primarily by the presence of `cannot fork` error messages, but it is also associated with an unusually large number of processes running concurrently, the machine taking several minutes to make a prompt available, or never making a prompt available. In the case of an overwhelming number of total processes, it is often a large number of the same process overwhelming the system, which indicates a `fork()` system call error in that particular program.

This problem can be prevented by making a few changes to configuration files in `/etc` on the shared root of the login node. These configurations set up the `ulimit` built-in and the Linux Pluggable Authentication Module (PAM) to enforce limits on resources as specified in the configuration files. There are two types of limits that can be specified, a soft limit and a hard limit. Users receive a warning when they reach the soft limit specified for a resource, but they can temporarily increase this limit up to the hard limit using the `ulimit` command. The hard limit can never be exceeded by a normal user. Because of the shared root location of the configuration files, the changes must be made from the boot node using the `xtopview` tool.

Procedure 53. Preventing login node hangs by setting soft and hard limits

1. On the boot node type the following in order to make changes to the shared root, where `login` is the class name for login nodes.

   ```
   boot:~ # xtopview -c login
   ```

   This presents a new prompt `class/login:/ #`. You now have access to files of the shared root as if they are local.

2. Next, add the following lines to the `/etc/security/limits.conf` file, where *soft_lim_num* and *hard_lim_num* are the number of processes at which you would like the hard and soft limits enforced. The `*` represents "apply to all users" but can also be configured to apply specific limits by user or group (see the `limits.conf` file's comments for further options).

   ```
   class/login:/ # vi /etc/security/limits.conf
   * soft nproc soft_lim_num
   * hard nproc hard_lim_num
   ```

   Save the file.

3. Verify that the following line is included in the appropriate PAM configuration files for any authentication methods for which you want limits enforced; the PAM configuration files are located in the `/etc/pam.d/` directory. For example, to enforce limits for users connecting via `ssh`, add the `pam_limits.so` line to the file `/etc/pam.d/sshd`. Other applicable authentication methods to include also are `su` in the file `/etc/pam.d/su` and local logins in `/etc/pam.d/login`.

   ```
   session required pam_limits.so
   ```

   For more information about the Pluggable Authentication Module (PAM), see the `PAM`(8) man page.

4. Type `exit` to return to the normal prompt on the boot node; the changes you made should be effective immediately on login nodes.

   ```
   class/login:/ # exit
   boot:~ #
   ```

5. To test that the limits are in place, from a login node type the following command, which should return the number specified as the soft limit for the number of processes available to a user, for example:

   ```
   boot:~ # ssh login
   nid00004:~ # ulimit -u
   ```

   For more information about using the `ulimit` command, see the `ulimit`(P) man page.

7.7 Handling Bus Errors

Bus errors are caused by machine-check exceptions. If you have received a bus error, try the following procedure:

Procedure 54. Power-cycling a component

Power down then power up components. The *physIDlist* is a comma-separated list of components present on the system (see Physical ID on page 56).

1. Power down the components.

   ```
   crayadm@smw:~> xtcli power down  PhysID
   ```

2. Power up the components.

   ```
   crayadm@smw:~> xtcli power up PhysID
   ```

7.8 Creating a Cray System Management Workstation (SMW) Bootable Backup Drive

The following procedure creates a System Management Workstation (SMW) bootable backup drive whose purpose is to replace the primary drive if the primary drive fails.

When this procedure is completed, the backup drive on the SMW will be a bootable replacement for the primary drive when the backup drive is plugged in as or cabled as the primary drive.

Note: In the following procedure, `/dev/sd`*X*`2` is the SMW disk (either `/dev/sdb2` or `/dev/sdc2`).

Procedure 55. Creating an SMW bootable backup drive

Caution: The disk device names shown in this procedure are only examples. You should substitute the actual disk device names for your system. For example, on an SMW with three SMW disks, the boot disk is `/dev/sda` and the bootable backup disk is `/dev/sdc`; on an SMW with two SMW disks, the boot disk is `/dev/sda` and the bootable backup disk is `/dev/sdb`.

1. Log on to the SMW as `crayadm` and `su` to `root`.

   ```
   crayadm@smw:~> su - root
   smw:~ #
   ```

2. If the backup drive disk partition table already exists and the partition table on the backup drive matches the partition table that is on the primary boot drive, skip this step; otherwise, create the backup drive disk partition table.

   Note: For optimal performance, the source and destination disks should be on different buses; drive slots 0 and 1 are on a different bus than drive slots 2 and 3.

In this example, the partition table consists of the following:

- Slice 1: 4 GB Linux swap partition
- Slice 2: Balance of disk space used for the root file system

a. Use the `fdisk` command to display the boot disk partition layout.

```
smw:~ # fdisk -lu /dev/sda
Disk /dev/sda: 320.0 GB, 320072933376 bytes
255 heads, 63 sectors/track, 38913 cylinders, total 625142448 sectors
Units = sectors of 1 * 512 = 512 bytes

  Device   Boot     Start         End      Blocks   Id  System
/dev/sda1              63     8401994     4200966   82  Linux swap / Solaris
/dev/sda2   *     8401995   625137344   308367675   83  Linux
```

b. Use the `fdisk` command to configure the bootable backup disk partition layout. Set the bootable backup disk partition layout to match the boot disk partition layout. First, clear all of the old partitions using the `d` command within `fdisk`; next create a Linux swap and a Linux partition; and then write your changes to the disk. For help, type **`m`** within `fdisk` (see the following sample output).

```
smw:~ # fdisk -u /dev/sdb

The number of cylinders for this disk is set to 38913.
There is nothing wrong with that, but this is larger than 1024,
and could in certain setups cause problems with:
1) software that runs at boot time (e.g., old versions of LILO)
2) booting and partitioning software from other OSs
   (e.g., DOS FDISK, OS/2 FDISK).

Command (m for help): p
Disk /dev/sdb: 320.0 GB, 320072933376 bytes
255 heads, 63 sectors/track, 38913 cylinders, total 625142448 sectors
Units = sectors of 1 * 512 = 512 bytes

   Device Boot      Start         End      Blocks   Id  System
/dev/sdb1              63     8401994     4200966   82  Linux swap
/dev/sdb2         8401995   625105214   308351610   83  Linux

Command (m for help): d
Partition number (1-5): 2
Command (m for help): d
Selected partition 1
Command (m for help): n
Command action
e extended
p primary partition (1-4)
p
Partition number (1-4): 1
First sector (63-625105215, default 63): (Press the Enter key)
Using default value 63
Last sector or +size or +sizeM or +sizeK (63-625105215, default 625105215): 8401994

Command (m for help): t
```

```
Selected partition 1
Hex code (type L to list codes): 82
Changed system type of partition 1 to 82 (Linux swap / Solaris)

Command (m for help): n
Command action
e extended
p primary partition (1-4)
p
Partition number (1-4): 2
First sector (8401995-625105215, default 8401995): (Press the Enter key)
Using default value 8401995
Last sector or +size or +sizeM or +sizeK (8401995-625105215, default 625105215): \
  (Press the Enter key)
Using default value 625105215

Command (m for help): w
The partition table has been altered!

Calling ioctl() to re-read partition table.
Syncing disks.
```

c. Display the boot backup disk partition layout.

```
smw:~ # fdisk -lu /dev/sdb
Disk /dev/sdb: 320.0 GB, 320072933376 bytes
255 heads, 63 sectors/track, 38913 cylinders, total 625142448 sectors
Units = sectors of 1 * 512 = 512 bytes


  Device   Boot     Start        End       Blocks   Id  System

/dev/sdc1              63     8401994     4200966   82  Linux swap / Solaris
/dev/sdc2   *     8401995   625137344   308367675   83  Linux
```

3. Initialize the swap device.

   ```
   smw:~ # mkswap /dev/sdb1
   ```

4. Standardize the `grub` disk device names.

   The device names that the installation process writes into the `/boot/grub/menu.lst` file are UDEV-based names (for example, `/dev/disk/`*by-id*`/scsi-SATA_ST3320620AS_922J3-part2` or `/dev/disk/`*by-id*`/ata-ST3320620A_9QFA85PV-part2`) instead of the more commonly used device names (for example, `/dev/sda2` or `/dev/hda2`). In the following procedures, edit the `/boot/grub/menu.lst` file to change ONLY the long UDEV-based name to the shorter, commonly used device name reflected in the output of the `df` command on your system.

   If the device names have already been standardized, skip to step 5.

   Caution: Mistakes in the `/boot/grub/menu.lst` file will affect your ability to boot the SMW.

a. SLES 11 sets up `/boot/grub/menu.lst` with UDEV-based names for the root device. For example:

```
smw:~ # more /boot/grub/menu.lst
###Don't change this comment - YaST2 identifier: Original name: linux###
title SUSE Linux Enterprise Server 11 - 2.6.27.19-5
    root (hd0,1)
    kernel /boot/vmlinuz-2.6.27.19-5-default \
    root=/dev/disk/by-id/ata-ST3320620AS_5QF00F84-part2 \
    resume=/dev/sda1 splash=silent crashkernel=256M-:128M@16M
    showopts vga=0x31a initrd /boot/initrd-2.6.27.19-5-default

###Don't change this comment - YaST2 identifier: Original name: failsafe###
title Failsafe -- SUSE Linux Enterprise Server 11 - 2.6.27.19-5
    root (hd0,1)
    kernel /boot/vmlinuz-2.6.27.19-5-default \
    root=/dev/disk/by-id/ata-ST3320620AS_5QF00F84-part2 showopts \
    ide=nodma apm=off noresume edd=off powersaved=off nohz=off highres=off
    processor.max_cstate=1 x11failsafe vga=0x31a
    initrd /boot/initrd-2.6.27.19-5-default
```

b. Execute the `df` command to get the name of the device to use in the `/boot/grub/menu.lst` file to replace the long UDEV-based device name. Then edit your `/boot/grub/menu.lst` file appropriately.

1) Execute the `df` command to get the name of the device to use in the `/boot/grub/menu.lst` file to replace the long UDEV-based device name. For example:

```
smw:# df
    Filesystem   1K-blocks      Used Available Use% Mounted on
    /dev/sda2    303528624  40652904 247457340  15% /
    udev           1030780       460   1030320   1% /dev
```

2) Save a copy of your `/boot/grub/menu.lst` file.

```
smw:# cp -p /boot/grub/menu.lst /boot/grub/menu.lst.save
```

3) Edit your `/boot/grub/menu.lst` file appropriately; use the device name (dev) you got from the `df` command output. Change the long name `disk/by-id/scsi-SATA_ST3320620AS_9QF922J3-part2` to `sda2`. Change the following lines:

```
title SUSE Linux Enterprise Server 11 - 2.6.27.19-5
    kernel /boot/vmlinuz-2.6.27.19-5-default \
    root=/dev/disk/by-id/ata-ST3320620AS_5QF00F84-part2 \
    resume=/dev/sda1 splash=silent crashkernel=256M-:128M@16M showopts vga=0x31a
```

to:

```
title SUSE Linux Enterprise Server 11 - 2.6.27.19-5
    kernel /boot/vmlinuz-2.6.27.19-5-default \
    root=/dev/sda2 resume=/dev/sda1 splash=silent \
    crashkernel=256M-:128M@16M showopts vga=0x31a
```

and change the following lines:

```
title Failsafe -- SUSE Linux Enterprise Server 11 - 2.6.27.19-5
```

```
    kernel /boot/vmlinuz-2.6.27.19-5-default \
    root=/dev/disk/by-id/ata-ST3320620AS_5QF00F84part2 \
    showopts ide=nodma apm=off noresume edd=off powersaved=off nohz=off \
    highres=off processor.max_cstate=1 x11failsafe vga=0x31a
```

to:

```
title Failsafe -- SUSE Linux Enterprise Server 11 - 2.6.27.19-5
    kernel /boot/vmlinuz-2.6.27.19-5-default \
    root=/dev/sda2 showopts ide=nodma apm=off noresume edd=off \
    powersaved=off nohz=off highres=off processor.max_cstate=1 x11failsafe vga=0x31a
```

4) Verify that the edited file is correct and matches the output of the `df` command.

```
smw:~ # more /boot/grub/menu.lst
###Don't change this comment - YaST2 identifier: Original name: linux###
title SUSE Linux Enterprise Server 11 - 2.6.27.19-5
    root (hd0,1)
    kernel /boot/vmlinuz-2.6.27.19-5-default root=/dev/sda2 \
    resume=/dev/sda1 splash=silent crashkernel=256M-:128M@16M showopts
    initrd /boot/initrd-2.6.27.19-5-default

###Don't change this comment - YaST2 identifier: Original name: failsafe###
title Failsafe -- SUSE Linux Enterprise Server 11 - 2.6.27.19-5
    root (hd0,1)
    kernel /boot/vmlinuz-2.6.27.19-5-default \
    root=/dev/sda2 showopts ide=nodma apm=off noresume edd=off
    powersaved=off nohz=off highres=off initrd /boot/initrd-2.6.27.19-5-default
```

c. Update the `grub` device table to utilize the standardized drive names and recognize any new drives added since the initial operating system installation.

```
smw:~ # grub-install.unsupported --recheck /dev/sda
```

The file `/boot/grub/device.map` is now updated to reflect all drives, utilizing the standardized drive naming. This file can be viewed for verification; for example:

```
smw:~ # cat /boot/grub/device.map
(fd0)   /dev/fd0
(hd0)   /dev/sda
(hd1)   /dev/sdc
```

5. Create a new file system on the backup drive root partition by executing the `mkfs` command.

```
smw:~ # mkfs -t ext3 /dev/sdb2
mke2fs 1.41.1 (01-Sep-2008)
Filesystem label=
OS type: Linux
Block size=4096 (log=2)
Fragment size=4096 (log=2)
19275776 inodes, 77091918 blocks
3854595 blocks (5.00%) reserved for the super user
First data block=0
Maximum filesystem blocks=4294967296
2353 block groups
```

```
32768 blocks per group, 32768 fragments per group
8192 inodes per group
Superblock backups stored on blocks:
        32768, 98304, 163840, 229376, 294912, 819200, 884736, 1605632, 2654208,
        4096000, 7962624, 11239424, 20480000, 23887872, 71663616

Writing inode tables: done
Creating journal (32768 blocks): done
Writing superblocks and filesystem accounting information: done

This filesystem will be automatically checked every 33 mounts or
180 days, whichever comes first.  Use tune2fs -c or -i to override.
smw:~ #
```

6. Mount the new backup root file system on `/mnt`.

   ```
   smw:~ # mount /dev/sdb2 /mnt
   ```

7. Confirm the running root file system device.

   ```
   smw:~ # df
   Filesystem           1K-blocks      Used Available Use% Mounted on
   /dev/sda2            303528624   6438700 281671544   3% /
   udev                   1030332       116   1030216   1% /dev
   /dev/sdb2            306128812    195568 290505224   1% /mnt
   ```

   The running root file system device is the one mounted on `/`.

8. Dump the running root file system to the backup drive.

   ```
   smw:~ # cd /mnt
   smw:~ # dump 0f - /dev/sda2 | restore rf -
   DUMP: WARNING: no file `/etc/dumpdates'
   DUMP: Date of this level 0 dump: Thu Dec 10 06:55:29 2009
   DUMP: Dumping /dev/sda2 (/) to standard output
   DUMP: Label: none
   DUMP: Writing 10 Kilobyte records
   DUMP: mapping (Pass I) [regular files]
   DUMP: mapping (Pass II) [directories]
   DUMP: estimated 4003398 blocks.
   DUMP: Volume 1 started with block 1 at: Thu Dec 10 06:57:38 2009
   DUMP: dumping (Pass III) [directories]
   DUMP: dumping (Pass IV) [regular files]
   restore: ./lost+found: File exists
   DUMP: 81.99% done at 10941 kB/s, finished in 0:01
   DUMP: Volume 1 completed at: Thu Dec 10 07:04:01 2009
   DUMP: Volume 1 4008910 blocks (3914.95MB)
   DUMP: Volume 1 took 0:06:23
   DUMP: Volume 1 transfer rate: 10467 kB/s
   DUMP: 4008910 blocks (3914.95MB)
   DUMP: finished in 383 seconds, throughput 10467 kBytes/sec
   DUMP: Date of this level 0 dump: Thu Dec 10 06:55:29 2009
   DUMP: Date this dump completed:  Thu Dec 10 07:04:01 2009
   DUMP: Average transfer rate: 10467 kB/s
   DUMP: DUMP IS DONE
   ```

9. Install the `GRUB` boot loader.

   To make the backup drive bootable, reinstall the `grub` boot facility on that drive.

a. Create a unique file on the backup drive to be used to identify that drive to `grub` boot facility.

```
smw:~ # cd /
smw:~ # touch /mnt/THIS_IS_SDX
```

b. Invoke the `grub` boot utility. Within the `grub` boot utility:

1) Execute the `find` command to locate the drive designation that `grub` uses.

2) Select the drive to which the boot blocks will be installed with the `root` command.

3) Use the `setup` command to set up and install the `grub` boot blocks on that drive.

Note: The Linux `grub` utility and boot system ALWAYS refer to drives as `hd`, regardless of the actual type of drives.

For example:

```
smw:~ # grub
GNU GRUB  version 0.97  (640K lower / 3072K upper memory)
[ Minimal BASH-like line editing is supported.  For the first word, TAB^[
lists possible command completions.  Anywhere else TAB lists the possible
completions of a device/filename. ]
grub> find /THIS_IS_SDX
find /THIS_IS_SDX
(hd1,1)
grub> root (hd1,1)
root (hd1,1)
Filesystem type is ext2fs, partition type 0x83
grub> setup (hd1)
setup (hd1)
Checking if "/boot/grub/stage1" exists... yes
Checking if "/boot/grub/stage2" exists... yes
Checking if "/boot/grub/e2fs_stage1_5" exists... yes
Running "embed /boot/grub/e2fs_stage1_5 (hd1)"...  17 sectors are embedded.
succeeded
Running "install /boot/grub/stage1 (hd1) (hd1)1+17 p
(hd1,1)/boot/grub/stage2 /boot/grub/menu.lst"... succeeded
Done.
grub> quit
```

10. Unmount the backup root partition.

```
smw:~ # umount /dev/sdb2
```

The drive is now bootable once plugged in or cabled as the primary drive.

7.9 Setting Up the Bootable Backup Drive as an Alternate Boot Device

The following procedure modifies a bootable backup drive, generated in Procedure 55 on page 218, in order to boot from and run the SMW from the backup root partition. To find out information about how to recover the SMW, see Procedure 60 on page 231.

Important: To boot from this backup drive, the primary boot drive must still be operable and able to boot the `grub` boot blocks installed. If the backup drive is modified to boot as an alternate boot device, it will no longer function as a bootable backup if the primary drive fails.

Procedure 56. Setting up the bootable backup drive as an alternate boot device

Caution: The disk device names shown in this procedure are provided as examples only. Substitute the correct disk devices for your system. For example, on an SMW with three SMW disks, the boot disk is `/dev/sda` and the bootable backup disk is `/dev/sdc`; on an SMW with two SMW disks, the boot disk is `/dev/sda` and the bootable backup disk is `/dev/sdb`.

1. Mount the backup drive's root partition.

   ```
   smw:~ # mount /dev/sdX2  /mnt
   ```

2. Create a new boot entry in the `/boot/grub/menu.lst` file. This entry should be a duplicate of the primary boot entry with the following changes:

   - Modify the title to uniquely identify the backup boot entry.
   - Modify the `root (hd0,1)` directive to reflect the Grub name of the backup drive. If you do not know the Grub name of the backup drive, it is provided in the `/boot/grub/device.map` file on the primary drive.
   - Modify the `root=` and `resume=` specifications to reference the backup drive device.

   An example `/boot/grub/menu.lst` file follows. Note the new entry at the end of the file. This example references `/dev/sda` as the primary drive and `/dev/sdc` as the backup drive.

```
smw:~ # cat /boot/grub/menu.lst
# Modified by YaST2. Last modification on Wed Dec 9 15:09:52 UTC 2009
default 0
timeout 8
##YaST - generic_mbr
gfxmenu (hd0,1)/boot/message
##YaST - activate

###Don't change this comment - YaST2 identifier: Original name: linux###
title SUSE Linux Enterprise Server 11 - 2.6.27.19-5
    root (hd0,1)
    kernel /boot/vmlinuz-2.6.27.19-5-default root=/dev/sda2 \
```

```
    resume=/dev/sda1 splash=silent crashkernel=256M-:128M@16M showopts vga=0x31a \
    initrd /boot/initrd-2.6.27.19-5-default

###Don't change this comment - YaST2 identifier: Original name: failsafe###
title Failsafe -- SUSE Linux Enterprise Server 11 - 2.6.27.19-5
    root (hd0,1)
    kernel /boot/vmlinuz-2.6.27.19-5-default root=/dev/sda2 showopts \
    ide=nodma apm=off noresume edd=off powersaved=off nohz=off highres=off \
    processor.max_cstate=1 x11failsafe vga=0x31a \
    initrd /boot/initrd-2.6.27.19-5-default

###Don't change this comment - YaST2 identifier: Original name: floppy###
title Floppy
    rootnoverify (fd0)
    chainloader +1

### New entry allowing a boot of the back-up drive when the primary drive
### is still present.
title BACK-UP DRIVE - SUSE Linux Enterprise Server 11 - 2.6.27.19-5
    root (hd0,1)
    kernel /boot/vmlinuz-2.6.27.19-5-default root=/dev/sdc2 \
    resume=/dev/sdc1 splash=silent crashkernel=256M-:128M@16M showopts vga=0x31a \
    initrd /boot/initrd-2.6.27.19-5-default
```

3. Modify the backup drive's `/etc/fstab` file to reference the secondary drive slot rather than the first drive slot.

   a. Examine the backup drive's `fstab` file.

```
smw:~ # cat /mnt/etc/fstab
/dev/sda1   swap                swap       defaults            0 0
/dev/sda2   /                   ext3       acl,user_xattr      1 1
proc        /proc               proc       defaults            0 0
sysfs       /sys                sysfs      noauto              0 0
debugfs     /sys/kernel/debug   debugfs    noauto              0 0
usbfs       /proc/bus/usb       usbfs      noauto              0 0
devpts      /dev/pts            devpts     mode=0620,gid=5     0 0
```

   b. Edit the `/mnt/etc/fstab` file, changing `/dev/sda1` and `/dev/sda2` to reference the backup drive. In the following example, the backup drive is `/dev/sdc`.

```
smw:~ # vi /mnt/etc/fstab
/dev/sdc1   swap                swap       defaults            0 0
/dev/sdc2   /                   ext3       acl,user_xattr      1 1
proc        /proc               proc       defaults            0 0
sysfs       /sys                sysfs      noauto              0 0
debugfs     /sys/kernel/debug   debugfs    noauto              0 0
usbfs       /proc/bus/usb       usbfs      noauto              0 0
devpts      /dev/pts            devpts     mode=0620,gid=5     0 0
```

4. Unmount the backup drive.

```
smw:~ # umount /dev/sdX2
```

The SMW can now be shut down and rebooted. Upon display of the **Please select boot device** prompt, select the **BACK-UP DRIVE - SLES 11** entry to boot the backup root partition.

7.10 Archiving the SDB

The service database (SDB) can be archived by using the `mysqldump` command. For more information, see http://dev.mysql.com/doc.

7.11 Backing Up Limited Shared-root Configuration Data

Cray recommends that if you cannot make a full copy, make a backup copy of the `.shared` root structure before making significant changes to the shared root. You can use the `xtoparchive` utility or the Linux utilities (`cp`, `tar`, `cpio`) to save the shared-root file system. Run these procedures from the boot node.

7.11.1 Using the `xtoparchive` Utility to Archive the Shared-root File System

Use the `xtoparchive` command to perform operations on an archive of shared root configuration files. Run the `xtoparchive` command on the boot node using the `xtopview` utility in the default view. The archive is a text-based file similar to a tar file and is specified using the required `archivefile` command-line argument. The `xtoparchive` command is intended for configuration files only. Binary files will not be archived. If a binary file is contained within a specification file list, it will be skipped and a warning will be issued.

Example 91. Using the `xtoparchive` utility to archive the shared-root file system

Use the following `xtoparchive` command to add files specified by the specifications listed in `specfile` to the archive file `archive.042208`; create the archive file if it does not already exist:

```
% xtoparchive -a -f specfile archive.042208
```

Note: To archive any specialized files that have changed, invoke the `archive_etc.sh` script. You can do this while your system is booted or from the boot root and shared root in a system set that is not booted. The `archive_etc.sh` script uses the `xtoprdump` and `xtoparchive` commands to generate an archive of specialized files on the shared root. For more information about archiving and upgrading specialized files, see the `shared_root`(5), `xtoparchive`(8), `xtopco`(8), `xtoprdump`(8), and `xtoprlog`(8) man pages.

7.11.2 Using Linux Utilities to Save the Shared-root File System

Use the Linux utilities (`cp`, `tar`, `cpio`) to save the shared-root file system.

Procedure 57. Backing up limited shared-root configuration data

Cray recommends that if you cannot make a full copy, make a backup copy of the `.shared` root structure before making significant changes to the shared root. Run this procedure from the boot node.

1. Change to the shared root directory that you are backing up.

   ```
   boot:/rr # cd /rr/current
   ```

2. Create a `tar` file for the directory.

   ```
   boot:/rr/current # tar czf /rr/dot_shared-20050929.tgz .shared
   ```

3. Change to the `/rr` directory.

   ```
   boot:/rr/current # cd /rr
   ```

4. Verify that the file exists.

   ```
   boot:/rr # ls -al dot_shared-20050929.tgz
   -rw-r--r--    1 root     root      7049675 Sep 29 14:21
   dot_shared-20050929.tgz
   boot:/rr #
   ```

For more information, see the `cp`(1), `tar`(1), and `cpio`(1) man pages.

7.12 Backing Up Boot Root and Shared Root

Before you back up your boot root and shared root, consider the following issues.

- You must be root to do this procedure.
- Do not have file systems mounted on the SMW and the Cray system at the same time.
- File system device names may be different at your site.
- If the backup file systems have not been used yet, you may need to run `mkfs` first.
- File systems should be quiescent and clean (`fsck`) to get an optimal dump and restore.

You can back up the boot root and the shared root by using the `xthotbackup` command or by using the Linux `dump` and `restore` commands.

7.12.1 Using the `xthotbackup` Command to Back Up Boot Root and Shared Root

Execute the `xthotbackup` command to create a bootable backup. The `xthotbackup` command must be executed with root privileges. The system set labels in `/etc/sysset.conf` define disk partitions for backup and source system sets which are used by `xthotbackup` to generate the appropriate `dump` and `restore` commands. The entire contents of the disk partitions defined in a source system set are copied to the corresponding disk partitions in the backup system set. The backup and source system sets must be configured with identical partitions. (Follow the steps provided on the `xthotbackup`(8) man page in the Initial Setup section to set up identical system sets.) The disk partitions in the backup system set are formatted prior to the dump and restore commands.

The `xthotbackup` command must be executed with root privileges. Load the `cray-install-tools` module to access the `xthotbackup` utility and the `xthotbackup`(8) man page.

Example 92. Using the `xthotbackup` command to create a bootable backup system set

Enter the following to dump all of the partitions from the source label, `BLUE`, to the backup label, `GREEN`, and then make them bootable.

```
smw:~ # xthotbackup -a -b BLUE GREEN
```

The `xthotbackup` command can also be used to copy selected file systems from source to the backup system set.

Example 93. Using the `xthotbackup` command to copy selected file systems from source to the backup system set

The following example dumps only the `SDB` and `SYSLOG` partitions in the system set labelled `BLUE` to the system set labelled `GREEN`.

```
smw:~ # xthotbackup -f SDB,SYSLOG BLUE GREEN
```

7.12.2 Using `dump` and `restore` Commands to Back Up Boot Root and Shared Root

Procedure 58. Backing up the boot root and shared root using the `dump` and `restore` commands

1. Verify that the Cray system is halted.
2. Open a root session.

   ```
   crayadm@smw:~> su -
   ```

3. Mount the boot root to the SMW.

   ```
   smw:~ # mount /dev/sda1 /bootroot0
   ```

4. Mount the backup boot root to the SMW.

   ```
   smw:~ # mount /dev/sdb1 /bootroot1
   ```

5. Change directories to the backup boot root.

   ```
   smw:~ # cd /bootroot1
   ```

6. Dump and restore boot root to the backup boot root.

   ```
   smw:~/bootroot1 # dump -0 -f - /bootroot0 | restore -rf -
   ```

7. When the dump is complete, unmount both boot-root file systems.

   ```
   smw:~/bootroot1 # cd /
   smw:~ # umount /bootroot0 /bootroot1
   ```

8. Mount the shared root to the SMW.

   ```
   smw:~ # mount /dev/sdc6 /sharedroot0
   ```

9. Mount the backup shared root to the SMW.

   ```
   smw:~ # mount /dev/sdg6 /sharedroot1
   ```

10. Change directories to the backup shared root.

    ```
    smw:~ # cd /sharedroot1
    ```

11. Dump and restore shared root to the backup shared root.

    ```
    smw:~/sharedroot1 # dump -0 -f - /sharedroot0 | restore -rf -
    ```

12. When the dump is complete, unmount both shared root file systems.

    ```
    smw:~/sharedroot1 # cd /
    smw:~ # umount /sharedroot0 sharedroot1
    ```

13. Exit the root session.

    ```
    smw:~ # exit
    ```

7.13 Backing Up User Data

Backing up user data is a site-specific activity. You can use Linux utilities to back up user files and directories.

7.14 Rebooting a Stopped SMW

Shutting down the SMW in a scheduled or unscheduled situation does not affect the operation of the mainframe, other than affecting the SMW-supplied functions of event logging, state management, and node-failure notifications to the mainframe. (No attempt is made to prevent loss of data or to carry out operations that occur when the SMW is offline.) When the SMW comes up, it restarts, establishes communications with all external interfaces, restores the proper state in the state manager, and continues normal operation without user intervention.

For a scheduled or unscheduled shutdown and reboot of the SMW, it is necessary to have uncorrupted configuration files on a local SMW disk.

Procedure 59. Rebooting a stopped SMW

1. Verify that your configuration files contain the most recent system configuration.
2. Boot the SMW.

7.14.1 SMW Recovery

Procedure 60. SMW primary disk failure recovery

The following procedure describes how to recover an SMW primary disk failure. To find out how to create a System Management Workstation (SMW) bootable backup drive, see Procedure 55 on page 218. To find out how to modify a bootable backup drive, in order to boot from and run the SMW from the backup root partition, see Procedure 56 on page 225.

Caution: Booting off the bootable backup disk is intended only for emergency use in the event of failure or loss of data on the primary disk.

To recover an SMW, you must reorder the drives at the front of the SMW. No BIOS or software configuration changes are required.

1. Shutdown the OS on the SMW, if possible.
2. Power the SMW off.
3. Unplug the power cord.
4. Open the disk drive access door, which is on the front of the SMW.
5. Remove the primary disk from its slot. The primary disk is located at the bottom of the column of disk drives at the front of the SMW.
6. Remove the bootable backup disk and place it in the primary disk slot.
7. Press the reset button (front), if required.
8. Boot the SMW.

7.15 Recovering from Service Database Failure

If you notice problems with the SDB, for example, if commands like `xtprocadmin` do not work, restart the service-node daemons.

Example 94. Recovering from an SDB failure

Type the following command on the SDB node:

```
sdb:~ # /etc/init.d/sdb restart
```

Entries in this file stop and restart MySQL.

7.15.1 Database Server Failover

The SDB uses dual-ported local RAID to store files.

If you have SDB node failover configured, one service processor acts as the primary SDB server. If the primary server daemon dies, or the node on which it is running dies, the secondary (backup) SDB server that connects to the same RAID storage starts automatically. IP failover directs all new TCP/IP connections to the server, which now becomes the primary SDB server. Connections to the failed server are ended, and an error is reported to the client.

7.15.2 Rebuilding Corrupted SDB Tables

The boot process creates all SDB tables except the accounting and boot tables. If you notice a small corruption and you do not want to reboot, you can change the content of a database table manually by using the tools in Table 10. If you cannot recover a database table in any other way, as a last resort reboot the system.

7.16 Using Persistent SCSI Device Names

Important: The information provided in this section does **not** apply to SMW disks.

SCSI device names (`/dev/sd*`) are not guaranteed to be numbered the same from boot to boot. This inconsistency can cause serious system problems following a reboot. When installing CLE, you **must** switch to persistent device names for file systems on your Cray system.

Cray recommends that you use the `/dev/disk/by-id/` persistent device names. Use `/dev/disk/by-id/` for the root file system in the `initramfs` image and in the `/etc/sysset.conf` installation configuration file as well as for other file systems, including Lustre (as specified in `/etc/fstab` and `/etc/sysset.conf`). For more information, see *Installing and Configuring Cray Linux Environment (CLE) Software*.

Alternatively, you can define persistent names using a site-specific `udev` rule or `cray-scsidev-emulation`. However, only the `/dev/disk/by-id` method has been verified and tested.

Caution: You must use `/dev/disk/by-id` when specifying the root file system. There is no support in the `initramfs` for `cray-scsidev-emulation` or custom `udev` rules.

7.16.1 Using `cray-scscidev-emulation` Device Naming

Cray provides a utility (`cray-scscidev-emulation`) that emulates the basic functionality of the obsolete `scsidev` method for SCSI device naming.

The device alias is created in `/dev/scsi` for any devices that match entries in the alias file, `/etc/scsi.alias`. Format the alias file as follows, where *SN* is the serial number of the hard disk, *PN* is the partition number of the disk, and *devname* is the desired alias name.

```
serial_number="SN", devtype=disk, [partition=PN,] alias=devname
```

For example, the following entry creates a device entry `/dev/scsi/cab2-3-c1-shroot` for partition `2` on the disk with the serial number `030B9ED30300`.

```
serial_number="030B9ED30300", devtype=disk, partition=2, alias=cab2-3-c1-shroot
```

Note: The following limitations apply when using `cray-scsidev-emulation`:

- This capability is not implemented in the `initramfs`; it cannot be used to specify the boot root.
- Only the format shown is supported; `scsidev` supported a number of additional formats.
- Only one alias per disk is supported.
- Only symbolic links are supported.

7.17 Using a Linux `iptables` Firewall to Limit Services

You can set up a firewall to limit services that are running on your system. Cray has enabled the Linux kernel to provide this capability. Use the `iptables` command to set up, maintain, and inspect tables that contain rules to filter IP packets.

For more information about `iptables` and firewall scripts, see the `iptables`(8) man page, http://iptables-tutorial.frozentux.net/iptables-tutorial.html, and http://www.linuxguruz.com/iptables/.

7.18 Handling Single-node Failures

A single-node failure is visible when you use the `xtnodestat` command.

You can parse the syslog to look for failures.

You can use the Cray Management Services (CMS) log manager to collect, analyze, and display messages from the system. For additional information, see *Using Cray Management Services (CMS)*.

If you suspect problems with a node, invoke the `xtcli status` command. Nodes that have failed show an `alert` status. Jobs are not scheduled on the node as long as the alert is set. If problems persist, consult your service representative.

To see cabinet status, use the System Environmental Data Collections (SEDC); see *Using and Configuring System Environment Data Collections (SEDC)*.

For more information, see the `xtnodestat`(1), `xtcli`(8), and `xtsedcviewer`(8) man pages.

7.19 Increasing the Boot Manager Time-out Value

On systems of 4,000 nodes or larger, the time that elapses until the boot manager receives all responses to the boot requests can be greater than the default 60-second time-out value. This is due, in large part, to the amount of other event traffic that occurs as each compute node generates its console output. To avoid this problem, change the `boot_timeout` value in the `/opt/cray/etc/bm.ini` file on the SMW to increase the default time-out value, as shown in Example 95.

Example 95. Increasing the `boot_timeout` value

For systems of 4,000 to 7,000 nodes, change the `boot_timeout` line to

```
boot_timeout 120
```

For systems larger than 7,000 nodes, change the `boot_timeout` line to

```
boot_timeout 180
```

7.20 RAID Failure

System RAID has its own recovery system that the manufacturer supplies. For more information, refer to the manufacturer documentation.

Using the Application Level Placement Scheduler (ALPS) [8]

ALPS (Application Level Placement Scheduler) is the Cray supported mechanism for placing and launching applications on CNL compute nodes. ALPS provides application placement, launch, and management functionality and cooperates closely with third-party batch systems for application scheduling across Cray systems. The third-party batch systems make policy and scheduling decisions, while ALPS provides a mechanism to place and launch the applications contained within batch jobs. ALPS also supports interactive application placement and launch.

Note: ALPS application placement and launch functionality is only for applications executing on compute nodes. ALPS does not provide placement or launch functionality on service nodes.

8.1 ALPS Functionality

ALPS performs the following functions:

- Assigns application IDs.
- Manages compute node resources.
- Provides a configurable node selection algorithm for placing applications. (See the `ALPS_NIDORDER` configuration parameter in `/etc/sysconfig/alps` Configuration File on page 243 for more information.)
- Launches applications.
- Delivers signals to applications.
- Returns `Supports` and `stderr` from applications.
- Provides application placement and reservation information.
- Supports batch and interactive workloads.
- Supports huge pages functionality for CNL applications.
- Provides an XML interface for third-party batch-system communication.
- Provides launch assistance to debuggers, such as TotalView.

- Supports application placement of nonuniform numbers of processing elements (PEs) per node, allowing full use of all compute node resources on mixed-node machines.
- Works with the CLE Node Health software to perform application cleanup following the non-orderly exit of an application (see ALPS and Node Health Monitoring Interaction on page 253). For additional information about the CLE Node Health software, see Configuring Node Health Checker (NHC) on page 157.
- If running Cray Checkpoint Restart (Cray CPR), assists in application checkpoint and restart; for information about using Cray CPR, see Chapter 10, Using Checkpoint/Restart on Cray Systems on page 275.

8.2 ALPS Architecture

The ALPS architecture includes the following clients and daemons, each intended to fulfill a specific set of responsibilities as they relate to application and system resource management. The ALPS components use TCP/IP sockets and User Datagram Protocol (UDP) datagrams to communicate with each other. The `apinit` daemon executes on compute nodes. All other ALPS components execute on service nodes (login, SDB, and boot nodes).

ALPS clients (for detailed descriptions, see ALPS Clients on page 237 and the man page for each ALPS client):

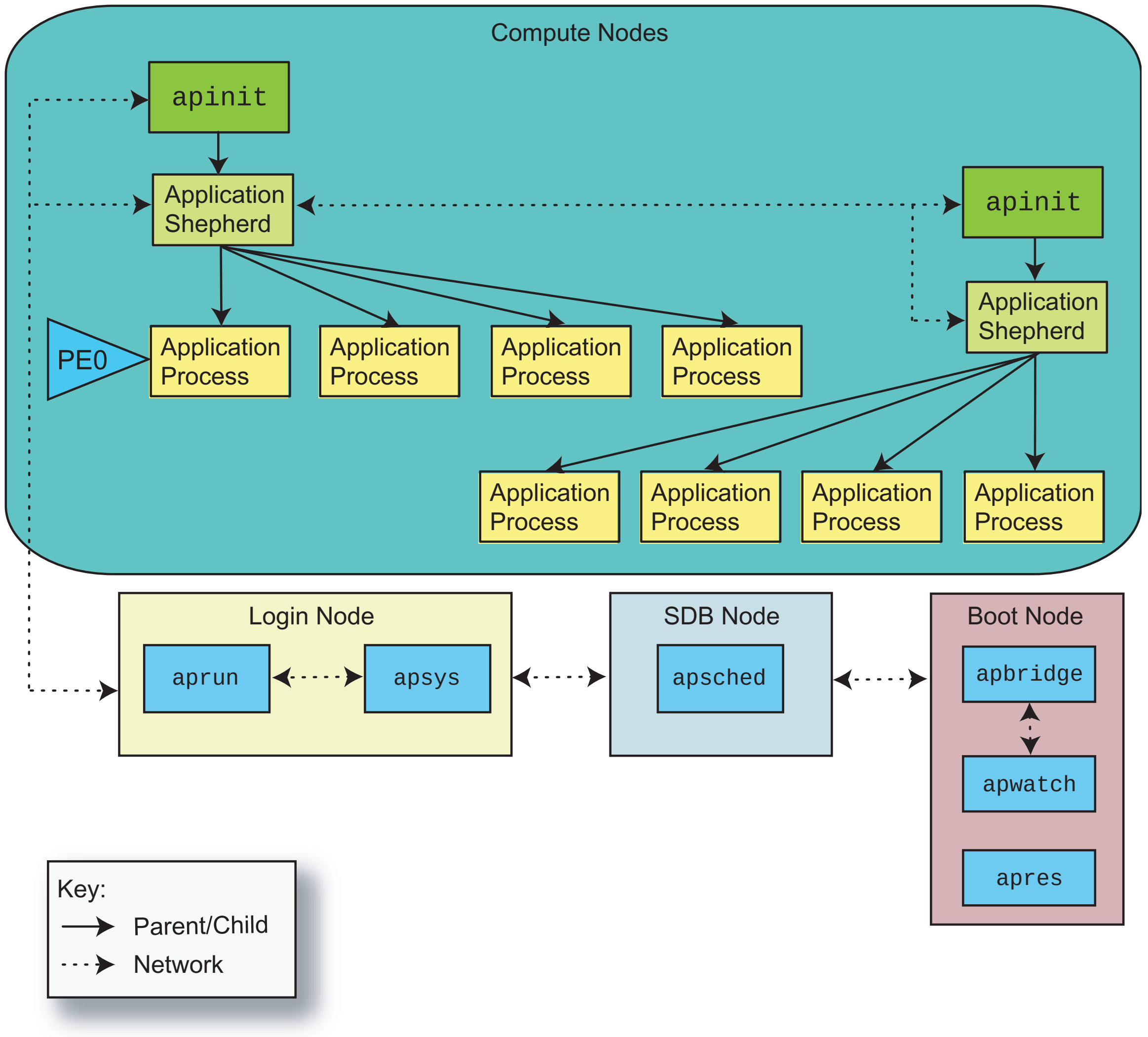
- `aprun`: Application submission
- `apstat`: Application placement and reservation status
- `apkill`: Application signaling
- `apmgr`: Collection of functions usually used by the system administrator in exceptional circumstances to manage ALPS
- `apbasil`: Workload manager interface

ALPS daemons (for detailed descriptions, see ALPS Daemons on page 240 and the man page for each ALPS daemon):

- `apsys`: Client local privileged contact
- `apinit`: Application management on compute nodes
- `apsched`: Reservations and placement decisions
- `apbridge`: System data collection
- `apwatch`: Event monitoring
- `apres`: ALPS database event watcher restart daemon

ALPS uses memory-mapped files to consolidate and distribute data efficiently, reducing the demand on the daemons that maintain these files by allowing clients and other daemons direct access to data they require. Figure 4, illustrates the ALPS process.

Figure 4. ALPS Process



8.2.1 ALPS Clients

The ALPS clients provide the user interface to ALPS and application management. They are separated into the following distinct areas of functionality: application submission, application and reservation status, application signaling, administrator interface to ALPS, and batch system integration.

8.2.1.1 The `aprun` Client

The `aprun` client is used for application submission. Specifically, a user executes the `aprun` command to run a compiled program across one or more compute nodes. The `aprun` client serves as the local representative of the application and is the primary interface between the user and an application running on compute nodes. The `aprun` client parses command-line arguments to determine the application resource requirements. These requirements are submitted locally to `apsys`, which forwards them to `apsched` for application placement.

After the application has an assigned placement list of compute nodes, `aprun` provides application-launch information to the `apinit` daemon on the first compute node in the placement list. The `aprun` client also provides user identity and environment information to `apinit` so that the user's login node session can be replicated for the application on the assigned set of compute nodes. This information includes the `aprun` current working directory, which must be accessible from the compute nodes.

The `aprun` client forwards stdin data to `apinit`, which is delivered to the first processing element (PE) of the application. Application `stdout` and `stderr` data is sent from `apinit` to `aprun` on the login node.

The `aprun` client catches certain signals (see the `aprun`(8) man page) and forwards the signal information to `apinit` for delivery to the application. Any signal that cannot be caught and that terminates `aprun` causes `apinit` to terminate the application.

Note: Do not suspend `aprun`. It is the local representative of the application that is running on compute nodes. If `aprun` is suspended, the application cannot communicate with ALPS, such as sending exit notification to `aprun` that the application has completed.

For more information about using the `aprun` command, see the `aprun`(8) man page.

8.2.1.2 The `apstat` Client

The `apstat` client reports on application placement and reservation information. It reflects the state of `apsched` placement decisions. The `apstat` client does not have dynamic run-time information about an application, so the `apstat` display does not imply anything about the running state of an application. The `apstat` display indicates statically that an application was placed and that the `aprun` claim against the reserved resources has not yet been released.

If no application ID (apid) is specified when executing the `apstat` command, the `apstat` command displays a brief overview of all applications.

For detailed information about this status information, see the `apstat`(1) man page.

8.2.1.3 The `apkill` Client

The `apkill` client is used for application signaling. It parses the command-line arguments and sends signal information to its local `apsys` daemon. The `apkill` command can be invoked on any login or service node and does not need to be on the same node as the `aprun` client for that application. Based upon the application ID, `apsys` finds the `aprun` client for that application and sends the signal to `aprun`, which sends signal information to `apinit` for delivery to the application.

The `apkill` client can send a signal only to a placed application, not a pending application.

For more information about the actions of this client, see the `apkill`(1) man page and the Linux `signal`(7) man page.

8.2.1.4 The `apmgr` Client

The `apmgr` command is a collection of ALPS-related functions for use by system administrators. These functions (subcommands) often require `root` permission and are usually used in exceptional circumstances to manage ALPS. The `apmgr` command is not typically installed on the boot node's file system; it is available on and is run from service nodes other than the boot node.

For information about using the `apmgr` subcommands, see the `apmgr`(8) man page.

8.2.1.5 The `apbasil` Client

The `apbasil` client is used for batch system integration. It is the interface between ALPS and the batch scheduling system. The `apbasil` client implements the Batch and Application Scheduler Interface Layer (BASIL). When a job is submitted to the batch system, the batch scheduler uses `apbasil` to obtain ALPS information about available and assigned compute node resources to determine whether sufficient compute node resources exist to run the batch job.

After the batch scheduler selects a batch job to run, the batch scheduler uses `apbasil` to submit a resource reservation request to the local `apsys` daemon. The `apsys` daemon forwards this reservation request to `apsched`. If the reservation-request resources are available, specific compute node resources are reserved at that time for the batch scheduler use only.

When the batch job is initiated, the prior confirmed reservation is bound to this particular batch job. Any `aprun` client invoked from within this batch job can claim compute node resources only from this confirmed reservation.

The batch system uses `apbasil` to cancel the confirmed reservation after the batch job terminates. The `apbasil` client again contacts the local `apsys` daemon to forward the cancel-reservation request to `apsched`. The compute node resources from that reservation are available for other use after the application has been released.

For additional information, see the `apbasil`(1) and `basil`(7) man pages.

8.2.2 ALPS Daemons

ALPS daemons provide support for application submission, placement, execution, and cleanup on the system.

8.2.2.1 The `apbridge` Daemon

The `apbridge` daemon collects data about the hardware configuration from the service database (SDB) and sends it to the `apsched` daemon. It also works with the `apwatch` daemon to supply ongoing compute node status information to `apsched`. The `apbridge` daemon is the bridge from the architecture-independent ALPS software to the architecture-dependent specifics of the underlying system.

The `apbridge` daemon is not intended for direct use; it is only installed in the boot root and is invoked from within `/etc/init.d/alps`.

For more information, see the `apbridge`(8) man page.

8.2.2.2 The apsched Daemon

The `apsched` daemon manages memory and processor resources of applications running on compute nodes.

Note: Only one instance of the ALPS scheduler can run across the entire system at a time.

When `apsched` receives a request for application placement from `aprun`, it either returns a message regarding placement or a message indicating why placement is not possible (errors in the request or temporarily unavailable resources). When an application terminates, an exit message is sent to `apsched`, and it releases the resources reserved for the application.

The `apsched` daemon writes a log file on the node on which `apsched` is executing. By default, this is the SDB node.

For more information, see the `apsched`(8) man page.

8.2.2.3 The apsys Daemon

The `apsys` daemon provides a central privileged point of contact and coordination between ALPS components running on login and other service nodes. The `apsys` daemon receives incoming requests and forks child agent processes to delegate responsibilities and improve scalability and responsiveness. An `apsys` daemon executes on each login node and writes a log file on each login node.

Each `aprun` client has an `apsys` agent associated with it. Those two programs are on the same login node and communicate with each other over a persistent TCP/IP socket connection that lasts for the lifetime of the `aprun` client. The `apsys` daemon passes `aprun` messages to `apsched` over a transitory TCP/IP socket connection and returns the response to `aprun`.

An `apsys` agent is created to service `apbasil` and `apkill` messages. These programs communicate over transitory TCP/IP socket connections. The `apsys` agent handles the `apkill` message itself and forwards `apbasil` messages to `apsched`.

Each `apsys` agent maintains a separate agents file that is located in the ALPS shared directory. The file name format is `agents.`*nid*, for example, `/ufs/alps_shared/agents.40`. For information about defining the ALPS shared directory, see `/etc/sysconfig/alps` Configuration File on page 243.

For more information, see the `apsys`(8) man page.

8.2.2.4 The `apwatch` Daemon

The `apwatch` daemon waits for events and sends compute node status changes to `apbridge`, which sends it to `apsched`. The `apwatch` daemon is not intended for direct use; it is only installed in the boot root and is invoked from within `/etc/init.d/alps`.

For more information, see the `apwatch`(8) man page.

8.2.2.5 The `apinit` Daemon

The `apinit` daemon launches and manages new applications. A master `apinit` daemon resides on every compute node, initiates all new activity on that node, and writes a log file on the compute node. The `aprun` client connects to the `apinit` daemon on the first node of an application's allocated node set and sends a launch message containing all of the information the compute nodes need to launch and manage the new application.

The `apinit` daemon then forks a child process (referred to as the `apshepherd` or just shepherd) and transfers responsibility for managing the application on that node to that child. If the application requires more compute nodes, the shepherd process communicates to the `apinit` daemon on the next compute node, which forks another shepherd child process.

If the application is placed on more than one compute node, ALPS uses a TCP fan-out control tree network for application management messages to do binary transfer of the application when requested, and to handle application `stdin`, `stdout`, and `stderr` data. The root of the fan-out control tree is `aprun`. The width of the fan out is configured within the `/etc/alps.conf` file and is `32`, by default.

The `apinit` daemon is under the control of RCA. If the `apinit` daemon fails, RCA restarts `apinit`. If RCA is unable to restart `apinit` after several attempts, ALPS is notified and the node is made unavailable (`DOWN`) for applications.

For more information, see the `apinit`(8) man page.

8.2.2.6 The `apres` Daemon

The ALPS `apres` event watcher restart daemon registers with the event router daemon to receive `ec_service_started` events. When the service type is the SDB (`RCA_SVCTYPE_SDBD`), ALPS updates its data to reflect the current values in the SDB. The `apres` daemon is invoked as part of the ALPS startup process on the boot node.

The `apres` daemon is not intended for direct use; it is only installed in the boot root and is invoked from within `/etc/init.d/alps`.

For more information, see the `apres`(8) man page.

8.2.2.7 ALPS Log Files

Each of the ALPS daemons writes information to its log file in `/var/log/alps` on whichever node that runs the daemon. The name of the log file consists of the daemon name appended with the month and day, such as `apsched0302`.

The `apinit` log file is in the `/var/log/alps` directory on each compute node and also has a node ID appended to it, such as `apinit0302.00206`. Because this directory is in memory, the `apinit` log file is lost when a compute node is rebooted.

Each system has one `apbridge` daemon, one `apwatch` daemon, and one `apres` daemon, all of which must execute on the same node. By default, this is the boot node. These three daemons write to one log file on that node. The log file name format is `apbridge`*mmdd*, for example, `apbridge1027`.

8.2.2.8 Changing Debug Message Level of apsched and apsys Daemons

The level of debug messages written by the `apsched` and `apsys` daemons is defined in the `/etc/alps.conf` configuration file. You can change the debug level dynamically by modifying the `alps.conf` file and sending a `SIGHUP` signal to `apsched` or `apsys`, as applicable, to read the `alps.conf` file.

8.3 Configuring ALPS

ALPS uses the following three files:

- `/etc/sysconfig/alps` configuration file
- `/etc/alps.conf` configuration file
- `/etc/init.d/alps` file, which is used to start and stop ALPS components and does not require customization

Note: When configuring the RAID LUNs (logical units), verify that write caching is enabled on the LUN that contains the ALPS shared file system. For more information about RAID configuration, see the *Installing Cray System Management Workstation (SMW) Software* and the *Installing and Configuring Cray Linux Environment (CLE) Software*.

8.3.1 `/etc/sysconfig/alps` Configuration File

The `/etc/sysconfig/alps` file is in both the boot root and in the shared root. If you defined the ALPS-related parameters in your `CLEinstall.conf` file, after installation the parameters and settings are placed into your `/etc/sysconfig/alps` file.

If you do not define the ALPS-related parameters in your `CLEinstall.conf` file, to use ALPS you must define the parameters in your `/etc/sysconfig/alps` file (required parameters are indicated) and then start the ALPS daemons.

Note: When changing parameter settings, update the `/etc/sysconfig/alps` file in **both** the boot root and in the shared root and restart the ALPS daemons on all service nodes.

`ALPS_MASTER_NODE`

(Required) Specifies the node name (`uname -n`) of the service node that runs `apsched`. Cray recommends that the SDB node be used as the `ALPS_MASTER_NODE`. For example: `ALPS_MASTER_NODE="nid00003"`

`ALPS_BRIDGE_NODE`

(Required) Specifies the node name (`uname -n`) of the service node that runs `apbridge`. This is usually the boot node. Network connectivity between the SMW and the `ALPS_BRIDGE_NODE` parameter is required. (Such connectivity is guaranteed to exist from the boot node.) This default value is enforced in the `/etc/init.d/alps` file. For example: `ALPS_BRIDGE_NODE="boot001"`

`ALPS_MOUNT_SHARED_FS`

Specifies if a separate file system is to be mounted at ALPS startup to hold control data; default is `no`. For configurations using multiple login nodes, a shared file system is required, and the shared file system must be mounted before ALPS is started. For example: `ALPS_MOUNT_SHARED_FS="no"`

`ALPS_SHARED_DIR_PATH`

(Required) Specifies the directory path to the file that contains ALPS control data. If `ALPS_MOUNT_SHARED_FS` is set to `yes`, this is assumed to be a mount point. Default is `/ufs/alps_shared`. For example: `ALPS_SHARED_DIR_PATH="/ufs/alps_shared"`

`ALPS_SHARED_DEV_NAME`

Specifies the device to mount at ALPS start-up. If it is null and `ALPS_MOUNT_SHARED_FS` is `yes`, the device is determined by `/etc/fstab`. This parameter is not used unless yes is specified for `ALPS_MOUNT_SHARED_FS`. For example: `ALPS_SHARED_DEV_NAME="ufs:/ufs/alps_shared"`

`ALPS_SHARED_MOUNT_OPTIONS`

Specifies the shared mount options. Set this parameter only if `ALPS_MOUNT_SHARED_FS` is `yes` and `ALPS_SHARED_DEV_NAME` is not null. For example: `ALPS_SHARED_MOUNT_OPTIONS="-t nfs -o tcp,rw"`

`ALPS_IP_PREFIX`

(Deferred implementation) Use of this parameter has no effect. Specifies the first two octets for IP addresses on the high-speed network (HSN). These are internal addresses within the HSN. For example: `ALPS_IP_PREFIX="192.168"`

`ALPS_NIDORDER`

`-On`	Assigns order of nodes based solely on ascending numerical Node ID (NID) order.

`-Ox` Assigns order of nodes by maximum dimension as the outer dimension; the smallest dimension will change most quickly. For example, a system whose topology is described as a 6x12x8 system would have the y dimension varied last and the x dimension varied most rapidly, ordering them as (0,0,0), (1,0,0), (2,0,0), (3,0,0), (4,0,0), (5,0,0), (0,0,1), (1,0,1), (2,0,1) and so on. This option often improves application performance over using the `-On` option. Applications that use a small percentage of the machine, especially on machines that are largely cubic in their dimensions, may not benefit from this configuration.

`-Oy` Assigns order of nodes by y-axis **last**, which may be better suited for Gemini-based torus networks.

`-Or` Assigns order of nodes by minimum dimension, a reverse of `-Ox`; in the example above, the y dimension would vary most quickly, the x least.

If `ALPS_NIDORDER` is not specified, the default action is `-On`.

For example: `ALPS_NIDORDER="-Ox"`

Note: Because this is a system-wide setting, Cray recommends that you change this option only when you reboot your system to ensure `apbridge` and `apsched` are restarted in the correct sequence.

`APWATCH_LIBRARY_PATH`

The `LD_LIBRARY_PATH` "add-on" needed for `apwatch`; it includes the path to the `gnet` and `glib` libraries and the `rsms` and `erd` libraries.

For example:

```
APWATCH_LIBRARY_PATH="/opt/gnet/lib:/opt/glib/lib:/opt/cray/librsmsevent.so: \
/opt/cray/libcray_event_router.so:/opt/gnome/lib64"
```

`APWATCH_ERD`

(Required) The host that has the event router daemon (erd) running; typically, this is the host name of the SMW.

For example: `APWATCH_ERD="smw"`

A separate file system for control data is mounted at ALPS startup. This is assumed to be a mount point. Specify the path to the ALPS control data directory using the parameter `ALPS_SHARED_DIR_PATH`. Specify the device to mount at ALPS start-up using the parameter `ALPS_SHARED_DEV_NAME`. If it is null and `ALPS_MOUNT_SHARED_FS` is `yes`, the device is determined by `/etc/fstab`.

The following example shows a sample `/etc/sysconfig/alps` configuration file.

Example 96. Sample `/etc/sysconfig/alps` configuration file

```
#ALPS Configuration File

ALPS_MASTER_NODE="sdb"

ALPS_BRIDGE_NODE="boot"

ALPS_NIDORDER="-Ox"

ALPS_MOUNT_SHARED_FS="no"

ALPS_SHARED_DIR_PATH="/ufs/alps_shared"

## Type:        string
## Default:     ""
## Example:     "ufs:/ufs/alps_shared"
#
# Device to mount at ALPS start-up.  If it is null
# but ALPS_MOUNT_SHARED_FS is "yes", then the device
# will be determined by /etc/fstab.  This parameter
# is not used unless ALPS_MOUNT_SHARED_FS is "yes".
#

ALPS_SHARED_DEV_NAME=""

## Type:        string
## Default:     ""
## Example:     "-t nfs -o tcp,rw"
#
# This parameter is not used unless ALPS_MOUNT_SHARED_FS
# is "yes" and ALPS_SHARED_DEV_NAME is not null.
#

ALPS_SHARED_MOUNT_OPTIONS=""

APWATCH_LIBRARY_PATH=
"/opt/gnet/2.0.5/64/lib:/opt/glib/2.4.2/64/lib:/opt/cray/lib64:/opt/gnome/lib64"

APWATCH_ERD="smw"
```

8.3.2 `/etc/alps.conf` Configuration File

The `/etc/alps.conf` file is in the shared root and contains ALPS static configuration information used by the `apsched` and `apsys` daemons. The configuration parameters are described in this section.

Note: You can change the parameter settings dynamically by modifying the `alps.conf` file and sending a `SIGHUP` signal to `apsched` or `apsys`, as applicable, to re-read the `alps.conf` file.

`bridge`
: Enables the `apbridge` daemon to provide dynamic rather than static information about the system node configuration to `apsched`. Cray strongly recommends setting the `bridge` parameter to use the `apbridge` daemon. By default, it is set to `1` (enabled).

`alloc`
: If this field is set to `0` or is not specified, the distinction between batch and interactive nodes is enforced. If this field is set as nonzero, no distinction is made by ALPS; job schedulers will likely still limit their placement only to nodes marked as batch. By default, it is set to `0`.

`fanout`
: This field is set to a default level of `32`. This value controls the width of the ALPS TCP/IP network fan-out tree used by `apinit` on the compute nodes for ALPS application launch, transfer, and control messages.

`debug`
: This field is set to a default level of `1` for both `apsched` and `apsys`. For information about valid values, see the `apsched`(8) and `apsys`(8) man pages.

`cpuAffinity`
: Supports switchable default CPU affinity in `apsched`. Valid values are `cpu`, `none`, and `numa`; the default value is `cpu`. `aprun` checks for and uses the default `cpuAaffinity` string from `apsched`. If the user has not explicitly set the `aprun -cc` option, `aprun` will use the default supplied by `apsched`. If there is not a default from `apsched`, `aprun` sets a default of `cpu`. For more information, see the `aprun`(1) man page.

`lustreFlush`
: Supports switchable default Lustre cache flushing as part of application exit processing on the compute nodes. Enabling this Lustre cache flushing provides more consistent application run times. When Lustre cache flushing is enabled, all of the Lustre cache flushing completes as part of the application exit processing. The next application executing on the same set or subset of compute nodes no longer inherits a variable amount of run time due to Lustre cache flushing from a previous application.

Valid values are `0` (disabled) and `1` (enabled); the default value is `1` (enabled). `Apsched` provides this default `lustreFlush` value to the `apinit` daemon to enable or disable Lustre cache flushing as part of application exit processing.

Note: This value cannot be set on an individual application basis; it is a system-wide setting.

`nodeShare`
: Controls which compute node cores and memory are put into an application cpuset on the compute node. The valid values are `exclusive` and `share`. The default value is `exclusive`.

The `exclusive` setting puts all of a compute node's cores and memory resources into an application-specific cpuset on the compute node. This allows the application access to any and all of the compute node cores and memory. This can be useful when specifying a particular CPU affinity binding string through the `aprun -cc` option.

The `share` setting restricts the application specific cpuset contents to only the application reserved cores and memory on NUMA node boundaries. That is, if an application requests and is assigned cores and memory on NUMA node 0, then only NUMA node 0 cores and memory will be contained within the application cpuset. The application will not have access to the cores and memory on other NUMA nodes on that compute node.

To override the default system-wide setting in `/etc/alps.conf` on an individual basis, use the `aprun -F` option. For more information, see the `aprun`(1) man page.

`cleanup_version`

Specifies which cleanup routines are used. Valid values are `1` or `2`. Value `1` indicates using existing cleanup (scalar, limited parallel actions); `2` indicates cleanup that is scaled for larger systems (highly parallel.) Default for systems installed before SMW 5.1 is `1`; default for systems installed with SMW 5.1 or later is `2`.

`cleanup_cto`

Specifies the maximum amount of time, in milliseconds, allowed for the connect system call to respond before assuming the target node is down. Default value is `1000` milliseconds.

Note: The `cleanup_cto` value applies only when you have also specified `cleanup_version=2`.

`cms`	(Deferred implementation) Indicates whether or not ALPS will use CMS to store reservation and claim information. Valid settings are `no` and `yes`; the default setting is `no`.

The following example shows a sample `/etc/alps.conf` configuration file.

Example 97. Sample `/etc/alps.conf` configuration file

```
# Sample apsched configuration file
apsched
     alloc          0
     bridge         1
     fanout         32
     debug          1
# Default CPU affinity: values cpu (default), none, numa
#    cpuAffinity     cpu
# Default lustre cache flushing at app exit: values 0, 1
#    lustreFlush     1
# Default app node share mode for cores and memory: values exclusive, share
#    nodeShare    exclusive
# (Deferred implementation) Default CMS support: values no (default), yes
     cms            no
/apsched

apsys
     debug          1
/apsys
```

8.4 Resynchronizing ALPS and the SDB Command After Manually Changing the SDB

Manual changes to node attributes and status can be reflected in ALPS by using the `apmgr resync` command. The `apmgr resync` command requests ALPS to reevaluate the configuration and attribute information and update its information. For example, after making manual changes to the SDB using the `xtprocadmin -e` or `xtprocadmin --noevent` command, use the `apmgr resync` command so that ALPS becomes aware of the changes.

8.5 Identifying Reserved Resources

The `apstat -r` command displays the batch job ID in the `From` field; for executables launched interactively, `apstat` displays `aprun` in the `From` field:

```
% apstat -r
  ResId     ApId  From          Arch   PEs N d Memory State
    141   156559 batch:542687     XT    17 1 1   4000 conf,claim
 A  141   156560 batch:542687     XT    17 - -   4000 conf,claim
    143   156562 aprun            XT     1 0 1   4000 atomic,conf,claim
```

The `apstat -A` *apid* command filters information by application IDs. You can include multiple application IDs, but it must be a space-separated list of IDs. For example:

```
% apstat -avv -A 1280947
Total (filtered) placed applications: 1
Placed  Apid ResId     User   PEs Nodes    Age   State Command
     1280947   619     shep  1024    86   0h28m  run   castep_for_sh

Application detail
Ap[2]: apid 1280947, pagg 15376, resId 619, user shep,
       gid 1037, account 0, time 0, normal
  Batch System ID =
1971375
  Created at Wed Feb 24 11:24:59 2010
  Number of commands 1, control network fanout 32
  Cmd[0]: castep_for_sh -n 1024 -d 1 -N 12 -r 0 -S 3 -sn 0 -sl 0, 1333MB, XT, nodes 86
  Placement list entries: 1024
  Placement list: 20-31,129-158,272-286,385-387,389-414
```

The `apstat -R` *resid* command filters information about reservation IDs. You can include multiple reservation IDs, but it must be a space-separated list of IDs. For example:

```
% apstat -rvv -R 619
 ResId     ApId From           Arch   PEs N d Memory State
   619  1280945 batch:1971375    XT  2100 24 1   1333 conf,claim
A  619  1280947 batch:1971375    XT  1024 - -   1333 conf,claim

Reservation detail for resid 619
Res[1]: apid 1280945, pagg 0, resId 619, user shep,
       gid 1037, account 8944, time 0, normal
  Batch System ID = 1971375
  Created at Wed Feb 24 11:24:59 2010
  Number of commands 1, control network fanout 32
  Cmd[0]: BASIL -n 2100 -d 1 -N 24 -r 0 -S 0 -sn 0 -sl 0, 1333MB, XT, nodes 88
  Reservation list entries: 88
  Reservation list: 20-31,129-158,272-287,385-387,389-415
```

8.6 Terminating a Batch Job

To terminate a batch job, use the job ID from the `apstat -r` display.

8.7 Setting a Compute Node to Batch or Interactive Mode

To set a node to be either batch or interactive mode, use the `xtprocadmin` command to set the `alloc_mode` column of the SDB `processor` table. Then execute the `apmgr resync` command so that ALPS becomes aware of the changes.

Example 98. Retrieving node allocation status

The `apstat -n` command displays the application placement status of the nodes that are UP and their allocation mode (`B` for batch or `I` for interactive) in the State column.

Note: The `apstat` utility does not have dynamic run-time information about an application, so an `apstat` display does not imply anything about the running state of an application. An `apstat` display indicates statically that an application was placed and that the `aprun` claim against the reserved resources has not yet been released.

```
% apstat -n
  NID Arch State HW Rv Pl  PgSz     Avl    Conf  Placed  PEs Apids
   20   XT UP  B 12  -  -    4K 3072000       0       0    0
   21   XT UP  B 12  -  -    4K 3072000       0       0    0
   22   XT UP  B 12  -  -    4K 3072000       0       0    0
   23   XT UP  B 12  -  -    4K 3072000       0       0    0
<snip>
   63   XT UP  B 12 12 12    4K 3072000 3072000 1572864   12 221180
   64   XT UP  B 12 12 12    4K 3072000 3072000 1572864   12 221180
   65   XT UP  B 12 12 12    4K 3072000 3072000 1572864   12 221180
   66   XT UP  B 12 12 12    4K 3072000 3072000 1572864   12 221182
<snip>
Compute node summary
   arch config     up    use   held  avail   down
     XT    744    744     46     12    686      0
```

8.8 Manually Starting and Stopping ALPS Daemons on Service Nodes

ALPS is automatically loaded and started when CNL is booted on compute nodes.

You can manually start and stop the ALPS daemons on the service nodes as shown in the following procedures.

Procedure 61. Starting and stopping ALPS daemons on a specific service node

1. To start the ALPS daemons on a specific service node, log on to that service node as `root` and type the `/etc/init.d/alps start` command; for example, to start the ALPS daemons on the boot node:

   ```
   boot:~ # /etc/init.d/alps start
   ```

2. To stop the ALPS daemons on a specific service node, log on to that service node as `root` and type the `/etc/init.d/alps stop` command; for example, to stop the ALPS daemons on the boot node:

   ```
   boot:~ # /etc/init.d/alps stop
   ```

Procedure 62. Restarting ALPS daemon on a specific service node

- To restart the ALPS daemon on a specific service node, log on to the service node as `root` and type the `/etc/init.d/alps restart` command; for example, to restart the ALPS daemons on the boot node:

  ```
  boot:~ # /etc/init.d/alps restart
  ```

  The `/etc/init.d/alps restart` command stops and then starts the ALPS daemons on the node.

8.9 Manually Cleaning ALPS and PBS After Downed Login Node

If a login node goes down and will not be rebooted, job reservations associated with jobs deleted with `qdel` may not be released by ALPS. In this case, the `apstat -r` command lists the reservations as state `pendCancel` and leaves the jobs orphaned. Use the following procedure to manually clean up ALPS and PBS.

Procedure 63. Manually cleaning up ALPS and PBS after a login node goes down

1. Verify that the batch job still appears in the `qstat` output.

```
crayadm@smw:~> qstat -as 106728.sdb

sdb:
                                                            Req'd  Req'd   Elap
Job ID          Username Queue    Jobname    SessID NDS TSK Memory Time  S Time
--------------- -------- -------- ---------- ------ --- --- ------ ----- -
-----
106728.sdb      root     workq    qsub.scrip   6231   1   1    --    --  R
00:00
   Job run at Thu Dec 03 at 14:31 on (login1:ncpus=1)
```

2. Purge job from PBS and verify that it was purged. On the SDB node, type:

   ```
   sdb:~ # qdel -W force 106728.sdb
   ```

3. Verify that the job no longer exists.

   ```
   sdb:~ # qstat -as 106728.sdb
   qstat: Unknown Job Id 106728.sdb
   sdb:~ #
   ```

4. Restart `apsched` on the SDB node:

   ```
   sdb:~# /etc/init.d/alps restart
   ```

5. Use `apmgr` to cancel the reservation that still exists in ALPS.

   ```
   sdb:~ # apstat -r | grep 106728
    ResId     ApId From           Arch   PEs N d Memory State
        5  2949806 batch:106728     XT     1 0 1    500 conf

   sdb:~ # apmgr cancel 5
   ```

6. Use `apstat` to verify that the reservation no longer exists.

   ```
   sdb:~ # apstat -r | grep 106728
   sdb:~ #
   ```

8.10 Verifying that ALPS is Communicating with Cray System Compute Nodes

Executing the following `aprun` command on a login node will return a list of host names of the Cray system compute nodes used to execute the last program.

Example 99. Verifying that ALPS is communicating with Cray system compute nodes

```
crayadm@login:~> cd /tmp
crayadm@login:/tmp> aprun -b -n 16 -N 1 /bin/cat /proc/sys/kernel/hostname
```

8.11 ALPS and Node Health Monitoring Interaction

ALPS and node health monitoring cooperate in performing application cleanup following an application exit. The Node Health Checker (NHC) is automatically invoked by ALPS upon the termination of an application.

During normal operations, applications are run on a set of nodes, complete successfully, then those node resources are freed up to be reallocated for other applications. When an application exit is considered *orderly*, a set of up to four unique application process exit codes and exit signals is gathered and consolidated by ALPS on each compute node within the application placement list. Once all of the application processes on a compute node have exited, that compute node adds its local exit information to this consolidated list of exit data.

The exit information is sent to `aprun` over the ALPS application specific TCP fan-out tree control network. All of the application processes must have completely exited before this exit information is received by `aprun`. `aprun` forwards the compiled exit information to `apsys` just before `aprun` itself exits.

Once all exit information has been received from the compute nodes, the application exit is considered orderly. An orderly exit does not necessarily mean that the application completed successfully. An orderly exit means that exit information about the application was received by `aprun` and forwarded to `apsys`. `apsys` sends an exit message to `apsched`, which releases the reserved resources for another application.

An *unorderly* exit means that exit information has not been received by `apsys` prior to an `aprun` exit. A typical occurrence of an unorderly exit consists of a `SIGKILL` signal being sent to `aprun` by the batch system after the application's wall time limit is exceeded.

Since there is no exit information available to `apsys` during an unorderly exit, `apsys` does not know the true state of the application processes on the compute nodes. Therefore, ALPS must perform application cleanup on each of the assigned compute nodes before it is safe to free those application resources for another application.

Application cleanup begins with ALPS contacting each assigned compute node and sending a `SIGKILL` signal to any remaining application processes. Node health monitoring checks compute node conditions and marks a compute node `admindown` if it detects a problem.

ALPS cannot free the application resources for reallocation until all of the application processes have exited or node health monitoring has marked applicable compute nodes `admindown` or `suspect`. Until that time, the application will continue to be shown in `apstat` displays.

8.11.1 `aprun` Actions

The `aprun` command is the ALPS application launch command on login nodes and the SDB node. `aprun` has a persistent TCP connection to a local `apsys`. `aprun` also has a persistent TCP connection to an `apinit` daemon child on the first compute node with in the assigned placement list, but not to an `apinit` on each assigned compute node.

After receiving a placement list from `apsched`, `aprun` writes information into the `syslog` as in the example below.

```
May 18 10:38:16 nid00256 aprun[22477]: apid=1985825, Starting, user=10320,
batch_id=2325008, cmd_line="aprun -n 1 -b /tmp/hostname.xx ",
num_nodes=1, node_list=384

May 18 10:38:16 nid00256 aprun[22477]: apid=1985825, Error, user=10320,
batch_id=2325008, [NID 00384] 2010-05-18 10:38:15 Apid 1985825: cannot
execute: exit(107) exec failed

May 18 10:38:17 nid00256 apsys[22480]: apid=1985825, Finishing, user=10320,
batch_id=2325008
```

In a typical case of an orderly exit, `aprun` receives application exit information over the connection from that `apinit`. `aprun` then forwards the exit information over the connection to `apsys`. The ordering of application exit signals and exit codes is arbitrary. `aprun` displays any nonzero application exit information and uses the application exit information to determine its own exit code:

```
Application 284004 exit signals: Terminated
```

In the case of an unorderly exit, `aprun` exits without receiving application exit information. When `aprun` exits, its TCP connections are closed. The socket closes trigger application cleanup activity by both `apinit` and `apsys` as described in following sections.

An unorderly exit may occur for various reasons. The usual causes of an unorderly exit include the following cases:

- The batch system sends a `SIGKILL` signal to `aprun` due to the application wall time expiring
- `apkill` or `kill` are used to send a `SIGKILL` signal to `aprun`
- `aprun` receives a fatal message from `apinit` due to some fatal error during launch or at other points during the application lifetime, causing `aprun` to write the message to `stderr` and exit
- `aprun` receives a fatal read, write or unexpected close error on the TCP socket it uses to communicate with `apinit`

8.11.2 `apinit` Actions

`apinit` is the ALPS privileged daemon that launches and manages applications on compute nodes. For each application, the `apinit` daemon forks a child `apshepherd` process. Within `ps` displays, the child `apshepherd` processes retain the name "`apinit`".

The per-application TCP fan-out control tree has `aprun` as the root. Each compute node `apshepherd` within this control tree has a parent controller and may have a set of controlling nodes. Whenever a parent controller socket connection closes, the local `apshepherd` attempts to kill any application processes still executing and then will exit. This socket closing process results in a ripple effect through the fan-out control tree, resulting in automatic application tear down.

Whenever the `aprun` TCP connection to the `apshepherd` on the first compute node within the placement list closes, the tear down process begins. During an application orderly exit, the exit information is sent to `aprun`, followed by the `aprun` closure of the socket connection, resulting in the exit of the `apshepherd`. The `apshepherd` exit causes its controlling socket connections to close as well. Each of those `apshepherds` will exit, and the application specific fan-out tree shuts down.

When the `aprun` TCP socket closure is not expected and the application processes are still executing, the `apshepherd` will send a `SIGKILL` signal to each local application process and then exit. There can be local delays in kernel delivery of the `SIGKILL` signal to the application processes due to application I/O activity. The application process will process the `SIGKILL` signal after the I/O completes. The `apinit` daemon is then responsible to monitor any remaining application processes.

This kill and exit process ripples throughout the control tree. However, if any compute node within the control tree is unresponsive, the ripple effect will stop for any compute nodes beyond that branch portion of the tree. In response to this situation, ALPS must take action independent of the shutdown of the control tree to ensure all of the application processes have exited or that compute nodes are marked either `admindown` or `suspect` by node health monitoring. The `apsys` daemon is involved in invoking the independent action.

8.11.3 apsys Actions

`apsys` is a local privileged ALPS daemon that runs on each login node and the SDB node. When contacted by `aprun`, the `apsys` daemon forks a child agent process to handle that specific local `aprun`. The `apsys` agent provides a privileged communication path between `aprun` and `apsched` for placement and exit information exchanges. The `apsys` agent name remains "`apsys`" within `ps` displays.

During an orderly application exit, the `apsys` agent receives exit information from `aprun` and forwards that information to `apsched`. However, during an unorderly exit, when the `aprun` socket connection closes prior to receipt of exit information, the `apsys` agent is responsible to start application cleanup on the assigned compute nodes.

To begin application cleanup, the `apsys` agent invokes cleanup version 1 (`apmgrcleanup`) or cleanup version 2, and the `apsys` agent blocks until cleanup completes. (Which cleanup version is controlled by the `cleanup_version` configuration parameter in `alps.conf` file; see `/etc/alps.conf` Configuration File on page 247 for more information.)

At the start of application cleanup, the `/var/log/alps/apsysMMDD` log file displays data similar to the following messages.

Cleanup version 1 messages:

```
14:00:20: [32606] Agent unexpected close of peer connection 6, apid 227061
14:00:20: [32606] Agent invoking cleanup v1 for apid 227061
14:00:22: /usr/bin/apmgrcleanup [32824] invoking
/opt/cray/nodehealth/default/bin/xtcleanup_after /tmp/apsysiY08fc 227061 0 with 1 entries
```

Cleanup version 2 messages:

```
14:00:20: [32606] Agent unexpected close of peer connection 6, apid 227061
14:00:20: [32606] Agent invoking cleanup v2 for apid 227061
14:00:20: Beginning cleanup of apid 227061, iteration 1
14:00:21: Post-cleanup: apid 227061 definitely resident on 1/1 nodes, maybe on 0
others
14:00:21: Beginning cleanup of apid 227061, iteration 2
14:00:21: Target Nodes: Match list portion for apid 227061 (1/1): 20
14:00:21: Target Nodes: Unreached list portion for apid 227061 (0/0):
14:00:21: Post-cleanup: apid 227061 definitely resident on 0/1 nodes, maybe on 0
others
14:00:21: Invoking health check: /opt/cray/nodehealth/default/bin/xtcleanup_after
/tmp/apsysWRPpna 227061 0
14:00:30: Successfully cleaned up apid 227061 on 1 nodes
```

After `apmgrcleanup` returns, the `apsys` log file contains something similar to the sample message below:

```
14:02:30: [32606] Agent sending ALPSMSG_EXIT message to apsched fd 7, apid 227061
14:02:30: [32606] Agent received ALPSMSG_EXITCONFIRM from apsched fd 7, apid 227061
```

In the above example, `apsched` has been told that the resources assigned to that `aprun` can now be reallocated to another application. The `apstat` display will no longer show information about this application.

8.11.4 Cleanup Version 1 Actions (`apmgrcleanup`)

Note: Which cleanup version used is controlled by the `cleanup_version` configuration parameter in `alps.conf` file; see `/etc/alps.conf` Configuration File on page 247 for more information.

When configured to use cleanup version 1, `apsys` invokes `apmgrcleanup` for each application unorderly exit. `apmgrcleanup` is a shell script that is invoked to do application cleanup for a specific application. As part of this cleanup activity, `apmgrcleanup` calls another script, which may invoke node health monitoring. `apmgrcleanup` executes with the permissions of the `apsys` caller, which runs as root. You must be root to edit the `apmgrcleanup` file.

`apmgrcleanup` works with a placement list of assigned compute nodes for a specific application. This application cleanup activity will guarantee that a new application is not placed on this set of compute nodes prematurely. A new application placed on these compute nodes prematurely would result in application failure due to compute node core and/or memory resources still being assigned to the current application.

`apmgrcleanup` contacts every node in the placement list supplied to it. `apmgrcleanup` first uses `apmgr` to send a kill request message for a specific application to each node on the placement list, then requests status information about an application on that compute node.

apmgrcleanup uses apmgr to send status request messages to the apinit on that set of compute nodes to find out when all of the local application processes have exited. The kernel may not immediately deliver a SIGKILL signal to application processes if those processes are involved in I/O activity.

apmgrcleanup begins by calling apmgr to send a ping kill message to the apinit daemon on each compute node in the placement list for the given application. If there are more than 500 nodes in the list, apmgrcleanup uses nway to perform eight apmgr invocations at a time, in a sliding window fashion, for parallelization. apmgrcleanup continues to loop until the list of nodes reaches zero.

apmgr writes messages to the syslog after each successfully sent ping kill message. These messages mean only that a message was received by the compute node apinit daemon. The application processes may still exist if the SIGKILL delivery to an application process remains pending due to I/O activity. Below is a sample of ping kill messages written to the syslog:

```
Apr 13 06:55:31 nid00016 apmgr[20277]: apid=821502, killed on nid=587
Apr 13 06:55:31 nid00016 apmgr[20279]: apid=821502, killed on nid=591
Apr 13 06:55:31 nid00016 apmgr[20281]: apid=821502, killed on nid=772
Apr 13 06:55:31 nid00016 apmgr[20283]: apid=821502, killed on nid=776
```

Inside its main loop, apmgrcleanup calls the xtcleanup_after script with the initial (full) placement list of compute nodes for the application. Each invocation includes a randomly generated file name (/tmp/apsys*XXXX*) that holds the node list and an invocation count.

```
Apr 13 06:55:31 nid00016 06:55:31: /usr/bin/apmgrcleanup [18964] invoking
/opt/xt-service/default/bin/snos64/xtcleanup_after /tmp/apsysdbajiE 821502
0 with 5 entries
```

Then invocation count tells xtcleanup_after if this is the first or subsequent call of the script. The xtcleanup_after script typically calls node health monitoring. The script is site configurable to modify its behavior as desired; however, modifying this script is not recommended.

On return from xtcleanup_after, apmgrcleanup will wait one or more seconds, depending on machine size, to avoid looping too quickly, then it rechecks the list of nodes. First, apmgrcleanup invokes apstat and checks for compute nodes that are not marked up, removing them from the /tmp/apsys*XXXX* file. Then, it calls apmgr to send a ping status request to the apinit daemon on the remaining compute nodes.

A compute node is removed from the /tmp/apsys*XXXX* file whenever the apinit on that compute node responds to the ping status request stating that no application processes remain on that compute node, or when the node is no longer marked up. The ping status request has a five-second time limit. Any nodes remaining, (i.e. not heard from, still marked up) will stay in the file of nodes for the next iteration of the apmgrcleanup loop.

When the `/tmp/apsys`*XXXX* file is empty, `apmgrcleanup` will exit. Then, `apsys` writes a message into the `syslog` and can tell `apsched` to release the `aprun` claim for that set of compute nodes. The `syslog` message includes both the batch job ID and the `aprun` exit code, making it easier to track.

```
May 19 08:26:52 nid00029 apsys[27933]: apid=200075, Finishing, user=10320,
exit_code=0, exitcode_array=0, exitsignal_array=0

May 19 08:34:48 nid00029 apsys[2376]: apid=200175, Finishing, user=10320,
exit_code=139, exitcode_array=130:0, exitsignal_array=11:9:0
```

After the initial `apmgr` ping, kill messages are sent to the `apinit` daemon on the set of compute nodes within the `/tmp/apsys`*XXXX* file, `apmgrcleanup` calls the `xtcleanup_after` script to invoke node health monitoring. If node health monitoring is enabled, compute nodes may be marked `admindown` or `suspect` by node health monitoring as described in Node Health Checker Actions on page 260.

8.11.5 Cleanup Version 2 Actions

Note: Which cleanup version used is controlled by the `cleanup_version` configuration parameter in `alps.conf` file; see `/etc/alps.conf` Configuration File on page 247 for more information.

When configured to use cleanup version 2, `apsys` uses an internal library to perform cleanup for each application unorderly exit. The `apmgrcleanup` and `apmgr` commands, used in cleanup version 1 are not used. Cleanup version 2 interacts with the `/tmp/apsys/`*XXXX* file and the `xtcleanup_after` script in the same way as in cleanup version 1, and makes the same guarantee that new applications will not be placed on compute nodes prematurely (See Cleanup Version 1 Actions (`apmgrcleanup`) on page 257 for details). The principle differences between Cleanup version 1 and Cleanup version 2 are the signal delivery and application query mechanism, and the scalability characteristics.

Cleanup version 2 uses a tree-based overlay network formed using the `apinit` daemons on compute nodes associated with an unorderly exit to deliver a `SIGKILL` signal to application processes and to query for application presence. The overlay network is separate from the ALPS launch fan-out tree. All compute nodes that have a lingering application presence and all compute nodes with an unknown application presence status are gathered and used to inform the cleanup algorithm when to complete.

In the `apsys` log file, compute nodes that have a lingering application presence are reported in a `Match` list. Compute nodes with an unknown application presence status are reported in an `Unreached` list. The following example indicates that `apid 227061` remains resident on only one compute node (node 20), and that application presence status information has been received from all compute nodes:

```
14:00:21: Target Nodes: Match list portion for apid 227061 (1/1): 20
14:00:21: Target Nodes: Unreached list portion for apid 227061 (0/0):
```

After cleanup version 2 completes, or after every iteration of cleanup starting with the third iteration, the `xtcleanup_after` script is invoked in an identical fashion to cleanup version 1.

8.11.6 Node Health Checker Actions

The Node Health Checker (NHC) is automatically invoked by ALPS upon the termination of an application. ALPS passes a list of nodes associated with the terminated application to NHC. NHC performs specified tests, which are specified in the NHC configuration file, to determine if compute nodes allocated to the application are healthy enough to support running subsequent applications. If not, it removes any nodes incapable of running an application from the resource pool.

NHC verifies that the Application Level Placement Scheduler (ALPS) acknowledges a change that NHC has made to a node's state. If ALPS does not acknowledge a change, then NHC recognizes this disagreement between itself and ALPS. NHC then changes the node's state to `admindown` state and exits.

For an overview of NHC, see the `intro_NHC`(8) man page. For additional information about configuring node health checker, see Configuring Node Health Checker (NHC) on page 157.

8.11.7 Verifying Application Cleanup

There are a number of circumstances that can delay completion of application cleanup after an unorderly exit. This delay is often detected through `apstat` displays that still show the application and the resource reservation for that application.

As described in previous sections, check the various log files to understand what activity has taken place for a specific application.

- Check the `/var/log/alps/apsysMMDD` log files for that `apid`; verify cleanup version 1 (`apmgrcleanup`) or cleanup version 2 has been invoked.
- If using cleanup version 1 on that same login node, use `ps` to check if `apmgrcleanup` is still executing.
- Check the applicable node health monitoring log file (`/var/log/xtcheckhealth_log`) for that `apid`.
- Check the SMW `/opt/craylog/bootlogs/console.YYMMDDHHMM` log file for that `apid.`

Using Comprehensive System Accounting [9]

Comprehensive System Accounting (CSA) is open-source software that includes changes to the Linux kernel so that the CSA can collect more types of system resource usage data than under standard Fourth Berkeley Software Distribution (BSD) process accounting. CSA software also contains interfaces for the Linux process aggregates (`paggs`) and jobs software packages. The CSA software package includes accounting utilities that perform standard types of system accounting processing on the CSA generated accounting files. CSA, with Cray modifications, provides:

- Project accounting capabilities, which provide a way to charge computer system resources to specific projects
- An interface with various other job management systems in use at Cray sites
- A data management system for collecting and reporting accounting data
- An interface that you use to create the project account and user account databases, and to later modify them, as needed
- An interface that allows the project database to use customer–supplied user, account, and project information that resides on a separate Lightweight Directory Access Protocol (LDAP) server
- An interface with the ALPS application management systems so that application accounting records that include application start, termination, and placement information can be entered into the system accounting database

Specific third-party software releases are required for batch system compatibility with CSA on Cray systems. For more information, access the **3rd Party Batch SW** link on the CrayPort website at http://crayport.cray.com.

Complete features and capabilities of CSA are described in the `csa`(8) and `intro_csa`(8) man pages. The accounting utilities provided for administrative use are: `csanodeacct`, `csaperiod`, and `csarun`. The related man pages are accessible by using the `man` command.

Note: CSA runs **only** on login nodes and compute nodes. The SMW, boot node, SDB node, Lustre MDS nodes, and Lustre OST nodes do not support CSA.

9.1 Interacting with Batch Entry Systems or the PAM `job` Module

Jobs are created on the system using either a batch job entry system (when such a system is used to launch jobs) or by the PAM `job` module for interactive sessions.

> **Note:** You must be running TORQUE snapshot (release) `2.4.0-snap.20080925140` or later to take advantage of CSA support for the Cray platform.
>
> You must run PBS Professional 9.2 or later to take advantage of CSA support for the Cray platform.

Compute node project accounting for applications submitted through workload managers (for example, PBS Professional) depends on the ability of the workload manager to obtain and propagate the project ID to ALPS at job submission time. If the workload manager does not support the ability to obtain and propagate the project ID to ALPS at job submission, the project ID must be set by using the `account`(1) command prior to issuing an ALPS `aprun`(1) command. Otherwise, project ID information will not be included in any CSA accounting records for the job.

9.2 CSA Configuration File Values

The CSA configuration file, `csa.conf`, is included with the Cray Linux Environment (CLE) software release package. By default, on Cray systems, this file is located at `/etc/opt/cray/csa/csa.conf` for login and compute nodes.

This file contains default settings for several configuration parameters you must change to tailor CSA to your individual site configuration.

> **Note:** The `csa.conf` file exists on the shared root and also on the CNL image for compute nodes; the two copies of this file **must** be identical (except for the `NODE_PROCESS_ACCOUNT` parameter, which may be different). You must create a new version of the CNL compute node image after editing the `csa.conf` file.

Each Cray system that runs CNL has its own unique hardware configuration. This includes the number of nodes on the system and the physical location of the nodes. In addition, each installation contains its own unique file system configuration.

Since the file system and node configurations for each Cray system is unique, the default `/etc/opt/cray/csa/csa.conf` file can only be used as a template. The parameters shown in the following table are used to define the accounting file system configuration and the node configuration for your system. You must change the settings of these parameters so that they conform to your system configuration.

Table 11. CSA Parameters That Must Be Specific to Your System

Parameter	Description
`ACCT_SIO_NODES`	Declares the number of account file system mount points. There must be at least one account file system mount point. The maximum number of mount points is 100. Multiple mount points are allowed so that the individual node accounting files can be distributed across more than one file system in order to provide better scaling for large system configurations. Use the `df` command to display the possible file system mount points. The actual maximum number of `ACCT_SIO_NODES` that may be specified is limited by the number of file systems available on your system.

`ACCT_FILE_SYSTEM_00`
 `...`
 `ACCT_FILE_SYSTEM_`*nn*
	Must be one entry for each declared file system mount point. Numbering must begin with `00`, and numbers must be consecutive. For example, if you have specified `ACCT_SIO_NODES 1`, you will only define `ACCT_FILE_SYSTEM_00`. If you have specified `ACCT_SIO_NODES 2`, you will also need to define `ACCT_FILE_SYSTEM_01`.

`_lus_nid00007_csa_XT`	The default file system mount point. It must be changed to correspond to a file system that exists on your system. There is one of these entries for each `ACCT_FILE_SYSTEM` declared. **Note:** The program that parses the configuration file does not allow any special characters, other than the underscore character (_) in configuration names. Therefore, in the file system paths used in the mount point description, each forward slash character (`/`) character must be represented by an underscore (_) character. This also means that an account file system mount point cannot have a _ character in the pathname.
`SYSTEM_CSA_PATH`	Defines the pathname on the common file system where CSA establishes its working directories for generating accounting reports. This parameter is only used on the service node image. It is not used on the compute nodes.
`NODE_PROCESS_ACCOUNT`	Defines whether all process account records written on a node will be written to the common file system, or whether the process account records for each application will be combined into a single application summary record that represents the total execution of the application on a node. This parameter may be set differently on the shared root and compute node images.

For other parameters in `csa.conf`, default settings should be acceptable.

9.3 Configuring CSA

When CSA is enabled, all system accounting, including service node accounting, is performed by CSA. Therefore, there is no need to have BSD process accounting enabled on service nodes.

Note: You must include the CSA RPM in your CNL boot image. To do this either set `CNL_csa=`**`yes`** in the `CLEinstall.conf` before the `CLEinstall` program is run or edit the `shell_bootimage_`*label*`.sh` script and specify `CNL_CSA=`**`y`** prior to updating your CNL boot image.

Perform the procedures in this section, in order, to correctly set up CSA.

9.3.1 Obtaining File System and Node Information

Procedure 64. Obtaining file system and node information

1. From a login node, enter the `df` command to determine which file systems are available for writing CSA accounting data.

```
login:~ > df

Filesystem           1K-blocks      Used Available Use% Mounted on
rootfs               173055264  66220448  98044064  41% /
initramdevs            4021372        84   4021288   1% /dev
192.168.0.1:/rr/current
                     173055264  66220448  98044064  41% /
192.168.0.1:/rr/current/.shared/node/8/etc
                     173055264  66220448  98044064  41% /etc
192.168.0.1:/snv      48133952  34803200  10885696  77% /var
192.168.0.1:/snv      48133952  34803200  10885696  77% /var
none                   4021372         4   4021368   1% /var/lock
none                   4021372        36   4021336   1% /var/run
none                   4021372        20   4021352   1% /var/tmp
tmpfs                  4021372       116   4021256   1% /tmp
sdb:/ufs              42061728  37362432   2562656  94% /ufs
sdb:/scratch         173055264 118125600  46138912  72% /scratch
sdb:/ostest          100759712  90996064   4645344  96% /ostest
11@ptl:/examplefs1   11864248176 2012019088 9249128752  18% /lus/nid00011
64@ptl:/examplefs2   11864248176 3714038044 8150210132  31% /lus/nid00064
```

2. Determine and record the file system information you want to use for CSA.

   The files systems of interest for saving accounting data are those two systems whose mount points are `/lus/nid00011` and `/lus/nid00064`, respectively. Record this information for later use.

3. Determine the hardware node configuration on your system.

   Run the `xtprocadmin` command to get a complete list of nodes.

```
login:~ > xtprocadmin

   NID    (HEX)    NODENAME     TYPE    STATUS        MODE PSLOTS FREE
     0      0x0  c0-0c0s0n0  service        up       batch      4    0
     3      0x3  c0-0c0s0n3  service        up       batch      4    0
     4      0x4  c0-0c0s1n0  service        up       batch      4    4
     7      0x7  c0-0c0s1n3  service        up       batch      4    4
...
   475    0x1db  c3-0c2s6n3  compute        up       batch      4    4
   476    0x1dc  c3-0c2s7n0  compute        up       batch      4    4
   477    0x1dd  c3-0c2s7n1  compute        up       batch      4    4
   478    0x1de  c3-0c2s7n2  compute        up       batch      4    4
   479    0x1df  c3-0c2s7n3  compute        up       batch      4    4
```

For this example system, you want to choose a set of nodes that will have their accounting files written to `/lus/nid00011` and another set of nodes that will have their accounting files written to `/lus/nid00064`. You also need to make sure there is no overlap between the two sets of nodes.

9.3.2 Editing the `csa.conf` File

After you have the file system mount point and node configuration information for your system, you are ready to edit the `csa.conf` file. By default, on Cray systems, this file is located at `/etc/opt/cray/csa/csa.conf` for login and compute nodes.

Note: You must use `xtopview` to edit the shared root image of `csa.conf` file on the boot node. You can use any text editor to edit the compute node image of `csa.conf` file on the SMW.

Procedure 65. Editing CSA parameters for the example system

1. Set the number for the `ACCT_SIO_NODES` parameter.

   From Procedure 64 on page 264, you know that both `/lus/nid00011` and `/lus/nid000064` will be used to host individual node accounting files. The number of file systems (in this case two) to be used to contain accounting files is the value for the `ACCT_SIO_NODES` parameter. Since this example shows using `/lus/nid00011` and `/lus/nid00064` to contain accounting files, set `ACCT_SIO_NODES` to `2`:

   ```
   ACCT_SIO_NODES   2
   ```

2. Declare a file system mount point for each SIO node specified.

   Note: The program that parses the configuration file does not allow any special characters, other than the underscore character (_) in configuration names. Therefore, in the file system paths used in the mount point description, each forward slash character (`/`) character must be represented by an underscore (_) character. This also means that an account file system mount point cannot have a _ character in the pathname.

The `df` command from the previous procedure showed a mount point on `/lus/nid00011` and another one on `/lus/nid00064`, these are the two mount points that need to be declared. Just because there are multiple mount points, however, does not mean that you need to use them. You may choose to have all accounting files written to a single file system. Since in this example you are configuring two mount points, you must specify `ACCT_FILE_SYSTEM_00` and `ACCT_FILE_SYSTEM_01` parameters:

```
ACCT_FILE_SYSTEM_00   _lus_nid00011
ACCT_FILE_SYSTEM_01   _lus_nid00064
```

3. Determine the node range values for the account system mount point parameters.

   All accounting file directories have `csa` as the first element of the path name, following the mount point. The next element in the path name after `csa` describes the node type. For Cray node types, the next element of the path name is `XT`.

   For Cray systems, the CSA software uses the node name, otherwise known as the *cname*, when creating pathnames for accounting files. For example, node name `c1-0c2s7n3` has a pathname of `cab0/row0/chassis2/slot7/mcomp3`. This path name is appended to applicable accounting system mount point name in order to create a full path name for the accounting file.

   The `xtprocadmin` command output from the previous procedure shows that the system has 4 cabinets, `c0-c3`. One simple way to configure the accounting file systems so that the files are divided fairly evenly between the two file systems in this example would be to specify that cabinet `0` and cabinet `1` have their data written to `/lus/nid00011`, and cabinet `2` and cabinet `3` have their data written to `/lus/nid00064`.

   Using the pathname conventions described above, and the node name data from Procedure 64 on page 264, you can define the file system mount point parameters:

```
_lus_nid00011_csa_XT    c0-0c0s0n0--c1-0c2s7n3
_lus_nid00064_csa_XT    c2-0c0s0n0--c3-0c2s7n3
```

4. Define the `SYSTEM_CSA_PATH` parameter.

   The `SYSTEM_CSA_PATH` parameter describes the file pathname for the system wide `csa` directories that are used for CSA work areas, and for containing the system-wide `pacct` file. The system-wide `pacct` file contains the merged contents of the individual node `pacct` files. Since the file pathname for the `SYSTEM_CSA_PATH` is not used as an input to the configuration file parser, the file path name is allowed to contain the `/` character.

Usually the `SYSTEM_CSA_PATH` parameter uses an account file system mount point as its base directory, however, this is not required. The `SYSTEM_CSA_PATH` parameter is only used on the login node where CSA file processing is performed. It is not necessary to set this parameter in the compute node image of `/etc/opt/cray/csa/csa.conf`, but setting it there does not cause any problems.

For this example, use the `/lus/nid00011` mount point for the CSA work areas:

```
SYSTEM_CSA_PATH    /lus/nid00011/csa
```

5. Define the `NODE_PROCESS_ACCOUNT` parameter.

   The `NODE_PROCESS_ACCOUNT` parameter defines if all process accounting records from nodes are to be collected. This parameter may be set differently for `/etc/opt/cray/csa/csa.conf` in the compute node image than in `/etc/opt/cray/csa/csa.conf` in the shared root file system. The `NODE_PROCESS_ACCOUNT` parameter allows your site to determine how much detailed accounting data is to be collected, processed, and saved from the nodes on the system.

   To understand the usefulness of this parameter, it may be helpful to know how CSA accounting records are handled on Cray systems. When ALPS launches an application to the compute nodes on a Cray system, CSA process accounting occurs on each compute node. All CSA job and process accounting records for each compute node are written to an in-memory file system on the node, and the records remain there until the application terminates. When the application terminates, ALPS notifies the CSA software on each compute node to process the accounting data for that node. The `NODE_PROCESS_ACCOUNT` parameter allows CSA to make a decision whether to write all of the individual process accounting records for each compute node to the common file system, or to read the individual process accounting records and combine them into a single application summary record that represents the total resources used by the application on the compute node. By choosing to have application summary records, the amount of data transferred from each compute node to the common file system may be substantially reduced. In doing so, the amount of internal system network traffic and the amount of data moved from compute nodes to disk can be decreased. Also, the total amount of CSA accounting data that must be processed later for creating usage reports, and the amount of CSA data to be permanently stored can be reduced.

   You may want to set `NODE_PROCESS_ACCOUNT` off for compute nodes, and to set it on for service nodes. This provides more accounting process detail on the login nodes where such information may be more useful. Therefore, this single parameter may be set differently on the shared root image than it is set on the compute node image of `/etc/opt/cray/csa/csa.conf`.

To use this split configuration, specify the following:

```
# Shared root version of /etc/opt/cray/csa/csa.conf:
NODE_PROCESS_ACCOUNT    ON

# Compute node image of /etc/opt/cray/csa/csa.conf:
NODE_PROCESS_ACCOUNT    OFF
```

6. Change the parameter that defines the group name used for setting the ownership and group on accounting files. This parameter is named `CHGRP` and defaults to:

   ```
   CHGRP          csaacct
   ```

   If you use a different group name, change the parameter to match your system configuration.

9.3.3 Editing Other System Configuration Files

You also must make configuration changes to other system files. Use the `xtopview` command on the boot node to make the changes. For detailed information about using `xtopview`, see Managing System Configuration with the `xtopview` Tool on page 129 or the `xtopview`(8) man page.

- Add the `csaacct` user name to `/etc/passwd` on the shared root.

  ```
  csaacct:*:391:391:CSA:/var/lib/csa:/sbin/nologin
  ```

- Add the `csaacct` group name to `/etc/group` on the shared root.

  ```
  csaacct:!:391:
  ```

- Update the shadow password file to reflect the changes you've made:

  ```
  /usr/sbin/pwconv
  ```

- Add the `csaacct` group name to `/etc/group` on the CNL image.

  Note: The `csaacct` group and *gid* must be the same on the shared root and CNL image.

- Create additional PAM entries in `/etc/pam.d/common-session` to enable CSA. For more information about creating PAM entries, see Setting Up Job Accounting on page 271.

9.3.4 Creating a CNL Image with CSA Enabled

After you have modified the compute node copy of `csa.conf`, you must rebuild the compute node image. For more information about how to rebuild the compute node image, see Preparing a Service Node and Compute Node Boot Image on page 66.

You can edit the shared root version of `csa.conf` and install the new version using the `xtopview` command. For more information about editing the shared root image of `csa.conf` using the `xtopview` utility, see Managing System Configuration with the `xtopview` Tool on page 129 or the `xtopview`(8) man page.

9.3.5 Setting Up Project Accounting

The project database allows your site to define project names and assign an account number to each project. Users can have a list of account numbers that they can use for charging computing resources. Each user has a default account number that is assigned at login time.

Procedure 66. Setting up CSA project accounting

The project database resides on the system SDB node as a MySQL database. To set up a CSA project accounting for your system, perform the following procedure.

1. Establish the project database, `UserProject`, and define the project database tables on the System Data Base (SDB) server:

```
sdb:~ # mysql -u root -h sdb -p < /opt/cray/projdb/default/sql/create_UserProject.sql
```

2. Grant administrative access privileges to the project database:

```
sdb:~ # mysql -u root -h sdb -p < /opt/cray/projdb/default/sql/create_accounts.sql
```

3. Create and edit the `/etc/opt/cray/projdb/projects` file so that it contains a list of valid account numbers and the associated project names.

   The `/etc/opt/cray/projdb/projects` file consists of a list of entries where each entry contains a project number followed by a project name. A colon character separates the project number from the project name. A project number and an account number are the same thing. The following example shows a simple project file:

```
0:root
100:sysadm
101:ProjectA
102:ProjectB
103:Big_Name_Project_that_is_insignificant_and_unimportant
1234567890:Big Name Project with Blanks in the Name
```

4. Create and edit the `/etc/opt/cray/projdb/useracct` file so that it contains a list of authorized users and the valid account numbers for each user.

   Each line of the user accounts file contains the login name of a user and list of accounts that are valid for that user. The first account number in the list is the user's default account. The default account number is assigned to the user at login time by the `pam_job` module. The user name is separated from the first account ID by a colon (`:`). Additional account numbers are separated by a comma (`,`).

The following shows a simple user account file:

```
root:0
u1000:100
u1001:101,103
u1002:100,101
u1003:100,103,1234567890
```

5. Edit the `~crayadm/.my.cnf` file in the home directory of the project database administrator so that it contains the following lines:

```
[client]
user=sys_mgmt
password=sys_mgmt
host=sdb
```

6. Change the permissions and owner on the `~crayadm/.my.cnf` file, as follows:

```
chmod 600 ~crayadm/.my.cnf
chown crayadm:crayadm ~crayadm/.my.cnf
```

7. If you are using customer–supplied user, account, and project information that resides on a separate LDAP server, edit the `/etc/opt/cray/projdb/projdb.conf` project accounting configuration file so that it contains site-specific values for the parameters listed in Table 12.

Table 12. Project Accounting Parameters That Must Be Specific to Your System

Parameter	Description
`PROJDBTYPE`	If you are using customer–supplied user, account, and project information that resides on a separate LDAP server, change from `MYSQL` (default) to `CUSTOM`.
`CUSTOM_VALIDATE`	If you are using customer–supplied user, account, and project information that resides on a separate LDAP server, specify the full path name to the customer–supplied function that performs the necessary validation, for example `/usr/local/sbin/validate_account`. Input parameters to the validation function are position order dependent, as follows: `user_name  account_number`

8. On a login node, run the `projdb` command with the `-c` option to create the project database. After the project database has been established, any users gaining access to the system via the job PAM module are assigned a default account ID at the time of system access.

```
login:/home/crayadm:~> projdb -c -p /etc/opt/cray/projdb/projects -u
/etc/opt/cray/projdb/useracct -v
```

Note: The project database package commands are installed in `/opt/cray/projdb/default/bin`, which must be in your `PATH` variable to access the commands.

9.3.5.1 Disabling Project Accounting

If you do not want to use project accounting on your site, either as provided by the MySQL database, or by a separate customer-supplied LDAP server, use the following procedure to disable project accounting.

Procedure 67. Disabling project accounting

1. In the `/etc/opt/cray/projdb/projdb.conf` file, set the `PROJDBTYPE` parameter to `CUSTOM`.
2. In the `/etc/opt/cray/projdb/projdb.conf` file, declare a `CUSTOM_VALIDATE` parameter and define it as `/usr/local/sbin/validate_account`.
3. As root, create the `/usr/local/sbin/validate_account` file with file permissions set to `755` and the following contents:

```
#!/bin/sh
echo 0
```

9.3.6 Setting Up Job Accounting

Note: You must include the `csa` RPM in your CNL boot image. To do this either set `CNL_csa=`**`yes`** in the `CLEinstall.conf` before the `CLEinstall` program is run or edit the `shell_bootimage_`*label*`.sh` script and specify `CNL_CSA=`**`y`** prior to updating your CNL boot image.

Procedure 68. Setting up CSA job accounting

- Use the `xtopview`(8) command to edit the `/etc/pam.d/common-session` file on the shared root image to make sure that jobs are created whenever a login occurs via `ssh`. Add the following entry to the `/etc/pam.d/common-session` file:

```
session  optional   /opt/cray/job/default/lib64/security/pam_job.so
```

After you make sure this is working for all `sshd` session logins, you may want to change the entry to:

```
session   required    /opt/cray/job/default/lib64/security/pam_job.so
```

For additional information about setting up job accounting on your system, read the `INSTALL` file that is included in the `job` RPM.

For more information about editing the shared root image of the `pam` configuration files using the `xtopview` utility, see Managing System Configuration with the `xtopview` Tool on page 129 or the `xtopview`(8) man page.

9.4 Creating Accounting `cron` Jobs

CSA depends on your system having a persistent `/var` file system for the shared root. For CSA to run successfully, you must establish the following `cron` jobs.

The normal order for the `cron` jobs is: `csanodeacct`, `csarun`, and then `csaperiod` (if necessary).

9.4.1 `csanodeacct` `cron` Job for Login Nodes

On CNL system compute nodes, when an application terminates, the Application Launch and Placement Scheduler (ALPS) initiates the CSA software that moves the local node accounting file records to a node-specific directory on the common file system (Lustre). On login nodes, this does not happen, and accounting records continue to accumulate indefinitely until the `csanodeacct` script is invoked to move the data to the common file system. Therefore, you need to periodically run a `cron` job on each login node to make sure that the local accounting files are moved as needed. This `cron` job must be owned by `root`.

Example 100. Running a `csanodeacct` `cron` job on each login node to move local accounting files

The following example shows moving accounting files from the local file system to the common file system on an hourly basis at 10 minutes before the hour. This `crontab` must be executed for each login node:

```
50 * * * * /opt/cray/csa/default/sbin/csanodeacct
```

9.4.2 `csarun` `cron` Job

You normally execute the `csarun` script at defined intervals to generate a set of system accounting reports.

Example 101. Executing the `csarun` script

To run `csarun` once per day at one minute before midnight, use a `crontab` entry of the following form:

```
59 23 * * * /opt/cray/csa/default/sbin/csarun
```

Note: This `crontab` must be executed from only **one** login node since it executes the `csanodemerg` script that merges all of the local node accounting files into a single system wide accounting file.

9.4.3 `csaperiod` `cron` Job

You can invoke the `csaperiod` script to run periodic accounting at different intervals than the regular system accounting interval.

Example 102. Running periodic accounting at different intervals than the regular system accounting interval

To run `csaperiod` every four hours at 5 minutes before the hour, use a `crontab` entry of the following form:

```
55 3,7,11,15,19,23 * * * /opt/cray/csa/default/sbin/csaperiod
```

Note: This `crontab` must be executed from only **one** login node since it executes the `csanodemerg` script that merges all of the local node accounting files into a single system-wide accounting file.

9.5 Enabling CSA

Using the `xtopview` command on the boot node is the only method to configure, enable, or disable services on the shared-root file system. You cannot configure, enable, or disable services on the login node itself. If your site has configured a `login` class for your system, invoke the following command sequence from the boot node as `root`:

```
boot# xtopview -x /etc/opt/cray/sdb/node_classes -c login
class/login:/# chkconfig job on
class/login:/# chkconfig csa on
class/login:/# exit
```

On the subsequent system boot, this starts up the specified services on all nodes of the `login` class.

Note: If your site has not configured a `login` class, you must enable CSA for the individual login nodes using the `xtopview -n [`*nid#*`]` syntax rather than the `xtopview -c login` syntax shown. You must repeat the process for each login node. See the `xtopview`(8) man page for complete command option information.

9.6 Using LDAP with CSA

The `projdb` command and the `-l` option on the `account` command are not supported with customer-provided account validation.

The following Cray supplied library functions do not support this feature: `db_add_project`(3), `db_add_user`(3), `db_get_proj_acct`(3), `db_get_proj_name`(3), `db_get_user_accts`(3), `db_has_table`(3), `db_print_table`(3), `db_truncate_table`(3), and `db_validate_acct`(3).

For a description of the `/etc/opt/cray/projdb/projdb.conf` file and additional information on using a customer-supplied database, see the `projdb`(8) and `intro_csa`(8) man pages.

Using Checkpoint/Restart on Cray Systems [10]

Checkpoint/Restart (CPR) provides a way to suspend and snapshot the state of a running application. This snapshot can then be used to restart the application at a later time for use in application recovery (after a failure) or coarse grained scheduling. This is useful in case of failure or in case you need to suspend a long-running application for some other reason.

This chapter provides Cray CPR details. For complete information about BLCR, see the Berkeley Lab Checkpoint/Restart documentation available on the web at http://upc-bugs.lbl.gov/blcr/doc/html/index.html.

Note: In the Berkeley Lab Checkpoint/Restart documentation, pay special attention to the caveats: in particular, that files open for writing are truncated to the file position at the time of checkpoint. Because each process accessing a shared file will most likely have a different file position, the file will be truncated to the smallest file position at the time of checkpoint.

10.1 Requirements and/or Limitations for Checkpoint/Restart

The Cray systems CPR feature is built upon the Berkeley Lab Checkpoint/Restart (BLCR) for Linux. CPR jobs on Cray systems also require a library which has integrated BLCR support; for that reason, applications must be linked with the currently supported Cray MPT libraries. For performance monitoring of applications that may be checkpointed and restarted, CrayPat (Cray performance analysis tool) 5.0.2 release is also required.

Note: Only applications using the MPI and SHMEM programming models are checkpointable.

Specific third-party batch system software releases are required for checkpoint/restart support. For current information, access the **3rd Party Batch SW** link on the CrayPort website at http://crayport.cray.com.

In addition, because of the known file-per-node I/O access of checkpoint/restart, the checkpoint directory's file system setting should be optimized for this access pattern. For Lustre, it is optimal to set the checkpoint directory stripe count to one.

```
lfs setstripe checkpoint_dir -s 0 -i -1 -c 1
```

10.2 Installation and Configuration

Several entities need to be installed and configured before CPR can be used with Cray applications.

10.2.1 Cray Installation and Configuration Options

The Cray Linux Environment (CLE) installation tool handles most of the details of installing the software necessary for checkpoint/restart support.

To enable checkpoint/restart set `cpr=`**`yes`** in the `CLEinstall.conf` before the `CLEinstall` program is run. To include the RPM for the CPR client in your CNL boot image, either set `CNL_cpr=`**`yes`** in the `CLEinstall.conf` before the `CLEinstall` program is run or edit the `shell_bootimage_`*label*`.sh` script and specify `CNL_cpr=`**`y`** prior to updating your CNL boot image. For more specific installation instructions, see *Installing and Configuring Cray Linux Environment (CLE) Software*.

Your batch system must also recognize and interpret CPR directives.

If you have not done so, invoke the following command sequence from the boot node as root:

```
boot# xtopview -x /etc/opt/cray/sdb/node_classes -c login
login> chkconfig blcr on
login> exit
```

On the subsequent system boot, this starts up CPR services on all nodes of that class.

If you did not add the configuration option `CNL_cpr=`**`yes`** to the `CLEinstall.conf` configuration file before the `CLEinstall` program was run, edit the `shell_bootimage_`*label*`.sh` script. In the `shell_bootimage_`*label*`.sh` script, specify `CNL_cpr=`**`y`** prior to updating your CNL boot image.

10.2.2 Configuring TORQUE and Moab to Work with CPR

Recent TORQUE releases have support for checkpoint/restart on the Cray platform.

Cray support is compiled in by default, so no additional configuration options are necessary. (TORQUE includes configuration option `--enable-blcr`.)

To enable the TORQUE's CPR support, certain variables must be set in the MOM configuration file, `mom_priv/config` in the TORQUE server home directory.

```
$checkpoint_script /opt/cray/cprbatchutils/default/libexec/checkpoint.torque
$restart_script /opt/cray/cprbatchutils/default/libexec/restart.torque
$checkpoint_run_exe /usr/bin/cr_run
```

Files `checkpoint.torque` and `restart.torque` are part of the `cray-cprbatchutils` package; file `cr_run` is a part of the `blcr` package.

Note: In typical Cray systems with TORQUE, TORQUE's server home directory is `/var/spool/torque`, which resides in a persistent `/var` file system. Therefore, you must make the configuration changes for each persistent `/var` directory associated with each node that runs a TORQUE MOM.

In addition, the destination location for checkpoint files must be on a file system accessible from the compute nodes (like Lustre). Because the TORQUE server default checkpoint directory is not on such a file system, you should override this value on a per queue basis using the following command:

```
qmgr -c "set queue queuename checkpoint_dir=checkpoint_dir"
```

Due to the known file-per-node I/O access of checkpoint/restart, the checkpoint directory's file system setting should be optimized for this access pattern. For Lustre, it is optimal to set the stripe count to one.

```
lfs setstripe checkpoint_dir 0 -1 1
```

10.2.3 Configuring PBS Professional to Work with CPR

Deferred Implementation: The PBS Pro integration with CPR on Cray systems will be available in a future release.

To enable CPR support in PBS Professional, you must set variables as shown below in the MOM configuration file, `mom_priv/config` in the PBS home directory:

```
$action checkpoint 300
!/opt/cray/cprbatchutils/default/libexec/checkpoint.pbspro %sid %jobid %uid %gid %path 0
$action checkpoint_abort 300
!/opt/cray/cprbatchutils/default/libexec/checkpoint.pbspro %sid %jobid %uid %gid %path 9
$action restart 300
!/opt/cray/cprbatchutils/default/libexec/restart.pbspro %sid %jobid %uid %gid %path
$restart_transmogrify true
$checkpoint_path checkpoint_dir
```

Files `checkpoint.pbspro` and `restart.pbspro` are part of the `cray-cprbatchutils` package; file `cr_run` is a part of the BLCR package.

Note: In typical Cray systems with PBS Professional, the PBS Professional home directory is `/var/spool/PBS`, which resides in a persistent `/var` file system. Therefore, you must make the configuration changes for each persistent `/var` directory associated with each node that runs a PBS Professional MOM.

10.3 Using Checkpoint/Restart

To use CPR, an application must be linked with the currently supported Cray MPT libraries and with BLCR. In addition, the batch system must recognize and interpret CPR directives.

10.3.1 Compiling Applications

Applications must be linked with the currently supported Cray MPT libraries to have the code necessary to support checkpointing. Thus, only applications using the MPI and SHMEM programming models are checkpointable. To enable the MPT checkpoint support, the application must also be linked with BLCR. Loading the BLCR module automatically adds the necessary options to Cray compiler scripts to link this library:

```
module load blcr
```

Because the Cray checkpoint/restart solution uses Berkeley Lab's Checkpoint/Restart (BLCR) software, it inherits its caveats and limitations in addition to the Cray MPT requirement. For more information, refer to the BLCR documentation: http://upc-bugs.lbl.gov/blcr/doc/html/index.html.

10.3.2 Using Checkpoint/Restart with TORQUE and Moab

For complete details about checkpointing and restarting with TORQUE and Moab, see the TORQUE documentation at http://www.clusterresources.com/torquedocs21/2.6jobcheckpoint.shtml.

The following examples show typical user tasks.

Example 103. Submit a job to TORQUE

To submit a job and tell TORQUE it is checkpointable:

`qsub -c enabled` ***jobscript***

Example 104. Submit a job to TORQUE that checkpoints every 30 minutes

To submit a job that checkpoints every 30 minutes:

`qsub -c periodic,interval=30` ***jobscript***

Example 105. Checkpoint and terminate a job using TORQUE

To checkpoint and terminate a job that is checkpointable:

`qhold` ***jobid***

Example 106. Restart a held job using TORQUE

To restart a held job:

`qrls` ***jobid***

Example 107. Restart a checkpointed job using TORQUE

To restart a checkpointed job in the completed state:

`qrerun` ***jobid***

10.3.2.1 Common Checkpoint/Restart Error Messages

For TORQUE and Moab batch system checkpoint failures, error messages are reported in the "comment" field of job status command (`qstat -f $JOBID`).

Table 13. BLCR Reported Checkpoint Error Messages

Message	Explanation
`Checkpoint failed: Checkpoint of application nodes failed`	A problem was encountered checkpointing application nodes. See application `stderr` and Table 2.
`Checkpoint failed: Checkpoint tool helper launch failed`	The batch system checkpoint directory has permissions that prevent checkpointing. The user application needs write access to this directory, as this is required for application checkpoints. If connectivity between nodes isn't functioning properly, this may also cause this error.

Any of the error messages shown in Table 14 also can be printed by `aprun` to `stderr` of the job/application.

Table 14. Checkpoint/Restart Error Messages

Message	Explanation
`Checkpoint of application 3136 failed: Support missing from kernel`	The checkpoint failed because BLCR is not installed or loaded on compute nodes.
`Checkpoint of application 3139 failed: Checkpoint support not linked into one or more processes`	The checkpoint failed because the `libcr` BLCR library was not linked into the user application. Users must specify `module load blcr` before compiling code. Loading the BLCR module automatically adds the necessary options to Cray compiler scripts to link this library.
`Checkpoint of application 463346 failed: No such file or directory` or `Checkpoint of application 890274 failed: Permission denied`	The checkpoint failed because a Lustre directory was not specified for the checkpoint data or was not writable by the application user ID.
`Checkpoint of application 1474693 action: Unsupported programming model`	The checkpoint failed because the target application was not linked with the currently supported MPT libraries.

In addition, a checkpoint request sends a signal to the user application; the following functions (and others) can return early or with `EINTR` due to interruption from signals: `poll`(2), `select`(2), `sleep`(3), `read`(2), and `write`(2). Applications may have unexpected results if the usage of the these functions is not POSIX compliant and does not account for signal interruption.

10.3.3 Using Checkpoint/Restart with PBS Professional

Deferred Implementation: The PBS Pro integration with CPR on Cray systems will be available in a future release.

For complete details about using checkpoint/restart with PBS Professional, see the PBS Professional documentation.

The following examples show typical user tasks.

Example 108. Submit a job to PBS Professional

To submit a job and tell PBS Professional it is checkpointable:

`qsub -c s` ***jobscript***

Example 109. Submit a job to PBS Professional that checkpoints every 3 minutes of CPU time

To submit a job to PBS Professional that checkpoints every 3 minutes of CPU time:

`qsub -c c=3` ***jobscript***

Example 110. Checkpoint and terminate a job using PBS Professional

To checkpoint and terminate a job that is checkpointable using PBS Professional:

`qhold` ***jobid***

Example 111. Restart a held job using PBS Professional

To restart a held job using PBS Professional:

`qrls` ***jobid***

Example 112. Restart a checkpointed job using PBS Professional

To restart a checkpointed job in the completed state using PBS Professional:

`qrerun` ***jobid***

Dynamic Shared Objects and Cluster Compatibility Mode in the Cray Linux Environment [11]

11.1 Configuring the Compute Node Root Runtime Environment (CNRTE) Using `CLEinstall`

Users can link and load dynamic shared objects in their applications by using the compute node root runtime environment (CNRTE) in the Cray Linux Environment (CLE). CLE includes software that enables compiling with dynamic libraries, using an alternate to the `initramfs` file system on the compute nodes, called the compute node root. The compute node root is essentially the read-only DVS-projected shared root file system. This supports the ability to run a limited set of dynamic executables on compute nodes.

The main benefit of this feature is expanded use of programs and libraries that require shared objects on Linux systems. If an independent software vendor (ISV) program ships with compiled binaries and dynamic libraries, you can also take advantage of this feature. Users are able to effectively reduce memory and executable footprint when shared objects, called multiple times, use the same segment of memory address space. Users can create applications that no longer need recompiling when libraries change.

Administrators enable this option at install time by modifying parameters in `CLEinstall.conf`.

For additional information, see *Installing and Configuring Cray Linux Environment (CLE) Software* and *Workload Management and Application Placement for the Cray Linux Environment*.

CNRTE is the framework used to allow compute node access to dynamic shared objects and libraries. Configuring and installing the compute node root runtime environment involves setting up the shared root as a DVS-projected file system. This process entails configuring DVS server nodes and updating the compute node boot images to enable them as clients.

To configure the compute node root runtime environment for CLE, do the following:

1. Determine which service or compute nodes will be the compute node root servers.

   There are essentially two classes of nodes in a Cray system: service or compute.

Service nodes have connectivity to external file systems and networks, access to the shared root of the boot node, and a full set of Linux services. Compute nodes have reduced services and a lightweight kernel to allow a maximized utilization of computational resources. Some services don't require external connectivity but are still desirable. There is also a practical limit to the number of available service nodes for each site. CLE allows you to run the service node image on a node otherwise considered a compute node to act as an internal DVS server of the Cray system shared root.

Note: Any compute nodes you choose here will no longer be a part of the available compute node pool. An allocation mode of `other` will be assigned to these compute nodes in the service database (SDB). These nodes will no longer belong to the group of batch and interactive nodes in the SDB and they will be unavailable to ALPS.

⚠ **Caution:** Do not place DVS servers on the same node as a Lustre (Object Storage, Metadata or Management) server. Doing so can cause load oversubscription on the node and reduce performance.

If the `/etc` files are specialized with a `cnos` class, the `cnos` class `/etc` files will be mounted on top of the projected shared root content on the compute nodes. This class specialization allows the compute nodes to have access to a different set of `/etc` files that exist on the DVS servers. Otherwise, the compute nodes will use the set of `/etc` files that are specific to their DVS server and that are contained in the shared root of the DVS server projects.

2. When editing the `CLEinstall.conf` file and running the `CLEinstall` program , modify the parameters specific to shared object support according to your site-specific configuration.

   When you set the following parameters in the `CLEinstall.conf` file, the `CLEinstall` program will automatically configure your system for the compute node root runtime environment.

   DSL=**`yes`**
   : This variable enables dynamic shared objects and libraries for CLE. The default is `no`.

     Note: Setting this option to `yes` will automatically enable DVS.

   DSL_nodes=17 20
   : The decimal NIDs of the nodes that will act as compute node root servers. These nodes can be a combination of service or compute nodes. Each NID is separated by a space.

   DSL_mountpoint=***/dsl***
   : This path is the DVS mount point on the compute nodes; it is the projection of the shared root file system.

DSL_attrcache_timeout=***14400***

This value is the attribute cache time out for compute node root servers. The value represents the number of seconds before DVS attributes are considered invalid and they are retrieved from the server again.

3. Follow the appropriate procedures in to complete the installation. You can either start your system manually or edit your boot automation scripts to add commands that will start the new compute node root servers.

The `/etc/opt/cray/cnrte/roots.conf` file contains site-specific values for custom root file systems. To specify a different pathname for `roots.conf` edit the configuration file `/etc/sysconfig/xt` and change the value for the variable, `CRAY_ROOTFS_CONF`. In the `roots.conf` file, the system default compute node root used is specified by the symbolic name `DEFAULT`. If no default value is specified, `/` will be assumed. In the following example segment of `roots.conf`, the default case uses `/dsl` as the reference root file system:

```
DEFAULT=/dsl
INITRAMFS=/
DSL=/dsl
```

Users can override the system default compute node root value by setting the `CRAY_ROOTFS` environment variable to a value from the `roots.conf` file. This changes the compute node root used for launching jobs. For example, to override the use of `/dsl` set `CRAY_ROOTFS` to `INITRAMFS`.

An administrator can modify the contents of this file to restrict user access. For example, if the administrator only wants to allow applications to launch using the compute node root, the `roots.conf` file would read like the following:

```
% cat /etc/opt/cray/cnrte/roots.conf
DEFAULT=/dsl
```

Procedure 69. Setting up the compute node root runtime environment using only re-purposed compute nodes as compute node root servers

In this example, To configure compute nodes 17 (*c0-0c0s4n1*) and 20 (*c0-0c0s5n0*) as DVS compute node root servers with a mount point, `/dsl`:

1. Edit the following fields in `CLEinstall.conf`:

   ```
   DSL=yes
   DSL_nodes=17 20
   DSL_mountpoint=/dsl
   DSL_attrcache_timeout=14400
   CNL_dvs=yes
   ```

2. Run `CLEinstall`.

   Once `CLEinstall` is completed, create the appropriate boot images using the shell script generated by `CLEinstall`.

Note: When re-purposing compute nodes as DVS servers, you must use the `SNL0` boot type string instead of the traditional `CNL0` boot type string. You should do this after you have booted all the service nodes but before you have booted the compute nodes. You must also boot the re-purposed compute nodes before you run the `shell_ssh.sh` script.

3. If you are using `xtbootsys` interactively you can start the re-purposed compute nodes with a service node image (**`SNL0`**) using option `17`:

```
Enter your boot choice: 17
Enter a boot type string (or nothing to do nothing): SNL0
Enter a boot type option (or nothing to do nothing): compute
Enter a component list (or nothing to do nothing): c0-0c0s4n1,c0-0c0s5n0
Enter 'any' to wait for any console output,
   or 'linux' to wait for a linux style boot,
   or 'mtk', 'threadstorm', 'ts', or 'xmt' to wait for a MTK style boot,
   or anything else (or nothing) to not wait at all: linux
Enter an alternative CPIO archive name (or nothing):
Do you want to send the ec_boot event ('no' means to
only load memory) ? [Yn]
```

   Alternatively, you can use the `xtcli` command in another session as in the following:

```
crayadm@smw:~> xtcli -s boot SNL0 compute c0-0c0s4n1,c0-0c0s5n0
```

4. Run `/tmp/shell_ssh.sh` as indicated in

5. To manually start DVS, issue the following commands:

```
boot001:~ # ssh c0-0c0s4n1 /etc/init.d/dvs start
boot001:~ # ssh c0-0c0s5n0 /etc/init.d/dvs start
```

   You can also edit your boot automation scripts to start the compute node root servers. Edit the boot automation file using your favorite editor to add a comma separated list of compute node root servers to the `boot_loadfile` and to start these DVS servers:

```
boot001:~# vi /opt/cray/etc/auto.mybootfile
```

   After the commands starting the SDB node and all service nodes input the following:

```
lappend actions  [list crms_boot_loadfile SNL0 compute "c0-0c0s4n1,c0-0c0s5n0" linux]
lappend actions { crms_sleep 5 }
```

6. Start the DVS servers by editing the boot automation scripts with the following lines after the service nodes have been booted:

```
lappend actions {crms_exec_via_bootnode "c0-0c0s4n1" "root" "/etc/init.d/dvs start"}
lappend actions {crms_exec_via_bootnode "c0-0c0s5n0" "root" "/etc/init.d/dvs start"}
```

7. Shutdown your system:

```
boot001:~# xtbootsys -s last -a auto.xtshutdown
```

8. Start the system using your newly-edited boot automation file:

   ```
   crayadm@smw: -> xtbootsys -a auto.mybootfile
   ```

Procedure 70. Setting up the compute node runtime environment using a mixture of service nodes and re-purposed compute nodes

Caution: Do not place DVS servers on the same node as a Lustre (Object Storage, Metadata or Management) server. Doing so can cause load oversubscription on the node and reduce performance.

In this example, service nodes 12 (*c0-0c0s3n0*) and 15 (*c0-0c0s3n3*) are free but system constraints require you to use an additional node, compute node 20 (*c0-0c0s5n0*), as a DVS compute node root server.

1. Edit the following fields in `CLEinstall.conf`:

   ```
   DSL=yes
   DSL_nodes=12 15 20
   DSL_mountpoint=/dsl
   DSL_attrcache_timeout=14400
   CNL_dvs=yes
   ```

2. Run `CLEinstall`.
3. Once `CLEinstall` is completed, create the appropriate boot images using the shell script generated by `CLEinstall`.
4.

   Note: When re-purposing compute nodes as DVS servers, you must use the `SNL0` boot type string instead of the traditional `CNL0` boot type string. You should do this after you have booted all the service nodes but before you have booted the compute nodes. In this example, starting all service nodes will start the compute node root servers that were already service nodes. In this case only the re-purposed compute nodes still need to be booted.

   If you are using `xtbootsys` interactively you can start the re-purposed compute node using option `17`:

```
Enter your boot choice: 17
Enter a boot type string (or nothing to do nothing): SNL0
Enter a boot type option (or nothing to do nothing): compute
Enter a component list (or nothing to do nothing): c0-0c0s5n0
Enter 'any' to wait for any console output,
   or 'linux' to wait for a linux style boot,
   or 'mtk', 'threadstorm', 'ts', or 'xmt' to wait for a MTK style boot,
   or anything else (or nothing) to not wait at all: linux
Enter an alternative CPIO archive name (or nothing):
Do you want to send the ec_boot event ('no' means to only load memory) ? [Yn]
```

   Alternatively, you can use the `xtcli` command in another session as in the following:

   ```
   crayadm@smw:~> xtcli -s boot SNL0 compute c0-0c0s5n0
   ```

5. Start DVS by issuing the following commands:

```
boot001:~ # ssh c0-0c0s3n0 /etc/init.d/dvs start
boot001:~ # ssh c0-0c0s3n3 /etc/init.d/dvs start
boot001:~ # ssh c0-0c0s5n0 /etc/init.d/dvs start
```

   You can also edit your boot automation scripts to start the compute node root servers. Edit the boot automation file using your favorite editor to add a comma separated list of compute node root servers to the `boot_loadfile` and to start these DVS servers:

```
boot001:~# vi /opt/cray/etc/auto.mybootfile
```

   After the commands starting the SDB node and all service nodes input the following:

```
lappend actions  [list crms_boot_loadfile SNL0 compute "c0-0c0s5n0" linux]
lappend actions { crms_sleep 5 }
```

   Start the DVS servers by editing the boot automation scripts with the following lines after the service nodes have been booted:

```
lappend actions {crms_exec_via_bootnode "c0-0c0s3n0" "root" "/etc/init.d/dvs start"}
lappend actions {crms_exec_via_bootnode "c0-0c0s3n3" "root" "/etc/init.d/dvs start"}
lappend actions {crms_exec_via_bootnode "c0-0c0s5n0" "root" "/etc/init.d/dvs start"}
```

6. Shutdown your system:

```
boot001:~# xtbootsys -s last -a auto.xtshutdown
```

7. Start the system using your newly-edited boot automation file:

```
crayadm@smw: -> xtbootsys -a auto.mybootfile
```

Procedure 71. Setting up the compute node runtime environment using only service nodes

Caution: Do not place DVS servers on the same node as a Lustre (Object Storage, Metadata or Management) server. Doing so can cause load oversubscription on the node and reduce performance.

In this example, you are using service nodes 12 (*c0-0c0s3n0*) and 15 (*c0-0c0s3n3*) as DVS compute node root servers.

1. Edit the following fields in `CLEinstall.conf`:

```
DSL=yes
DSL_nodes=12 15
DSL_mountpoint=/dsl
DSL_attrcache_timeout=14400
CNL_dvs=yes
```

2. Once `CLEinstall` is completed, create the appropriate boot images using the shell script generated by `CLEinstall` and start all service nodes.

3. Start DVS by issuing the following commands:

```
boot001:~ # ssh c0-0c0s3n0 /etc/init.d/dvs start
boot001:~ # ssh c0-0c0s3n3 /etc/init.d/dvs start
```

   You can also edit your boot automation scripts to start DVS on the compute node root servers. Edit the boot automation file using your favorite editor:

```
boot001:~# vi /opt/cray/etc/auto.mybootfile
```

   Enter the following lines after the service nodes have been booted in the script:

```
lappend actions {crms_exec_via_bootnode "c0-0c0s3n0" "root" "/etc/init.d/dvs start"}
lappend actions {crms_exec_via_bootnode "c0-0c0s3n3" "root" "/etc/init.d/dvs start"}
```

4. Shutdown your system:

```
boot001:~# xtbootsys -s last -a auto.xtshutdown
```

5. Start the system using your newly-edited boot automation file:

```
crayadm@smw: -> xtbootsys -a auto.mybootfile
```

Example 113. Rebooting all compute nodes when a subset are repurposed as DVS servers

> **Note:** Rebooting compute nodes using the `xtbounce` or `xtcli` commands and `all_comp` option will reboot any compute nodes re-purposed as DVS servers.

If you are re-purposing compute nodes as DVS servers, you will need to modify the order in the system boot automation scripts so that when you reboot the compute nodes you will have access to compute node root servers. These servers must be booted right after the service nodes and before all compute nodes are started. If you are a site that uses many of these service nodes, Cray recommends splitting nodes into batches of 80 or less and booting them separately in the automation script. The following is a sample of a boot script, `reboot_computes`, that bounces the compute nodes, restarts the compute node root server (node 20), starts DVS, and boots all remaining compute nodes:

```
set data(password,root) "root_password"

# Shutdown all computes.
lappend actions { crms_exec "xtbounce -s all_comp" }
# reboot DVS server node
lappend actions  [list crms_boot_loadfile SNL0 compute "c0-0c0s5n0" linux]
# Start DVS
lappend actions {crms_exec_via_bootnode "c0-0c0s5n0" "root" "/etc/init.d/dvs start"}
# reboot compute nodes:
 lappend actions [list crms_boot_loadfile CNL0 compute p0 nowait]
```

11.2 Configuring Cluster Compatibility Mode

A Cray XT or Cray XE series system is not a cluster but a massive parallel processing (MPP) computer. An MPP is simply one computer with many networked processors used for distributed computation, and, in the case of Cray XT and Cray XE architectures, a high-speed communications processor that facilitates optimal bandwidth and memory operations between those processors. When operating as an MPP machine, the Cray compute node kernel (Cray CNL) typically does not have a full set of the Linux services available that are used in cluster ISV applications.

Cluster Compatibility Mode (CCM) is a software solution that provides the services needed to run most cluster-based independent software vendor (ISV) applications out-of-the-box with some configuration adjustments. CCM supports ISV applications running in four simultaneous cluster jobs on up to 256 compute nodes per job instance. It is built on top of the Compute Node Root Runtime Environment (CNRTE), the infrastructure used to provide dynamic library support in Cray systems.

CCM is tightly coupled to the workload management system. It enables users to execute cluster applications alongside workload-managed jobs running in a traditional MPP batch or interactive queue. Essentially, CCM uses the batch system to logically designate part of the Cray system as an emulated cluster for the duration of the job as shown in Figure 5 and Figure 6.

Figure 5. Cray System Job Distribution Cross-section

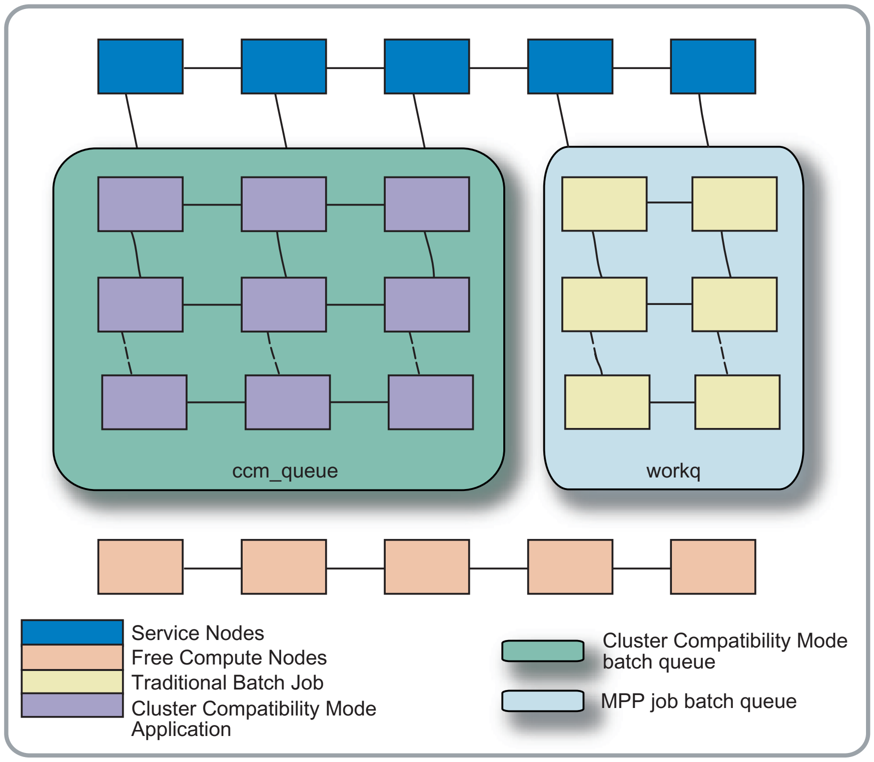
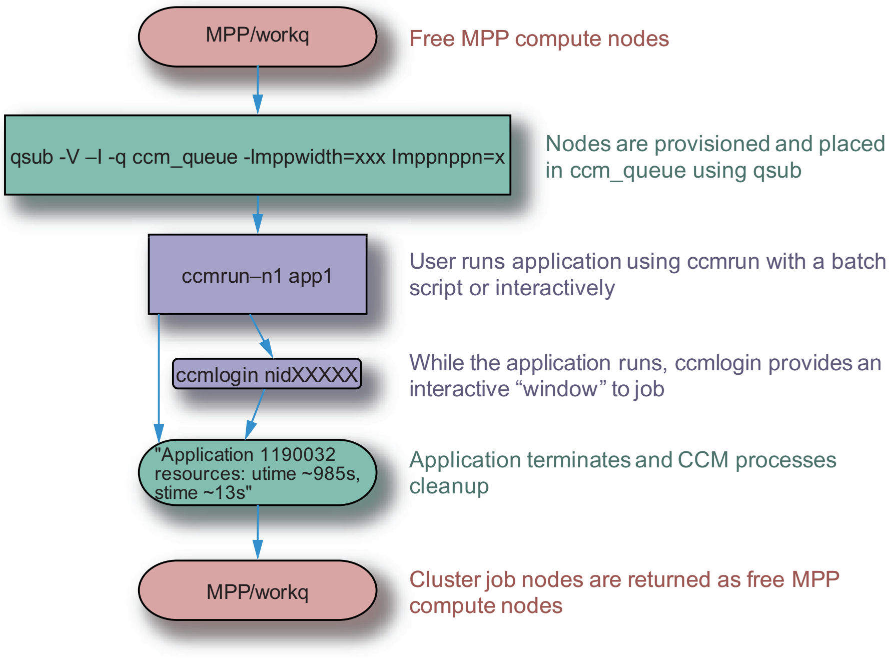


Figure 6. CCM Job Flow Diagram


MPP/workq
Free MPP compute nodes
qsub -V –I -q ccm_queue -lmppwidth=xxx lmppnppn=x
Nodes are provisioned and placed in ccm_queue using qsub
ccmrun–n1 app1
User runs application using ccmrun with a batch script or interactively
ccmlogin nidXXXXX
While the application runs, ccmlogin provides an interactive "window" to job
"Application 1190032 resources: utime ~985s, stime ~13s"
Application terminates and CCM processes cleanup
MPP/workq
Cluster job nodes are returned as free MPP compute nodes

11.2.1 Preconditions

- CNRTE (dynamic library support) is installed.
- **(Optional)** RSIP must be installed if you have applications that need access to a license server; see *Installing and Configuring Cray Linux Environment (CLE) Software*.
- PBS 10.2RC2 (Emerald) or Torque-2.4.1b1-snap.200908271407 or later versions are installed.

11.2.2 Configuration Options Relevant to Installation

The following variables in are used for installation of CCM. Variables such as `CCM_ENABLERSH`, `CCM_QUEUES`, and `CCM_WLM` can be changed in `/etc/opt/cray/ccm/ccm.conf` after installation. For more information on how to install CCM, please see *Installing and Configuring Cray Linux Environment (CLE) Software*.

CCM=**`yes`**	Set this parameter to *yes* to enable Cluster Compatibility Mode and install the appropriate RPMs.

CCM_ENABLERSH=**`yes`**

Optional: Enables services or daemons that most ISV applications need to run. Examples of these services are `xinetd`, `portmap`, `rsh`, and `rlogin`. If you set `CCM_ENABLERSH` to `no` some ISV applications will not work. If you don't specify this parameter, `rsh` is enabled by default.

CCM_QUEUES=***ccm_queue1, ccm_queue2***

Specifies one or more batch queues used in the workload management system. The default value is `ccm_queue`.

> **Important:** The syntax in the configuration file, `ccm.conf`, and the installer variable `CCM_QUEUES` differ. In the installer, the queues are listed as comma-separated values. In the configuration file they are space-separated.

After your batch system software is installed, you must manually create the queues you specify here. For steps required to create CCM batch queues, see Procedure 75 on page 293.

CCM_WLM=***pbs***

Set the value to either `pbs` or `torque` to choose your preferred workload management software.

CCM_ENABLENIS=***no***

Optional: This option can be set to `yes` to start `ypservices` on the compute node. If NIS is not properly configured, calls will time out to the network, significantly slowing down CCM startup, so this option is disabled by default.

11.2.3 Post-install Options and Configuration

The following are exclusively post-install options included in `/etc/opt/cray/ccm/ccm.conf`:

CCM_DEBUG=***no***

Setting this option to `yes` enable debug logging for CCM. These logs will be stored on the PBS MOM node in`/var/log/crayccm`. Cray recommends the site setting this option to yes.

CCM_INADDRANYBIND=***yes***

This option tells RSIP to bind `INADDR_ANY` requests to the local network interface rather than using the RSIP address space. Changing this to `no` will cause `INADDR_ANY` bind requests to consume RSIP ports and may prevent application scaling.

To configure `yp`, `/etc/defaultdomain` and `/etc/yp.conf` must be properly configured on the compute node specialized view. Cray recommends that you use the `cnos` class within `xtopview` to set up this specialized view.

Procedure 72. Using DVS to mount home directories on the compute nodes for CCM

For each DVS server node you have configured, follow these steps to mount `/ufs` from the NFS server `ufs`.

1. Create the `/ufs` mount point on the DVS server by using `xtopview` in the node view. For example, if your DVS server is `c0-0c0s2n3` (node 27 on a Cray XE system), type the following:

```
boot:~ # xtopview -m "mounting home dirs" -n 27
node/27:~ # mkdir -p /ufs
```

2. Add a line to `/etc/fstab` and specialize the file for the node class.

```
node/27:~ # vi /etc/fstab
ufs:/ufs        /ufs    nfs     tcp,rw  0 0
node/27:~ # xtspec -n 27 /etc/fstab
node/27:~ # exit
```

3. To allow the compute nodes to mount their DVS partitions, add an entry in the `/etc/fstab` file in the compute image for each DVS file system. For example:

```
smw:~ # /opt/xt-images/templates/default/etc/fstab
/ufs /ufs dvs path=/ufs,nodename=c0-0c0s2n3,loadbalance
```

4. For each DVS mount in the `/etc/fstab` file, create a mount point in the compute image.

```
smw:~ # mkdir -p /opt/xt-images/templates/default/ufs
```

5. Update the boot image to include these changes; follow the steps in Procedure 2 on page 68.

Procedure 73. Modifying CCM and Platform-MPI system configurations

Follow these steps to set up network, debugging, and Platform-MPI settings for CCM.

1. Edit the CCM configuration file by using `xtopview` in the default view and make changes for your configuration.

   ```
   boot:~ # xtopview -m "configuring ccm.conf"
   default/:/ # vi /etc/opt/cray/ccm/ccm.conf
   ```

   If you have configured CCM with `CLEinstall`, these options have already been set:

   ```
   CCM_QUEUES="ccm_queue"
   CCM_DEBUG=no
   CCM_ENABLERSH=yes
   CCM_ENABLENIS=no
   CCM_WLM="pbs"
   CCM_INADDRANYBIND=yes
   ```

   Change the default values to enable NIS or additional debugging, or to modify any of the values you defined in the `CLEinstall.conf` file.

2. **(Optional)** If your applications will use Platform-MPI (also known as *HP-MPI*), Cray recommends you create the `/etc/hpmpi.conf` file with these values.

```
default/:/ # vi /etc/hpmpi.conf
MPI_IC_ORDER="TCP"
MPI_REMSH=ssh
MPIRUN_OPTIONS="-cpu_bind=MAP_CPU:0,1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,18,19,20,21,22,23"
```

3. Exit `xtopview`.

   ```
   default/:/ # exit
   boot:~ #
   ```

Procedure 74. Setting up files for the cnos class

The `cnos` compute nodes that have access to the shared root through CNRTE will have a specialized class of its own `/etc` files. Login files and all `/etc` files should be migrated to the `cnos` class in order for CCM to work.

1. Use `xtopview` to access the `cnos` class specialized files:

   ```
   boot:~#  xtopview -m "CCM cnos setup" -c cnos
   ```

   Note: If the SDB has not been started, use the `-x /etc/opt/cray/sdb/node_classes` option to specify node/class relationships.

2. To add a file or modify a file, edit the file and then specialize it for the `cnos` class

   ```
   class/cnos:/# vi /etc/file
   class/cnos:/# xtspec -c cnos /etc/file
   ```

   Repeat the above steps for each new file that you want to add or modify for the compute nodes.

3. Exit `xtopview`.

   ```
   class/cnos:/# exit
   ```

   Note: You are prompted to type **`c`** and enter a brief comment describing the changes you made. To complete your comment, type **`Ctrl-d`** or a period on a line by itself. Do this each time you exit `xtopview` to log a record of revisions into a version control system.

Procedure 75. Linking the CCM prologue/epilogue scripts on login nodes

Prerequisites: This procedure requires that you have already installed a workload management system such as PBS or Moab TORQUE.

Add a line to reference to append the CCM prologue and epilogue scripts to the end of the existing batch prologue and epilogue. The PBS batch prologue is configured on all PBS MOM nodes in `/var/spool/PBS/mom_priv/prologue.` The Moab TORQUE batch prologue is configured on all Torque MOM nodes in `/var/spool/torque/mom_priv/prologue.`

Note: This procedure assumes that you are using `/bin/bash` as your shell, but this can be modified appropriately for others.

1. Add the following lines to prologue:

   ```
   #!/bin/bash
   ccm_dir=/opt/cray/ccm/default/etc

   if [ -f $ccm_dir/cray-ccm-prologue ] ; then
      . $ccm_dir/cray-ccm-prologue $1 $2 $3
   fi
   ```

2. Add the following lines to epilogue:

   ```
   #!/bin/bash
   ccm_dir=/opt/cray/ccm/default/etc

   if [ -f $ccm_dir/cray-ccm-epilogue ] ; then
     . $ccm_dir/cray-ccm-epilogue $1 $2 $3 $4 $5 $6 $7 $8 $9
   fi
   ```

3. Set the executable bit for `prologue` and `epilogue` if not set:

   ```
   system :/var/spool/PBS/mom_priv # chmod a+x prologue epilogue
   ```

4. Change the default batch timeout value. Cray recommends changing this to 120 seconds. This allows the system enough time to startup and shutdown all infrastructure on the nodes associated with the CCM job. To change the batch timeout, append the following line to `/var/spool/PBS/mom_priv/config` or `/var/spool/torque/mom_priv/config`:

   ```
   $prologalarm 120
   ```

Procedure 76. Using `qmgr` to create a general CCM queue and queues for separate ISV applications

1. Set up a general CCM queue by issuing the following `qmgr` commands on the PBS server node:

   ```
   # module load pbs
   # qmgr
   Qmgr: create queue ccm_queue
   Qmgr: set queue ccm_queue queue_type = Execution
   Qmgr: set queue ccm_queue resources_max.mpparch = XT
   Qmgr: set queue ccm_queue resources_min.mpparch = XT
   Qmgr: set queue ccm_queue resources_min.mppwidth = 1
   Qmgr: set queue ccm_queue resources_default.mpparch = XT
   Qmgr: set queue ccm_queue resources_default.mppwidth = 1
   Qmgr: set queue ccm_queue enabled = True
   Qmgr: set queue ccm_queue started = True
   Qmgr: exit
   ```

2. Repeat step 1 for additional application-specific queues, if desired.

OpenFabrics Interconnect Drivers for CLE Systems [12]

InfiniBand (IB) and OpenFabrics remote direct memory access (RDMA) is supported on service nodes for Cray systems running the Cray Linux Environment (CLE) operating system.

No separate installation is required. The kernel-space libraries and drivers are built against Cray's kernel. OFED and InfiniBand RPMs are included in the CLE release and installed by default. However, OFED will not run on your Cray system until you configure the I/O nodes to use IB.

To configure IB and OFED, see the procedures provided in this chapter; to configure IB and OFED during installation or upgrade of your CLE software, see *Installing and Configuring Cray Linux Environment (CLE) Software*.

12.1 OFED Overview

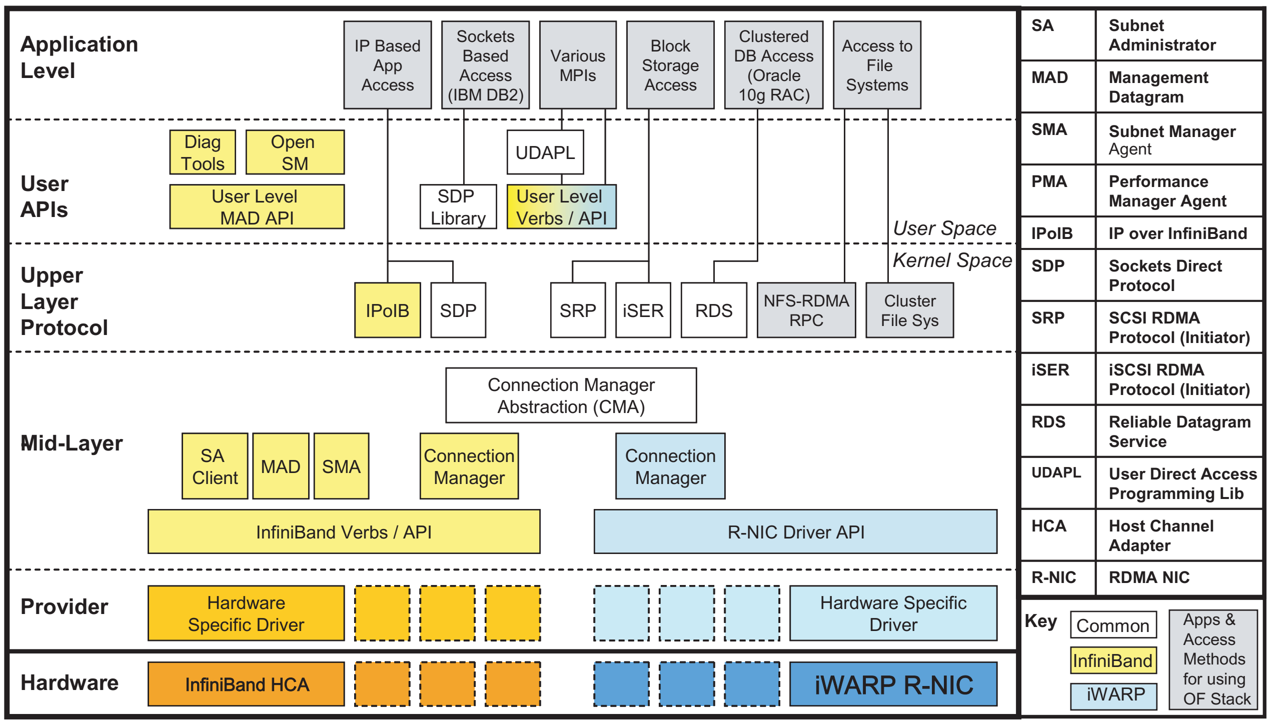
Cray has adopted InfiniBand as an I/O interconnect. Double data rate (DDR) IB host channel adapters (HCAs) accommodate user data transfers at up to 1.5 GB/s bidirectionally. IB also enables efficient zero-copy, low-latency RDMA transfers between network peers. As a result, IB gives Cray the most efficient transfer mechanism from Cray's high speed network (HSN) to external I/O devices.

CLE includes a subset of the OpenFabrics Enterprise Distribution (OFED) to support the use of InfiniBand on the Cray I/O nodes. OFED is the software stack on the host that coordinates user-space and kernel-space access to the IB hardware. IB support is restricted to service I/O (X/SIO) nodes that are equipped with the PCI Express (PCIe) card for network connectivity.

IB can be used on Lustre OSS nodes as a storage interconnect between the Cray system and direct-attach IB storage, or it can be used on Lustre router nodes as a network interconnect between the Cray system and external Lustre servers.

The OFED software stack consists of many different components. These components can be categorized as kernel modules (drivers) and user/system libraries and utilities, commands and daemons for InfiniBand administration, configuration, and diagnostics. Cray maintains the kernel modules so that they are compatible with CLE on the service nodes.

Figure 7. The OFED Stack (source: OpenFabrics Alliance)



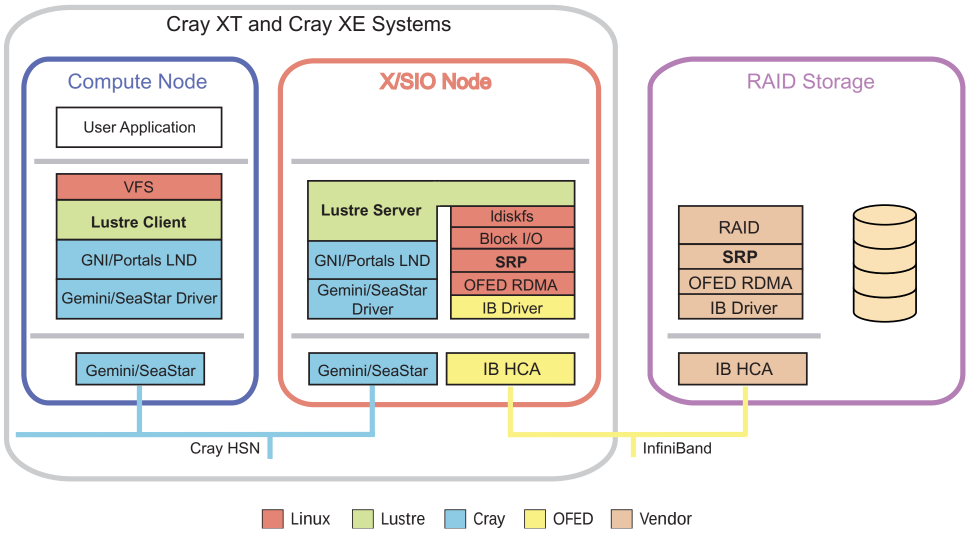
12.2 Using InfiniBand

InfiniBand is a payload-agnostic transport. It can move small messages or large blocks efficiently between network endpoints. The following examples demonstrate how Cray uses InfiniBand and the OFED stack to support block I/O, file I/O, and standard network inter-process communication.

12.2.1 Storage Area Networking

InfiniBand can transport block I/O requests to external storage targets. ANSI T10's SCSI RDMA Protocol (SRP) is currently the only SCSI-transporting protocol supported on Cray systems with InfiniBand. Figure 8 shows SRP on InfiniBand connecting the Cray to an external RAID array. The OFED stack is shown in the storage array for clarity; it is provided by your site-specific third party storage vendor.

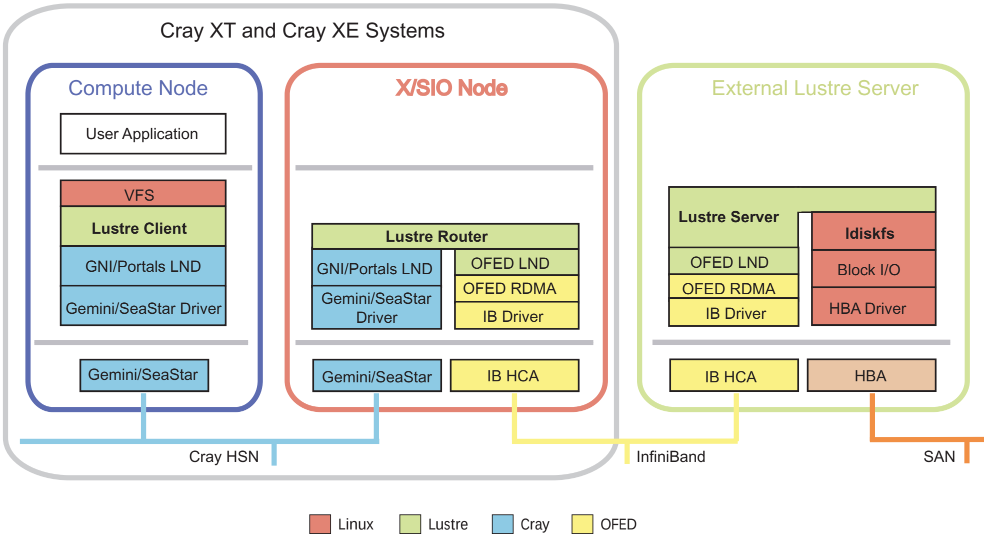
Figure 8. Cray System Connected to Storage Using SRP



12.2.2 Lustre Routing

Cray uses InfiniBand on the service nodes to connect Cray compute nodes to external Lustre (eLustre) servers Figure 9. In this configuration, the service node is no longer a Lustre server. Instead, it runs a Lustre router provided by the LNET layer. The router moves LNET messages between the Cray HSN and the external IB network, which transports file-level I/O requests between the clients on the Cray HSN and the servers on the IB fabric. Please speak with your Cray service representative regarding an eLustre solution for your Cray system.

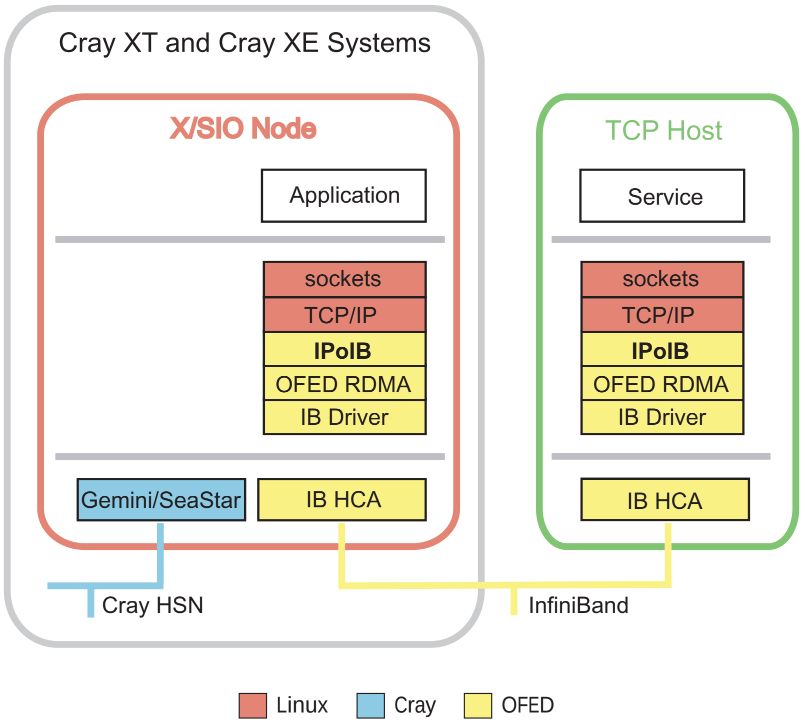
Figure 9. Cray Service Node Acting as an Infiniband Lustre Router



12.2.3 IP Connectivity

InfiniBand can also carry socket-based inter-process traffic typical of commodity clusters and TCP/IP networking. InfiniBand supports the IP over IB (IPoIB). Since IB plugs-in below the socket interface, neither the application nor the service needs to be recompiled to communicate over an InfiniBand network. Both protocols are diagrammed on a service node in Figure 10.

Figure 10. Cray Service Node in IP over IB Configuration



12.3 Configuration

In addition to the OFED RDMA stack, Cray supports three upper layer protocols (ULPs) on its service nodes as shown in Table 15. Because all ULPs use the OFED stack, the InfiniBand Configuration (3.1) must be followed for all IB service nodes.

Note: It is only necessary to configure the specific ULPs that you intend to use on the service node.

For example, a Lustre server with a direct-attached storage array uses the SCSI RDMA Protocol (SRP), not the LNET Router. On the other hand, if the Lustre servers are external to the Cray system, the service node uses the LNET router instead of SRP. IP over InfiniBand (IPoIB) is used to connect non-RDMA, socket applications across the IB network.

Table 15. Upper Layer InfiniBand I/O Protocols for Cray Systems

Upper Layer Protocol	Purpose
IP over IB (IPoIB)	Provides IP connectivity between hosts over IB.
Lustre (OFED LND)	Base driver for Lustre over IB. On service nodes, enables efficient routing of Lustre clients on HSN to external IB-connected Lustre servers. The name of the LND is `o2iblnd`.
SCSI RDMA Protocol (SRP)	T10 standard for mapping SCSI over IB and other RDMA fabrics. Supported by DDN and LSI for their IB-based storage controllers.

12.4 InfiniBand Configuration

Procedure 77. Configuring InfiniBand on service nodes

InfiniBand includes the core OpenFabrics stack and a number of upper layer protocols (ULPs) that use this stack. Configure InfiniBand by modifying `/etc/modprobe.conf.local` and `/etc/sysconfig/infiniband` for each IB service node.

1. Use the `xtopview` command to access service nodes with IB HCAs.

   For example, if the service nodes with IB HCAs are part of a node class called `lnet`, type the following command:

   ```
   boot:~ # xtopview -x /etc/opt/cray/sdb/node_classes -c lnet
   ```

   Or

   Access each IB service node by specifying either a node ID or physical ID. For example, access node 8 by typing the following:

   ```
   boot:~ # xtopview -x /etc/opt/cray/sdb/node_classes -n 8
   ```

2. Specialize the `/etc/modprobe.conf.local` and `/etc/sysconfig/infiniband` files:

   ```
   node/8:/ # xtspec -n 8 /etc/modprobe.conf.local
   node/8:/ # xtspec -n 8 /etc/sysconfig/infiniband
   ```

3. On Cray systems, the IB HCA is a PCI Express (PCIe) card. Cray systems with a PCIe riser support only message signaled interrupts (MSI). The driver used for this HCA does not, by default, support MSI. You must enable MSI support by editing `/etc/modprobe.conf.local` and adding the following lines:

   ```
   node/8:/ # vi /etc/modprobe.conf.local
   # Enable MSI for Mellanox ConnectX HCAs
   options mlx4_core msi_x=1
   ```

4. Add IB services to the service nodes by using standard Linux mechanisms, such as executing the `chkconfig` command while in the `xtopview` utility or executing `/etc/init.d/openibd start | stop | restart` (which starts or stops the InfiniBand services immediately). Use the `chkconfig` command to ensure that IB services are started at system boot.

   ```
   node/8:/ # chkconfig --force openibd on
   ```

5. While in the `xtopview` session, edit `/etc/sysconfig/infiniband` and make these changes.

   ```
   node/8:/ # vi /etc/sysconfig/infiniband
   ```

   a. By default, IB services do not start at system boot. Change the `ONBOOT` parameter to **`yes`** to enable IB services at boot.

      ```
      ONBOOT=yes
      ```

   b. By default at boot time, the Internet Protocol over InfiniBand (IPoIB) driver loads on all nodes where IB services are configured. Change the value for `IPOIB_LOAD` to **`no`** to disable IPoIB services.

      ```
      IPOIB_LOAD=no
      ```

   c. The SCSI RDMA Protocol (SRP) driver loads by default on all nodes where IB services are configured to load at boot time. If a node does not need SRP services, change the value for `SRP_LOAD` to **`no`** to disable SRP.

      ```
      SRP_LOAD=no
      ```

6. Exit `xtopview`.

   ```
   node/8:/ # exit
   boot:~ #
   ```

   Note: You are prompted to type **`c`** and enter a brief comment describing the changes you made. To complete your comment, type **`Ctrl-d`** or a period on a line by itself. Do this each time you exit `xtopview` to log a record of revisions into an RCS system.

7. Proper IPoIB operation requires additional configuration. See Procedure 79 on page 302.

12.5 Subnet Manager (OpenSM) Configuration

InfiniBand fabrics require at least one Subnet Manager (SM) operating on each IB subnet in order to activate its respective IB port connected to the fabric. This is one critical difference between IB fabrics and Ethernet, where simply connecting a cable to an Ethernet port is sufficient to get an active link. Managed IB switches typically include an SM and, therefore, do not require any additional configuration of any of the hosts. Unmanaged IB switches, which are considerably less expensive, do not include a SM and, thus, at least one host connected to the switch must act as a subnet manager. InfiniBand standards also support switchless (point-to-point) connections as long as an SM is installed. An example of this case is when a service blade is connected to direct-attached storage through InfiniBand.

The OpenFabrics distribution includes OpenSM, an open-source IB subnet management and subnet administration utility. Either one of the following configuration steps is necessary if no other subnet manager is available on the IB fabric. The subnet manager RPMs are installed in the shared root by running `CLEinstall`. OpenSM can be started from the service node on a single port at boot time or manually from the command line to load multiple instances per host.

12.5.1 Starting OpenSM at Boot Time

Procedure 78. Starting a single instance of OpenSM on a service node at boot time

This procedure assumes that the IB HCA is in node 8.

1. Use `xtopview` to access service nodes with IB HCAs.

   ```
   boot:~ # xtopview -x /etc/opt/cray/sdb/node_classes -n 8
   ```

2. Specialize `/etc/sysconfig/opensm` for the IB node.

   ```
   node/8:/ # xtspec -n 8 /etc/sysconfig/opensm
   ```

3. Edit `/etc/sysconfig/opensm.conf` to have OpenSM start at boot time

   ```
   # To start OpenSM automatically set ONBOOT=yes
   ONBOOT=yes
   ```

4. Add IB services to the service nodes by using standard Linux mechanisms, such as executing the `chkconfig` command while in the `xtopview` utility or executing `/etc/init.d/opensmd start|stop|restart|status` (which starts or stops the OpenSM service immediately). The `chkconfig` command can be used to ensure that the OpenSM service is started at system boot.

   ```
   default:~ # /sbin/chkconfig --force opensmd on
   ```

12.6 Internet Protocol over InfiniBand (IPoIB) Configuration

Procedure 79. Configuring IP Over InfiniBand (IPoIB) on Cray systems

1. Use `xtopview` to access each service node with an IB HCA by specifying either a node ID or physical ID. For example, to access node 8, type the following:

   ```
   boot:~ # xtopview -x /etc/opt/cray/sdb/node_classes -n 8
   ```

2. Specialize the `/etc/sysconfig/network/ifcfg-ib0` file.

   ```
   node/8:/ # xtspec -n 8 /etc/sysconfig/network/ifcfg-ib0
   ```

3. Modify the site-specific `/etc/sysconfig/network/ifcfg-ib0` file on each service node with an IB HCA.

   ```
   node/8:/ # vi /etc/sysconfig/network/ifcfg-ib0
   ```

   For example, to use static IP address, *172.16.0.1*, change the `BOOTPROTO` line in the file.

   ```
   BOOTPROTO='static'
   ```

   Add the following lines to the file.

   ```
   IPADDR='172.16.0.1'
   NETMASK='255.255.0.0'
   ```

   To configure the interface at system boot, change the `STARTMODE` line in the file.

   ```
   STARTMODE='onboot'
   ```

4. Repeat steps 2 and 3 to configure IPoIB on both ports on a two port IB HCA for `/etc/sysconfig/network/ifcfg-ib1`. Use a unique IP address from separate networks for each port.

12.7 Configuring SCSI RDMA Protocol (SRP) on Cray Systems

Procedure 80. Configuring and enabling SRP on Cray Systems

While in `xtopview` on the boot node, perform the following steps:

1. Edit `/etc/sysconfig/infiniband`

   ```
   default/:/ # vi /etc/sysconfig/infiniband
   ```

   and enter the following text:

   ```
   ## Path:        System/Infiniband
   ## Description: Infiniband configuration
   ## Type:        yesno
   ## Default:     no
   ## ServiceRestart: openibd
   #
   # Enable SRP daemon
   #
   SRP_DAEMON_ENABLE=yes
   ```

2. Edit `srp_daemon.conf` to increase the maximum sector size for SRP.

   ```
   default/:/ # vi /etc/srp_daemon.conf
   ```

   ```
   a        max_sect=8192
   ```

3. Edit `/etc/modprobe.conf.local` to increase the maximum number of gather-scatter entries per SRP I/O transaction.

   ```
   default/:/ # vi /etc/modprobe.conf.local
   ```

   ```
   options ib_srp srp_sg_tablesize=255
   ```

4. Exit from `xtopview`.

   ```
   default/:/ # exit
   boot:~ #
   ```

12.8 Lustre Networking (LNET) Router

Oracle provides the LNET layer as a separate transport for communication between the Lustre client and server. LNET isolates the file system code from the Lustre Networking Drivers (LNDs), which provide an interface to the underlying network transport. For more information on Lustre networking please see *Lustre Operations Manual*.

Although LNET is automatically loaded with the Lustre servers and clients, it can be launched by itself to create a standalone router between networks instantiated by a LND. LNET routing is most efficient when the underlying transports are capable of remote direct memory access (RDMA). Lustre currently supports LNDs for a number of RDMA transports, including GNILND used for Cray XE (Cray Gemini) and Portals, which is used on Cray XT (SeaStar) systems, and the OpenFabrics' InfiniBand stack. Cray builds and distributes the OFED LNDm, Portals LND, and GNI LND as part of its Lustre distribution.

Routing Lustre requires that three types of nodes be configured: the router, the Portals client, and the InfiniBand server. LNET uses IP addresses to identify LND ports. While the Portals LND uses node IDs to enumerate its ports, the OFED LND uses IP addresses. As a result, IPoIB must be configured on each IB port. See Subnet Manager (OpenSM) Configuration on page 301 for more information. For the rest of this discussion, assume that LNET routers are being created on two Cray service nodes, both of which have a single IB port connected to a switched InfiniBand fabric. The network configuration is shown in Internet Protocol over InfiniBand (IPoIB) Configuration on page 302.

Table 16. LNET Network Address Configuration for Cray XT

Portals Address	Network Component	InfiniBand Address
16	Router 1	10.10.10.17
19	Router 2	10.10.10.20
192.168.0.255	IP Subnet	10.10.10.255
255.255.255.0	Subnet Mask	255.255.255.0

12.8.1 Configuring the LNET Router

Procedure 81. Configuring the LNET router

The following description covers the configuration of the router on node 19. These steps must be repeated on the other router node as well.

1. Use `xtopview` to access service nodes with IB HCAs.

   ```
   boot:~ # xtopview -x /etc/opt/cray/sdb/node_classes
   ```

2. Copy the `/etc/init.d/lnet` script. A router controller (RC) script is necessary to start LNET in the absence of any Lustre file services. A sample RC script is available in Sample Lustre Router Control File on page 307. Copy the script to the shared root within `xtopview` (this example assumes the script was copied to the boot node).

   ```
   cp -p /software/lnet.rc /etc/init.d/lnet
   ```

   Note: Cray does not provide an RC script with its release packages. You must verify that this script will work for your configuration or contact your Cray service representative for more information.

3. Use `chkconfig` to enable LNET since there are no mounts or Lustre server activity to load the LNET module implicitly.

   ```
   default:~ # /sbin/chkconfig lnet on
   ```

4. Add LNET directives to the Cray shared root in `/etc/modprobe.conf.local`.

   ```
   options lnet ip2nets="ptl0 192.168.*.*; o2ib 10.10.10.*"
   options lnet routes="ptl0 10.10.10.[20,17]@o2ib;  o2ib [19,16]@ptl0"
   ```

   For Cray XE systems, `ptl` is replaced by `gni`. Here `ip2nets` is used instead of `networks` because it provides for an identical `modprobe.conf` across all Lustre clients in the Cray system.

   `o2ib` is the LNET name for the OFED LND. `ptl` is the LNET name for the Portals LND. The `ip2nets` directive tells LNET to load both LNDs and associates each LND with an IP subnet. It replaces any previous networks directive (for example, `lnet networks=ptl`). On service nodes without an IB adapter, the `o2ib` LND does not load because there are no ports with the IP subnet used defined in `ip2nets`.

   Note: Each Cray system sharing the external Lustre file system must have a unique `gniptl` identifier for the LNET options. In this case, the Cray XT is using `ptl0`. Other systems would use other numbers to identify their Portals or Gemini networks (such as `ptl1`, `ptl2`, and so on).

5. Cray recommends enabling these options to improve network resiliency. Edit `/etc/modprobe.conf.local` on the Cray shared root to include:

   ```
   options lnet check_routers_before_use=1
   options lnet router_ping_timeout=5
   options lnet dead_router_check_interval=60
   options lnet live_router_check_interval=60
   ```

6. Exit from `xtopview`.

   You are prompted to add a comment about the operations you have performed. Enter **`c`**, and then enter a brief comment about the changes you made to the file.

7. If `/etc/init.d/lnet` is not provided, type the following commands to control the router manually on the Cray service node.

   - Startup:

     ```
     modprobe lnet
     lctl net up
     ```

   - Shutdown:

     ```
     lctl net down
     lustre_rmmod
     ```

12.8.2 Configuring the InfiniBand Lustre Server

Procedure 82. Configuring the InfiniBand Lustre Server

The host on the other edge of the IB fabric must be configured to use the router nodes. Add an `lnet routes` directive for each Cray system sharing the external file system. Ensure that the portal identifier is unique for each system (for example, `gni0`, `gni1` or `ptl0`, `ptl1`) and maps to the correct IP address for the router. Perform these steps on the remote host:

1. Edit `/etc/modprobe.conf` on the remote host to include the route to the Portals network.

   ```
   options lnet networks=o2ib(ib0)
   options lnet routes="gni0 10.10.10.[20,17]@o2ib"
   ```

   (Optional) If there are two Cray systems accessing the file system exported by these hosts, then both Cray systems must be included in the `lnet routes` directive.

   ```
   options lnet routes="gni0 10.10.10.[20,17]@o2ib;
   gni1 10.10.10.[71,72,73,74]@o2ib"
   ```

   In this example, there are two Cray systems: `gni0` with two router nodes and `gni1` with four.

2. Make `/etc/modprobe.conf` consistent with the changes made in Procedure 81 on page 304 by adding the following LNET directives:

   ```
   options lnet check_routers_before_use=1
   options lnet router_ping_timeout=5
   options lnet dead_router_check_interval=60
   options lnet live_router_check_interval=60
   ```

   Because Lustre is running on the external host, there is no need to start LNET explicitly.

12.8.3 Configuring the Portals Lustre Clients

Procedure 83. Configuring Lustre clients

Since compute nodes are running the Lustre client, they do not need explicit commands to start LNET. There is, however, additional configuration required to get LNET to use the routers on the service nodes to reach the external servers. These changes are made to `/etc/modprobe.conf` for the compute node image used in booting the system.

1. Edit `/etc/modprobe.conf` for the compute node boot image. The `lnet networks` directive identifies the LND. If there is more than one Cray system sharing the file system, then this identifier (`gni` or `ptl`) must be unique for each Cray system.

   ```
   options lnet networks=ptl0
   options lnet routes="o2ib [19,16]@ptl0"
   ```

2. Modify `/etc/fstab` in the compute node boot image to identify the external server. The format indicates the IP address of the external server and the LNET network used to reach it.

   ```
   10.10.10.1@o2ib:/boss1  /mnt/boss1      lustre  rw,flock
   ```

   Here, the `fstab` mount option `rw` gives read/write access to the client node. The additional `flock` option is to allow Lustre's client node to have exclusive access to the file lock.

   In this example, the Lustre file system with the `fsname "boss1"` is exported by the Lustre metadata server on the InfiniBand fabric at IP address 10.10.10.1. Because both routers have access to this subnet, the Lustre client performs a round-robin with its requests to the routers.

Accessing any externally supplied Lustre file system requires that both the file server hosts and the LNET routers be up and available before the clients attempt to mount the file system. Boot time scripts in the compute node image take care of reading `fstab` and running the necessary `mount` commands. In production, this is the only opportunity to do Lustre mount because kernel modules get deleted at the end of the boot process.

12.9 Sample Lustre Router Control File

```
#Lnet.rc
#!/bin/bash
#
# $Id: lnet.rc bogl Exp $
#
### BEGIN INIT INFO
# Provides:          lnet
# Required-Start:    $network openibd
# X-UnitedLinux-Should-Start:
# Default-Start:     3
```

```
# Default-Stop:      0 1 2 5 6
# Description:       Enable lnet routers
### END INIT INFO
#set -x
PATH=/bin:/usr/bin:/usr/sbin:/sbin:/opt/xt-lustre-ss/default/usr/
sbin:/opt/xt-lustre-ss/default/usr/bin
. /etc/rc.status
rc_reset
case "$1" in
     start)         echo -n "Starting lnet "
         modprobe lnet
       lctl net up > /dev/null
         rc_status -v
         ;;
     stop)
       echo -n "Stopping lnet "
         lctl net down > /dev/nul
l         lustre_rmmod || true
       rc_status -v
         ;;
     restart)
       $0 stop
       $0 start
       rc_status
       ;;
     *)
         echo "Usage: $0 {start|stop|restart}"
         exit 1
         ;;
esac
rc_exit
```

Cray XE Network Resiliency [13]

The Gemini application-specific integrated circuit (ASIC) allows Cray XE systems to take advantage of two high speed network reliability features:

- Link resiliency, which handles link failures and adds the capability to warm swap a compute blade
- Recovery, in some instances, to a routeable configuration from an unrouteable configuration where multiple Gemini router chips are disabled

13.1 Link Resiliency

Cray XE systems using Gemini interconnect technology have hardware and software support that allows the system to handle certain types of hardware failures without requiring a system reboot. In addition, the same technology allows for the removal and replacement of compute blades without a system reboot. These features contribute to a reduction in both planned and unplanned system downtime.

In the case of loss of power to a Gemini mezzanine, blade, or set of blades, or the warm swap out of a blade, applications running on the affected blades will either be killed, or in the case of a warm swap out, be allowed to complete.

Note: Warm swap of service blades is not supported. However, recovery from link failure is handled identically for both types of blade.

There are several components to Gemini link resiliency:

- Hardware design that permits failed link detection and corrective action
- Software on the L0 (`gmnwd`) on each blade that detects failed links and power loss to Gemini mezzanine cards
- A daemon on the SMW (`xtnlrd`(8)) that coordinates the system response to failures
- Another daemon on the SMW (`xthwerrlogd`(8)) that logs hardware errors
- An administrative command on the SMW (`xtwarmswap`(8)) to facilitate warm swap of blades

When a Cray XE system is booted using `xtbootsys`, the `xtnlrd` and `xthwerrlogd` daemons are started on the SMW. Link monitoring on each L0 is also enabled at this time, and link failures are logged by `xthwerrlogd` and responded to by `xtnlrd` by rerouting the High Speed Network around the failures.

13.1.1 Automatic Response to Failures

13.1.1.1 Failure Of A Single High Speed Network Channel

When a single Gemini channel fails, 2 link endpoints (LCBs) are reported as failed by `gmnwd` on the L0s at each end of the channel. The failures appear in the `xtnlrd` log file as follows:

```
2010-05-21 19:45:37 pandora-smw cb_link_failed: failed_component c0-0c0s7g0l42, type 23, \
error_code 0x1207, error_category 0x2
   [...]
2010-05-21 19:45:37 pandora-smw cb_link_failed: failed_component c0-0c0s7g1l57, type 23, \
error_code 0x1207, error_category 0x2
```

These failures are followed by a series of steps as the recovery actions are performed. For each link endpoint with a fatal error, that link endpoint has an alert flag set, which tells routing that the link is not available and should be routed around.

Recovery steps are visible in the log file, but in summary are:

1. `initial`: wait for failures
2. `aggregate_failures`: wait 10 seconds by default for any more links to fail
3. `link_failed`: begins to process the failed links
4. `alive`/`check_alive`: determines which blades are alive
5. `route_compute`/`check_route_compute`: computes and stages new routes to the L0s
6. `quiesce`/`check_quiesce`: stops all High Speed Network traffic temporarily
7. `route_install`/`check_route_install`: asserts new routes in the Gemini chips
8. `unquiesce`/`check_unquiesce`: resumes all High Speed Network traffic
9. `add_remove`: for future use
10. `finish`: performs final cleanup
11. `initial`: waits for failures (process restarts)

The total time to perform these various steps is typically around 30 seconds.

13.1.1.2 Failure Of A High Speed Network Cable

Loss of a Gemini cable results in 32 link endpoints (LCBs) failing, which appears in the `xtnlrd` log file as 32 entries similar to those in Failure Of A Single High Speed Network Channel on page 310. The same series of steps is performed to recover from the failure, and the same time consideration applies.

In this case, all 32 link endpoints have an alert flag set.

13.1.1.3 Power Loss To A Gemini Mezzanine On A Blade

Loss of power to a Gemini mezzanine results in 32 link endpoint (LCB) failures being reported to `xtnlrd`, since the endpoints on the blade whose mezzanine lost power is not reported as failed. Both Gemini chips on that blade are, however, reported as failed, and an alert flag is set on the Gemini and link endpoint components, resulting in the entire blade being routed around.

The steps to perform the reroute are the same as in Failure Of A Single High Speed Network Channel on page 310. One difference in the log file is that, in this case, an `ec_l0_voltage` event will appear, signifying that the mezzanine lost power.

Total time to recover from this situation is comparable to Section 13.1.1.1.

13.1.1.4 Power Loss To A Blade

Blade power loss appears very similar to mezzanine power loss, except that in this case, no `ec_l0_voltage` event is received by `xtnlrd`. In addition, in the `alive` stage of the recovery process shows a time-out for the blade that lost power, such as:

```
2010-05-08 15:36:50 castor-smw generic_rsp_timeout: ERROR: Did not receive responses \
from the following L0s: c0-0c1s0
```

As in Section 13.1.1.3, loss of power to a blade results in 32 link endpoints outside of the failed blade having an alert flag set on them, together with both Gemini chips on the failed blade. As a result of this, the system reroutes around the failed blade.

Due to the time-out, which is 30 seconds by default, recovery from a failed blade typically takes around 60 seconds.

13.1.1.5 Power Loss To A Cabinet

Cabinet power loss is the most widespread single High Speed Network event that is handled by `xtnlrd`. This case is, in general, very similar to Section 13.1.1.4, although rather than a single blade, cabinet power loss results in 24 blades, and 48 Gemini chips, losing power.

In a fully-configured and operational Cray XE system, loss of power to a cabinet results in 960 link endpoints being reported to `xtnlrd` as having failed. All of these link endpoints are marked with an alert flag as part of the recovery process, along with the 48 Gemini chips in the cabinet which failed (2 per blade).

During the recovery process, the same set of steps will be taken, but this time, 24 blades will time out and be removed from routing.

Due to the time out, which is 30 seconds by default, recovery from a failed cabinet typically takes around 60 seconds.

13.1.2 Using `xtwarmswap`

The administrative interface to the Gemini resiliency feature is through the `xtwarmswap` command on the SMW, which coordinates with the `xtnlrd` daemon to perform the various steps that are necessary to perform warm swap operations.

13.1.2.1 Reusing One Or More Previously-failed High Speed Network Links

Before previously-failed links can be reintegrated into the High Speed Network configuration, an administrator must clear the alerts, and use a warm swap command to tell the system to reroute using all available links.

The necessary steps are:

1. Use a `xtcli clr_alert` *LCB names* command to clear the alerts
2. Use a `xtwarmswap -s` *partition name* to tell the system to reroute using all available links

The `xtwarmswap` command results in `xtnlrd` performing the same link recovery steps as for a failed link, with two differences: no alert flags are set, and an `init_new_links` step is performed in order to initialize both ends of any links that should be used, and which are not currently up, before new routes are asserted into the Gemini routing tables.

The elapsed time for the warm swap and synchronization operation is typically around 60 seconds.

13.1.2.2 Reusing One Or More Previously-failed Blades, Mezzanines, or Cabinets

A previously-failed blade (or blades) has alert flags set on Geminis and on link endpoints (LCBs); these alert flags must be cleared before the blades, mezzanines, or cabinets can be reused.

Because it may not be obvious which link endpoints are relevant to a particular blade, a script called `xtclear_link_alerts` is provided. The `xtclear_link_alerts` script takes a single comma-separated list of blades and/or cabinets, and clears all alerts on those components, and on all Gemini components on the blade(s), and on all LCBs at both ends of the links to the blade(s).

Once the alert flags have been cleared appropriately, a warm swap and add should be done, to bring the blades back into the High Speed Network configuration. Doing so runs cold start on the blades and re-initializes the links to the blades, as in Section 13.1.2.1.

Specifically, the steps are:

1. Ensure that blades/mezzanines/cabinets have power
2. Ensure that the `xtalive` command to all required blades succeeds
3. Run the `xtclear_link_alerts` *blade,...* command
4. Run the `xtwarmswap --add` *blade,...* command
5. Run the `xtcli boot` *args blade,...* command

Because the `xtwarmswap --add` command cold starts the added blades, the time to bring the blades back into service includes around 10 minutes for cold start, in addition to around 60 seconds for the link recovery handling, as in Section 13.1.2.1.

13.1.2.3 Planned Removal Of A Compute Blade

A compute blade can be removed (for example, for maintenance or replacement) while the system is running. However, applications using the nodes on the blade to be removed must be killed, or allowed to drain, before the removal process can proceed.

On the boot node, as `root`, perform the following steps:

1. Use the `xtprocadmin -s` *slot* `-k s admindown` command to down the compute blade
2. Wait for applications using the nodes on blade to finish or use the `apkill` *apid* command to kill the application

Next, on the SMW, as `crayadm`, perform the following steps:

1. Use the Use the `xtcli halt` *blade* command to halt the blade
2. Use the `xtwarmswap --remove` *blade* command to remove the compute blade from service
3. Physically remove the blade, if desired

The warm swap remove stage of the process uses the Gemini resiliency infrastructure, and takes around 60 seconds to complete.

13.1.2.4 Planned Installation Of A Compute Blade

Once a blade has been repaired or replaced, you can use a warm swap to use the nodes on the blade once more.

The steps are essentially the same as in Section 13.1.2.2:

1. Physically insert the blade into the slot
2. Ensure that the blade has power
3. Ensure that the `xtalive` command to the blade succeeds
4. Run the `xtclear_link_alerts` *blade* command
5. Run the `xtwarmswap --add` *blade* command
6. Run the `xtcli boot CNL0` *args* *blade* `command`

Because the `xtwarmswap --add` command cold starts the added blade, the time it takes to being the blade back into service includes around 10 minutes for cold start, in addition to about 60 seconds for the link recovery handling, as in Section 13.1.2.1.

13.2 Unrouteable Cray XE Configurations

Cray XE systems contain a high-speed network (HSN) connected via a 3D mesh/torus. The algorithm that computes the routing tables for this system at times fails, resulting in an unrouteable configuration. This occurs when the configuration has multiple Gemini router chips disabled. This section describes the conditions that result in an unrouteable configuration and, in some cases, provides suggestions for additional configuration modifications that will result in a routeable configuration.

With a normal Cray XE system configuration, all three dimensions of the HSN are complete tori. There are no holes in the network. The routing table computation is always successful in this situation. During normal operation, however, the need arises to disable different components due to hardware failure and possible subsequent repair action. When this occurs, the routing table computation needs to take these missing components into account to route around these holes in the network. Sometimes, the given holes in the network are such that some routes are no longer possible. Since the network must allow all nodes to talk to all other nodes, this results in an unrouteable configuration. The algorithm used to compute the routing tables detects these situations and issues the error messages to indicate the failure. This section discusses the different scenarios which result in such an unrouteable configuration. In some cases, there are only a few nodes for which routes cannot be computed. In these cases, it may be possible to disable a small number of additional components that will then allow the resulting configuration to again be routeable.

Note: Every time a Gemini router chip is disabled, this results in lost access to two nodes. So the loss of a Gemini router results not only in lower network capacity, but also in lost computational capability. When possible, it is preferable to disable individual links. Doing so results in less impact to the overall system capacity.

13.2.1 The Routing Algorithm

In order to understand why a configuration becomes unrouteable, an understanding of how the routing algorithm works is helpful. The routing algorithm itself is designed to compute routes that contain no dependency cycles. If dependency cycles exist in the routes, the network can deadlock under moderate to heavy loads. This would result in a complete system failure.

There are three types of dependency cycles that can be created in a multidimensional torus network; these are:

- Dimensional turn dependency cycles
- Torus dependency cycles
- Request/response dependency cycles

Dimensional turn dependency cycles are avoided by disallowing certain turns in the routes. This makes such cycles impossible. The algorithm accomplishes this by using direction ordered routing. Specifically, computed routes follow these rules:

1. Route the packet in X+/-, Y+, or Z+, until the X dimension is resolved.
2. Route the packet in Y+/- or Z+, until the Y dimension is resolved.
3. Route the packet in Z+/- until the Z dimension is resolved. At this point, the packet must have arrived at its destination.

These steps avoid turns from Y- into the X dimension, and Z- into the X or Y dimensions. Note that once a packet resolves a given dimension, it is no longer allowed to travel in that dimension.

Both torus and request/response dependency cycles are normally resolved by the use of virtual channels included in the network design. The Gemini router chip, however, only includes two virtual channels in its design. The two virtual channels are used to prevent request/response dependency cycles. Torus dependency cycles, however, cannot be addressed using virtual channels.

Although there are no virtual channels available to prevent torus dependency cycles, there are multiple physical channels between Gemini router chips. So in order to avoid dependency cycles, the physical channels between the Gemini router chips are divided into two groups, and those two groups of physical channels are used in the same fashion as two virtual channels. The first step for using two groups to prevent dependency cycles is to designate a particular location on the torus as a dateline. With that defined, the basic rules for processing packets passing through the dateline are quite simple. If a packet comes into the dateline in group 0 and is continuing in the same direction, it needs to move to group 1. If a packet comes into the dateline on group 1 and wants to continue in the same direction, we have an error condition, and the packet gets dropped. If a packet does get dropped, this indicates either an error in the computed routing tables, or some hardware error.

With an understanding of the dateline mechanism, there is one additional rule to follow when computing routes:

4. A packet cannot cross a dateline unless it is going to reach its final destination in the current dimension with no additional turns.

13.2.2 Physical Components Versus Logical Components

When considering unrouteable configurations, the relationship between different disabled Gemini router chips is what results in a configuration being unrouteable. The relationship between the routers, however, needs to be considered via the logical components. Since Cray supports a number of topologies, the physical-to-logical mapping varies. Here is a quick review of the topology classes:

Table 17. Physical-to-Logical Mappings Summary by Topology Class

Topology Class	Physical Configuration	X Dimension	Y Dimension	Z Dimension
0	1 row of up to 3 cabinets. Can be 1-9 chassis.	Chassis are cabled together in the X dimension torus sized at the number of chassis.	Each chassis is looped back on itself in the Y dimension. This results in a Y dimension of size 2.	Each chassis is looped back on itself to form a torus of size 8.
1	1 row of cabinets.	Cabinets in each row are cabled together such that corresponding Gemini chips connect together to form a torus.	The three chassis in a cabinet are cabled together. The corresponding blades in each chassis are connect together to form a torus of size 6.	
2	2 rows of cabinets.		Chassis are cabled together across rows to form a torus sized at 2 * nbr-rows.	The Z dimension cables a single chassis from each row together to form a torus of size 16.
3 even	Even number of rows.		Chassis are cabled together across rows to form a torus sized at 2 * nbr-rows.	The Z dimension cables the three chassis of a cabinet together to form a

Topology Class	Physical Configuration	X Dimension	Y Dimension	Z Dimension
3 odd	Odd number of rows.		Chassis are cabled together across rows to form a mesh sized at 2 * nbr-rows.	torus of size 24.

The best way to check physical-to-logical coordinate information is to use the `rtr --system-map` command. A sample of the output for this command is:

```
smw:~> rtr --system-map
NID  NIC-Addr Node         Gemini        X  Y  Z
---- -------- ------------ ------------  -- -- --
0    0        c0-0c0s0n0   c0-0c0s0g0    0  0  0
1    1        c0-0c0s0n1   c0-0c0s0g0    0  0  0
2    4        c0-0c0s1n0   c0-0c0s1g0    0  0  1
3    5        c0-0c0s1n1   c0-0c0s1g0    0  0  1
4    8        c0-0c0s2n0   c0-0c0s2g0    0  0  2
5    9        c0-0c0s2n1   c0-0c0s2g0    0  0  2
6    12       c0-0c0s3n0   c0-0c0s3g0    0  0  3
7    13       c0-0c0s3n1   c0-0c0s3g0    0  0  3
8    16       c0-0c0s4n0   c0-0c0s4g0    0  0  4
9    17       c0-0c0s4n1   c0-0c0s4g0    0  0  4
10   20       c0-0c0s5n0   c0-0c0s5g0    0  0  5
11   21       c0-0c0s5n1   c0-0c0s5g0    0  0  5
12   24       c0-0c0s6n0   c0-0c0s6g0    0  0  6
13   25       c0-0c0s6n1   c0-0c0s6g0    0  0  6
14   28       c0-0c0s7n0   c0-0c0s7g0    0  0  7
15   29       c0-0c0s7n1   c0-0c0s7g0    0  0  7
30   32       c0-0c0s0n2   c0-0c0s0g1    0  1  0
31   33       c0-0c0s0n3   c0-0c0s0g1    0  1  0
28   36       c0-0c0s1n2   c0-0c0s1g1    0  1  1
29   37       c0-0c0s1n3   c0-0c0s1g1    0  1  1
26   40       c0-0c0s2n2   c0-0c0s2g1    0  1  2
27   41       c0-0c0s2n3   c0-0c0s2g1    0  1  2
24   44       c0-0c0s3n2   c0-0c0s3g1    0  1  3
25   45       c0-0c0s3n3   c0-0c0s3g1    0  1  3
22   48       c0-0c0s4n2   c0-0c0s4g1    0  1  4
23   49       c0-0c0s4n3   c0-0c0s4g1    0  1  4
20   52       c0-0c0s5n2   c0-0c0s5g1    0  1  5
21   53       c0-0c0s5n3   c0-0c0s5g1    0  1  5
18   56       c0-0c0s6n2   c0-0c0s6g1    0  1  6
19   57       c0-0c0s6n3   c0-0c0s6g1    0  1  6
16   60       c0-0c0s7n2   c0-0c0s7g1    0  1  7
17   61       c0-0c0s7n3   c0-0c0s7g1    0  1  7
smw:~>
```

The last three columns are the logical XYZ coordinates. This is useful for correlating Gemini routers and nodes with logical coordinates. Another useful option is the `rtr --system-summary` option, which shows the size and type (torus or mesh) of each dimension. A sample of the output for this command is:

```
smw:~> rtr --system-summary
Dim Size Type
--- ---- ----
X      1  mesh
Y      2  mesh
Z      8  torus
smw:~>
```

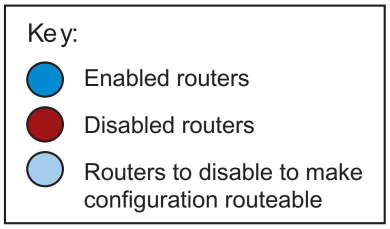
13.2.3 Unrouteable Configurations

The reason why a configuration becomes unrouteable is because gaps in the network cannot be routed around based on the rules used to compute the routes. The simplest such configuration is two nonadjacent routers in a single Z-dimension loop. Additional unrouteable configurations include two nonadjacent routers in a dimension loop with additional dimension blocks, disabled routers not adjacent to a mesh edge, and a disabled nonlinear complete Z-dimension loop.

In the subsequent sections, the various types of unrouteable configurations are discussed. The references to different router chips are made via X,Y,Z coordinates. By using the `rtr` command with the `--system-map` and `--system-summary` options, the logical coordinates can be translated into physical nodes.

This legend applies to the diagrams included in the following subsections:

Figure 11. Diagram Key

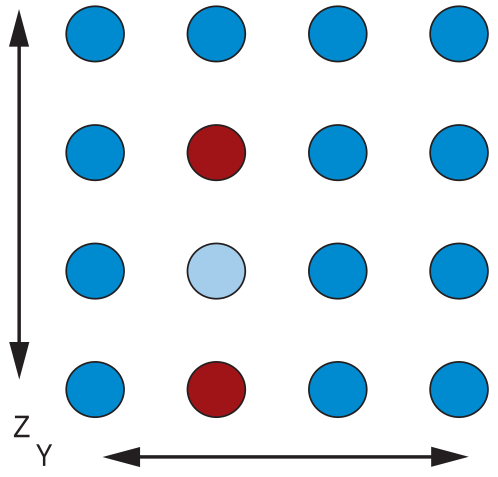


13.2.3.1 Two Nonadjacent Routers in a Single Z-dimension Loop

In the unrouteable configuration shown in Figure 12, there are two routers in a single Z-dimension loop that are disabled. This fails because it breaks the loop into two unconnected sections. Once the X and Y dimensions are resolved, routing is then restricted to a single Z-dimension loop. Routers in one of the sections of the Z-dimension loop cannot reach the other section because it is blocked by the disabled routers in both the Z+ and Z- directions.

When mapping this onto a physical system, suppose 0,0,2 and 0,0,4 are disabled. This will result in an unrouteable configuration. The problem is when a router like 0,0,3 tries to compute routes to 0,0,1. It fails because the X and Y dimensions are already resolved. Because of this, it is only allowed to route in the Z dimension, either Z+ or Z-. Neither of these work, however, because in the Z+ direction, 0,0,4 is disabled, and in the Z- direction 0,0,2 is disabled.

Figure 12. Two Nonadjacent Routers in a Single Z-dimension Loop

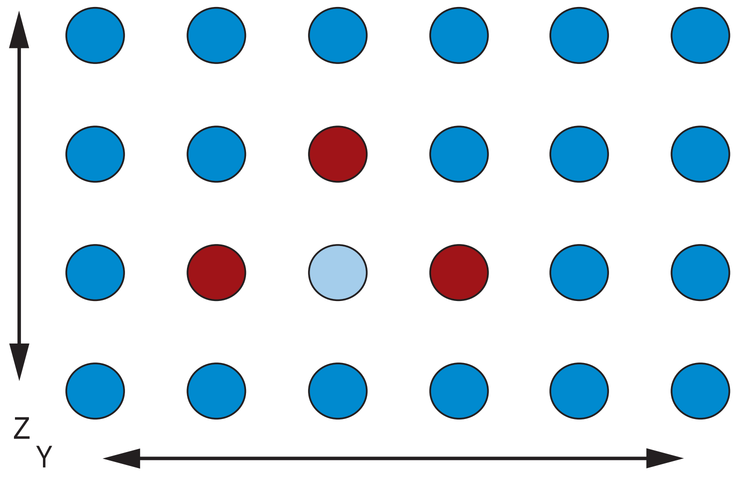


In order to make this configuration routeable again, the additional router in between the two disabled routers needs to be disabled. In the example above, by disabling 0,0,3, the resulting configuration routes properly.

13.2.3.2 Two Nonadjacent Routers in a Single Dimension Loop with Additional Dimension Blocks

This unrouteable configuration, which is shown in Figure 13, is similar to the previous one. The difference is that if you have the same scenario for the X or Y dimension, there are still routing options, unless the additional routing options are blocked. So, for example, the following would result in an unrouteable configuration: 0,1,1 0,3,1 0,2,2. Consider the router 0,2,1. It cannot route in the X dimension because it is already resolved. It cannot route in either direction in the Y dimension because it is blocked by 0,1,1, and 0,3,1. It cannot route in the Z+ direction because of 0,2,2. Finally, it cannot route in the Z- direction because that would violate the routing rules. A similar example with the X dimension could also be formulated. In that case, however, both the Y+ and Z+ directions would have to be blocked.

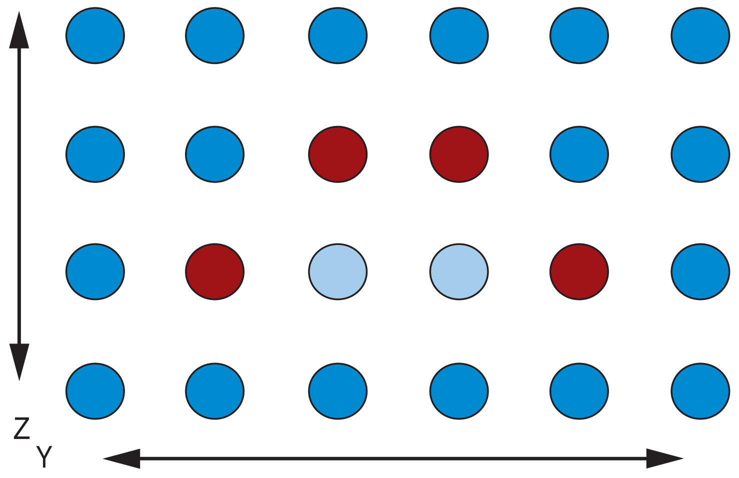
Figure 13. Two Nonadjacent Routers in a Single Dimension Loop with Additional Dimension Blocks



In order to make this configuration routeable again, disable the node in the middle. In the above example, 0,2,1.

This same situation can occur with the two routers separated by a larger amount, for example, 0,1,1 0,4,1, and blocked by the two routers, 0,2,2 and 0,3,2 (see Figure 14). Again, routing is blocked in the same way as the first example. In this case, adding the additional disables of 0,2,1 and 0,3,1 will allow the configuration to then route properly.

Figure 14. Two Nonadjacent Routers Further Separated in a Single Dimension Loop with Additional Dimension Blocks



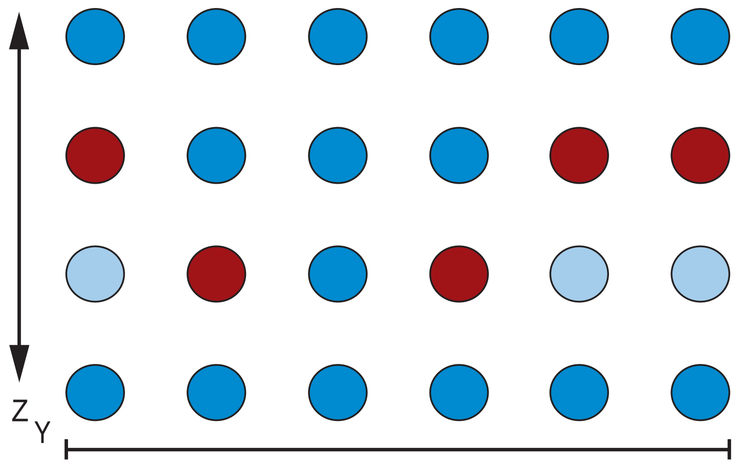
13.2.3.3 Disabled Routers Not Adjacent to a Mesh Edge

This unrouteable configuration, which is shown in Figure 15, occurs when a router is disabled in a mesh dimension that is not adjacent to the edge of the mesh dimension.

While dimensions are normally a torus, a mesh dimension can occur in a number of situations. The most common one is for class 0 topologies. In this case, the Y dimension is of size 2. This gets treated as a mesh because routing in the Y dimension will always be a single hop. So a packet is either in the right place in the Y dimension, or else it takes a single hop in the Y dimension, and then it is in the right place. So whether it is called a mesh or a torus, from a routing perspective it is a mesh. Other situations that could result in a mesh dimension include disabling of larger components or groups of components that result in a complete break in a normal torus dimension. Finally, a class 3 topology with an odd number of rows also results in a mesh in the Y dimension due to cabling restrictions.

For the X and Y dimensions, the subsequent dimensions (Y and Z) will be blocked in the plus directions. This can occur at either mesh edge. Since the Z dimension is typically not a mesh, this is not expected in the Z dimension. The diagram shows two different instances, one on each mesh edge.

Figure 15. Disabled Routers Not Adjacent to a Mesh Edge



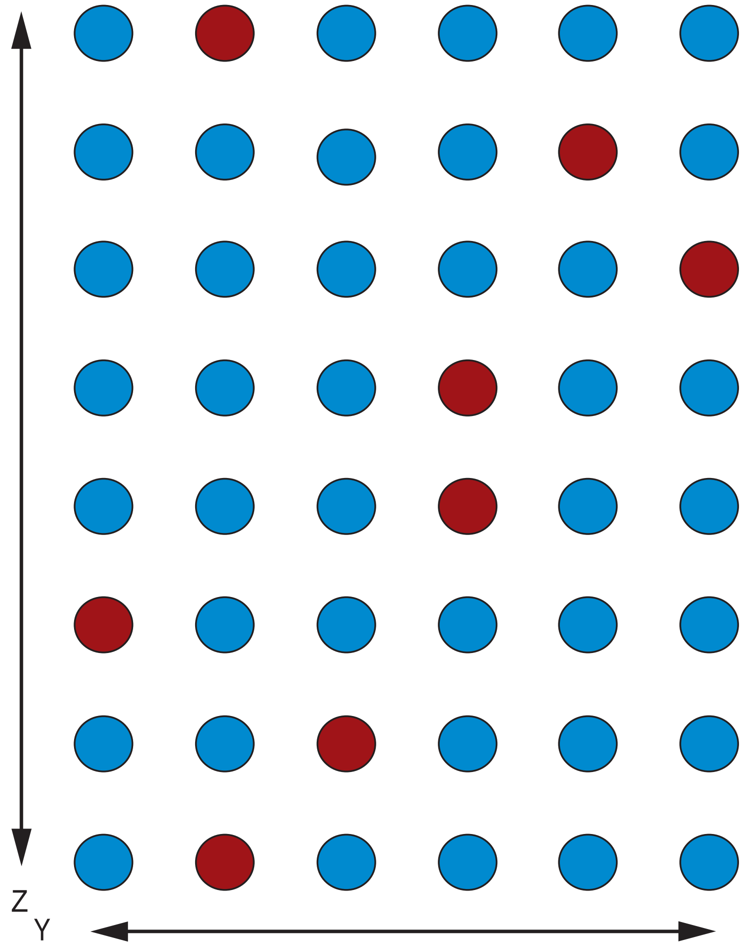
13.2.3.4 Disabled Nonlinear Complete Z-dimension Loop

This particular unrouteable configuration, which is shown in Figure 16, is perhaps the most difficult to understand. There appears to be no set pattern to it. It is also not obvious at first glance why routing fails. There appears to be plenty of room around the disabled routers.

The routing failure occurs at the dateline, when trying to route in the Y dimension. At some point when routing in the Y dimension, a disabled router is encountered. The normal solution is to route in the Z-plus direction. This is disallowed, however, if routing in the Z-plus direction results in the Z-dimension dateline to be crossed. No matter where the dateline is placed, at some point in this configuration, routing around a disabled router runs into this restriction. Hence, routing fails. In this case, the best solution is to fix the hardware.

This failure scenario is unlikely to occur, and as the Z dimension gets larger, it is even less likely to occur.

Figure 16. Disabled Nonlinear Complete Z-dimension Loop



13.2.3.5 Routing Table Limitations

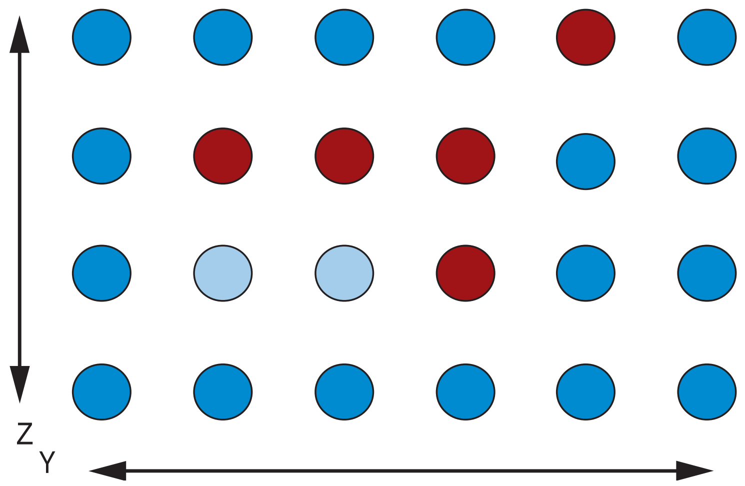
Another possible scenario that results in an unrouteable configuration is when the routing tables themselves cannot be made to fit into the 32 entries available. When computing routes, all the Gemini IDs must be made to fit into a 32-entry table, using the mask and match values to account for every ID used in the entire configuration. Normally, a lot few entries are actually needed. Even large configurations can be made to fit into the 32-entry table limit. Depending on the size of the configuration and the location of disabled Gemini routers, the routing tables can grow to the point where they do not fit into the 32-entry limit. If this happens, it is most likely limited to a particular Gemini router. If this happens, the routing software issues an error indicating which Gemini had the error. In this scenario, the router that had the error can be disabled, and the remainder of the configuration may be routeable. In some situations, multiple Geminis may need to be disabled before the configuration is routeable.

13.2.3.6 Other Unrouteable Scenarios

There are other configurations that cannot be routed. Some of these appear to be routeable, but the routing software still fails. In some cases, this is a limitation of the routing software. The diagram in Figure 17 shows one such scenario.

This particular configuration is unrouteable under the assumption that the Y dimension is of size 6 and is a torus. The thing that appears to be really unusual about this is the additional router required to allow this to route. This configuration fails routing 0,2,1 to 0,3,3 (actually, anything with Y-dimension ordinate of 3). When it attempts to route, it finds Y-plus and Z-plus to be blocked. So it must route to Y-minus. Once it reaches 0,0,1, it could route in Z-plus. However, it computes that from this point, and it can continue in the Y-minus direction. Routing prefers this as it is attempting to resolve the Y dimension. So it wraps around the torus until it reaches 0,4,1. At this point, it finds the it can turn the corner into Z-plus. It then hits a block in Z-plus. This is where it declares the configuration unrouteable. Interestingly, if it routed in Z-plus when it reached 0,0,1, it would have routed successfully. By additionally disabling 0,1,1 and 0,2,1, the routes that failed are no longer an issue.

Figure 17. Additional Unrouteable Configuration Scenario



This example is one situation that fails to route. There may be others that have not been discovered; however, the routing software has been tested and should detect unrouteable situations.

13.2.4 Disabling of Other Components

This section has focused on Gemini router chips that are disabled. It is possible to get similar unrouteable configurations by disabling other components. Namely, the disabling of links and/or blades can also result in unrouteable configurations. The disabling of individual links typically is not a problem. There are enough redundant links to allow for successful routing. If all links between two routers are disabled, this creates a situation very similar to when the connected router is disabled, and thus all the routing failure scenarios could still occur.

For blades, the situation described in Two Nonadjacent Routers in a Single Z-dimension Loop on page 318 could occur for multiple blade swaps. Suppose two nonadjacent blades in a single chassis were to be removed. This would result in an unrouteable configuration. The solution would be to disable the additional blades in between the two suspect blades. Of course, this assumes the blades are not required service blades that cannot be disabled.

13.2.5 Conclusion

A Cray XE system is a flexible system in that it can accommodate many downed components. While most combinations of multiple components being disabled are allowed, there are some combinations that are not allowed. In most cases, this can be worked around by disabling a couple of additional components. While this can usually be done in a rectangular structure, in 3 dimensions, or perhaps in a box structure, quite often it is not necessary to disable the full rectangle or box. The best approach is to use the routing software to determine if a particular configuration is usable.

SMW and CLE System Administration Commands [A]

In addition to the SUSE Linux Enterprise Server (SLES) commands available to you, this appendix lists the Cray developed commands for administering CLE on your Cray system.

The system provides the following types of commands for the system administrator:

- Hardware Supervisory System (HSS) commands invoked from the System Management Workstation (SMW) to control HSS operations; HSS commands are provided with SMW release packages.

  Cray Management Services (CMS) commands invoked from the SMW for CMS administration. CMS commands are provided with SMW release packages. For more information about CMS commands, see *Using Cray Management Services (CMS)* provided with SMW release packages.

- Cray Linux Environment (CLE) commands invoked from a node to control the service and compute partitions; CLE commands are provided with CLE release packages.

A.1 HSS Commands

Table 18 shows the HSS commands and their functions.

Table 18. HSS Commands

Command	Description
`dbMonitor`	Controls the monitor process script that starts during system boot to watch `mysqld` and restart `mysqld` if it should crash
`getSedcLogValues`	Displays specified `sedc_manager` log file records
`rtr`	Routes the Cray network
`sedc_manager`	Invokes the System Environment Data Collections (SEDC) SMW manager
`SMWconfig`	Automatically configures software on SMW
`SMWinstall`	Automatically installs and configures software on SMW

Command	Description
`SMWinstallCLE`	Updates the CMS software on `bootroot` and `sharedroot` for system sets with CLE software installed
`xtalive`	Gets a response from an HSS daemon
`xtbootdump`	Parses a *bootinfo-file* to determine if `xtdumpsys` needs to be invoked
`xtbootimg`	Creates, extracts, or updates a Cray bootable image file
`xtbootsys`	Boots specified components in a Cray system
`xtbounce`	Powers components of the Cray system down then up
`xtcheckmac`	Checks for duplicate MAC addresses among L1 and L0 controllers
`xtclass`	Displays the network topology class for this system
`xtclean_logs`	Removes HSS log files based on age
`xtclear`	Clears component flags in the state manager
`xtcli`	Runs the HSS command line
`xtcli boot`	Specifies the types of components to boot
`xtcli clear`	Clears flag status in component state
`xtcli part`	Updates partition configurations
`xtcli power`	Powers a component up or down
`xtcon`	Provides a two-way connection to the console of any running service node
`xtconsole`	Displays console text from a node
`xtconsumer`	Displays HSS events
`xtdaemonconfig`	Configures HSS daemons dynamically
`xtdimminfo`	Collects and displays summaries from hardware errors reported in the console file
`xtdiscover`	Discovers and configures the Cray system hardware
`xtdumpsys`	Gathers information when a system stops responding or fails
`xterrorcode`	Displays event error codes
`xtfileio`	Reads or writes a file on an L1 or L0 controller
`xtflash`	Performs automated reflashing and rebooting of L1s and L0s on a Cray system
`xtfwlog`	For Cray XT systems: Prints out Cray SeaStar chip firmware log
`xtfwstat`	For Cray XT systems: Prints generally useful information from a Cray SeaStar chip
`xtgenid`	Generates HSS physical IDs
`xtgetsyslog`	Retrieves the `/var/log/messages` file from L1 or L0 controllers

Command	Description
`xthb`	Reports on-chip heartbeats
`xthwinv`	Retrieves hardware component information for selected modules
`xtlogfilter`	Filters information from event router log files
`xtlogin`	Logs on to cabinet and blade control processors
`xtmcinfo`	Gets microcontroller information from cabinet and blade control processors
`xtmem2file`	Reads CPU or Cray SeaStar chip memory and saves it in a file
`xtmemio`	Reads or writes 32-bit or 64-bit words from CPU or Cray SeaStar chip memory
`xtmemwatch`	Watches a memory location change
`xtnetwatch`	Watches the Cray system interconnection network for link control block (LCB) and router errors
`xtnid2str`	Converts node identification numbers to physical names
`xtnlrd`	For Cray XE systems: Responds to fatal link errors by rerouting the system
`xtnmi`	Collects debug information from unresponsive nodes
`xtptltrace`	For Cray XT systems: Dumps the Portals message trace buffer
`xtrsh`	Invokes a diagnostic utility that concurrently executes programs on batches of cabinet control processors (L1) and/or blade control processors (L0)
`xtsedcviewer`	Command-line interface for SEDC
`xtshow`	Shows components with selected characteristics
`xtwarmswap`	For Cray XE systems: Allows Cray XE modules to be warm swapped
`xtwatchsyslog`	Shows all log messages for cabinet control processors (L1 controllers) and blade control processors (L0 controllers)

A.2 CLE System Administration Commands

Table 19 shows CLE commands and their functions.

Table 19. CLE Commands

Command	Description
`apmgr`	Provides interface for ALPS to cancel pending reservations.
`csacon`	Condenses records from the sorted `pacct` file.
`csanodeacct`	Initiates the end of application accounting on a node.
`csanodemerg`	Initiates collection of individual compute node accounting files.
`csanodesum`	Reads and consolidates application node accounting records.
`generate_config.sh`	Generates the Lustre file system configuration file.
`lastlogin`	Records last date on which each user logged in
`lbcd`	Invokes the load balancer client daemon.
`lcrash`	Used to analyze a dump file generated by the `ldump` command.
`lbnamed`	Invokes the load balancer service daemon.
`ldump`	Dumps node memory to a file. This is later analyzed with the `lcrash` command. ldump may be used to dump service nodes and compute nodes running CNL. The `ldump` command is run on the SMW.
`lustre_control.sh`	Manages Lustre file systems using standard Lustre commands and a site specific Lustre file system definition file.
`nhc_recovery`	Releases compute nodes on a crashed login node that will not be rebooted.
`projdb`	Creates and updates system project database for CSA.
`rca-helper`	Used in various administrative scripts to retrieve information from the Resiliency Communication Agent (RCA).
`rsipd`	Invokes the Realm-Specific IP Gateway Server.
`xt-lustre-proxy`	Invokes the Lustre startup/shutdown, health monitor, and automatic failover utility.
`xtalloc2db`	Converts a text file to the `alloc_mode` table in the Service Database (SDB).
`xtattr2db`	Converts a text file to the `attributes` table in the Service Database (SDB).
`xtauditctl`	Distributes `auditctl` requests to nodes on a Cray system.
`xtaumerge`	Merges audit logs from multiple nodes into a single audit log file.
`xtcdr2proc`	Gets information from the RCA.

Command	Description
`xtcheckhealth`	Executes the Node Health Checker.
`xtcleanup_after`	Called by ALPS to check node health.
`xtclone`	Clones the master image directory and overlays a site-specific template.
`xtcloneshared`	Clones node or class directory in shared root hierarchy.
`xtdb2alloc`	Converts the `alloc_mode` table in the Service Database (SDB) to a text file.
`xtdb2attr`	Converts the `attributes` table in the Service Database (SDB) to a text file.
`xtdb2etchosts`	Converts service information in the SDB to a text file.
`xtdb2filesys`	Converts the `filesystem` table of the SDB to a text file.
`xtdb2lustrefailover`	Converts the `lustre_failover` table in the SDB to a text file.
`xtdb2lustreserv`	Converts the `lustre_serv` table of the SDB to a text file.
`xtdb2nodeclasses`	Converts the `service_processor` table of the SDB to a text file.
`xtdb2proc`	Converts the `processor` table of the SDB to a text file.
`xtdb2segment`	Converts `segment` table in the Service Database (SDB) to a text file.
`xtdb2servcmd`	Converts the `service_cmd` table of the SDB to a text file.
`xtdb2servconfig`	Converts the `service_config` table of the SDB to a text file.
`xtdbsyncd`	Invokes the HSS/SDB synchronization daemon.
`xtfilesys2db`	Converts a text file to the SDB `filesystem` table.
`xtgetconfig`	Gets configuration information from `/etc/sysconfig/xt` file.
`xthotbackup`	Creates a backup copy of a system set on the boot RAID.
`xthowspec`	Displays file specialization in the shared root directory.
`xtlusfoevntsndr`	Sends failover events to clients for Lustre imperative recovery.
`xtlusfoadmin`	Displays Lustre automatic failover database tables and enables/disables Lustre server failover.
`xtlustrefailover2db`	Converts a text file to the SDB `lustre_failover` table.
`xtlustreserv2db`	Converts a text file to the SDB `lustre_service` table.
`xtnce`	Displays or changes the class of a node.
`xtnodeclasses2db`	Converts a text file to the `service_processor` table in the SDB.
`xtnodestat`	Provides current job and node status summary information on a CNL compute node.
`xtoparchive`	Performs archive operations on shared root files from a given specification list.

Command	Description
`xtopco`	Checks out RCS versioned shared root specialized files.
`xtopcommit`	Commits changes made inside an `xtopview` session.
`xtoprdump`	Lists shared root file specification and version information.
`xtoprlog`	Provides RCS log information about shared root specialized files.
`xtopview`	Views file system as it would appear on any node, class of nodes, or all service nodes.
`xtpackage`	Facilitates creation of boot images.
`xtpkgvar`	Creates a skeleton structure of `/var`.
`xtproc2db`	Converts a text file to the `processor` table of the SDB.
`xtprocadmin`	Gets/sets the processor flag in the SDB.
`xtrelswitch`	Performs release switching by manipulating symbolic links in the file system and by setting the default version of module files that are loaded at login.
`xtrsipcfg`	Generates and optionally installs the necessary RSIP client and server configuration files.
`xtsegment2db`	Converts a text file to `segment` table in the Service Database (SDB).
`xtservcmd2db`	Converts a text file to the `service_cmd` table of the SDB.
`xtservconfig`	Adds, removes, or modifies the `service_config` table of the SDB.
`xtservconfig2db`	Converts a text file to the `service_config` table of the SDB.
`xtshutdown`	Shuts down the Cray XT series service nodes in an orderly fashion.
`xtspec`	Specializes files for nodes or classes.
`xtunspec`	Unspecializes files for nodes or classes.
`xtverifyconfig`	Verifies the coherency of `/etc/init.d` files across all shared root views.
`xtverifyshroot`	Checks the configuration of the shared-root file system.

System States [B]

Table 20 defines state definitions for system components. States are designated by uppercase letters. Table 21 shows states that are common to all components.

> **Note:** The state of `off` means that a component is present on the system. If the component is an L0, node, or ASIC, then this will also mean that the component is powered off. If you disable a component, the state shown becomes `disabled`. When you use the `xtcli enable` command to enable that component for use once again, its state switches from `disabled` to `off`. In the same manner, enabling an empty component means that its state switches from `empty` to `off`.

Table 20. State Definitions

State	L1	L0	Cray ASIC	CPU	Link
OFF	Powered off	Powered off	Powered off	Powered off	Link is down
ON	Powered up and booted	Powered up and booted	Powered up	Powered up	Link is up
HALT	–	–	–	OS halted	–
STANDBY	–	–	–	Booted; for systems with SeaStar ASICs, Portals is quiesced	–
READY	Operational; running without problems and sending heartbeats	Operational; running without problems and sending heartbeats	Routing table is loaded	Booted; for systems with SeaStar ASICs, Portals is not quiesced	–

Table 21. Additional State Definitions

State	Description
DISABLED	Operator disabled this component.
EMPTY	Component does not exist.
N/A	Component cannot be accessed by the system.
RESVD	Reserved; new jobs are not allocated to this component.

There are two error flags. These can occur with any state.

- WARNING

  A condition was detected that is outside the normal operating range but is not yet dangerous.

- ALERT

  A dangerous condition was detected, and the unit that it affected has shut itself down.

Table 22 shows the states by component for which the `xtcli` commands run.

Table 22. `xtcli` Commands and Allowed States

`xtcli` **Command**	**Subcommand**	**L1 Controller**	**L0 Controller**	**Cray ASIC**	**Node**	**Link**
`power`	`up`	ON	OFF	OFF	OFF	N/A
	`down`	READY	ON	ON, READY, DIAG	ON, HALT, DIAG	N/A
	`up_slot`	–	OFF	OFF	OFF	N/A
	`down_slot`	–	**ON**	any	any	N/A
	`force_down`	any	any	any	any	N/A
`halt`		N/A	N/A	N/A	STANDBY, READY	N/A
`boot`		N/A	N/A	N/A	ON	OFF

Error Codes [C]

Table 23 shows the Cray system error codes. When a Cray system error occurs, the related message is displayed on the SMW.

You can also use the `xterrorcode` command on the SMW to display a single error code or the entire list of error codes. A system error code entered in a log file is a bit mask; invoking the `xterrorcode` *bitmask_code_number* command on the SMW displays the associated error code noted in the following table for example:

```
smw:~> xterrorcode 131279
Maximum error code (RS_NUM_ERR_CODE) is 297
code = 207, string = 'node voltage fault'
```

Table 23. System Error Codes

Code	Meaning
0	Success
1	L1 event aborted
2	Cabinet Power Up Fault
3	Cabinet Power Down Fault
4	Cabinet Emergency Power Off Fault
5	Cabinet Systems Daemon Aborted
6	Cabinet MicroController Communications Fault
7	Cabinet Uplink Fault
8	L1 to Event Router Communications Fault
9	Cabinet Cage Communications Fault
10	Cabinet Fan VFD Communications Fault
11	Cabinet Exhaust Pod Communications Fault
12	Cabinet Fan Pod Communications Fault
13	Cabinet Valere Communications Fault
14	Cabinet Received Invalid L0 ID
15	Cabinet Received Unexpected Event
16	Cabinet Blocked Inlet Fault
17	Cabinet Fan Overload Fault

Code	Meaning
18	Cabinet L1 Micro Initial Test Fault
19	Cabinet Set Thermal Mode Fault
20	Cabinet Calibration Valve Fault
21	Cabinet Fan RPM Fault
22	Cabinet (L1) Controller Core Temp Fault
23	Cabinet Exhaust Air Over Temp Fault
24	Cabinet Inlet Air Over Temp Fault
25	Fan Pod Temperature Fault
26	Cabinet 5V Fault
27	Cabinet 3.3V Fault
28	Cabinet 2.5V Fault
29	Cabinet Sensor Check Fault
30	Cabinet Low Air Pressure Fault
31	L0 Heartbeat Fault
32	Cabinet Received Unexpected L0 Heartbeat
33	Cabinet Slot Up Fault
34	Cabinet Slot Down Fault
35	Invalid Fan Pod ID
36	Cabinet Power Up Warning
37	Cabinet Power Down Warning
38	Cabinet Slot Up Warning
39	Cabinet Slot Down Warning
40	Cabinet Power Transition Time-out
41	Cabinet Power Down Time-out
42	Cabinet Slot Up Time-out
43	Cabinet Slot Down Time-out
44	Cabinet Fan Speed Warning
45	Cabinet Controller Temp Warning
46	Cabinet Exhaust Temp Warning
47	Cabinet Inlet Temp Warning
48	Fan Pod Temperature Warning
49	Cabinet 5V Warning
50	Cabinet 3.3V Warning

Code	Meaning
51	Cabinet 2.5V Warning
52	Cabinet Sensor Check Warning
53	Cabinet Calibration Valve Warning
54	Cabinet Low Air Pressure Warning
55	L0 Not Responding Warning
56	L1 Received Invalid State Response
57	Too Many Faults to Route
58	`l0rtrd`: Out of Memory
59	`l0rtrd`: Software Error
60	`l0rtrd`: SSI Access Failed
61	Routing Configuration Error
62	LCB PLL Lock Timeout
63	LCB Write Failed
64	LCB Initialization Failed
65	LCB/routing Phase 1 Timeout
66	LCB/routing Phase 2 Timeout
67	LCB/routing Phase 3 Timeout
68	Router Initialization Timeout
69	LCB link inactive
70	LCB Read Failed
71	L1 Heartbeat Failed
72	Request format error, or invalid flash partition
73	System call on target L0 or L1 failed
74	Image file was inaccessible or bad checksum
75	An operation has timed out
76	No space on L0/L1 ramdisk for images
77	Burn-to-flash I/OCtl failed; corrupt flash chip
78	Internal inconsistency
79	`ev_len` is not big enough
80	There are no svc ids
81	There are duplicate svc ids
82	Only L0 svc ids are allowed
83	Only one bulk transfer context is allowed

Code	Meaning
84	Badly formed bulk transfer context
85	No filename in the bulk transfer context
86	No valid databuf pointer in the bulk transfer context
87	Datalen is zero in the bulk transfer context
88	`BULK_FLAG_WRITE` must be set in the bulk transfer context
89	`bulk_data_compute_bytes_needed()` failed
90	For L0 svc id, file transfers only
91	For node svc id, memory transfers only
92	Invalid characters found in filename
93	Unable to setup L0 <-> RCA config area
94	Unable to un-setup L0 <-> RCA config area
95	SSI write failed
96	SSI read failed
97	SSI HT map failed
98	SSI HT unmap failed
99	`ioctl()` to `/dev/l0sys` failed
100	Unable to load program into processor memory
101	Unable to load dram config info
102	Heartbeat check failed
103	Coldstart failed to complete
104	Shell parsing routine failed
105	Unable to create file
106	Unable to open file
107	Unable to write file
108	Unable to read file
109	`fstat()` failed
110	Unable to spawn process
111	`i2c` write failed
112	`i2c` read failed
113	Invalid L0 board type
114	Unable to reset jtag
115	Unable to initialize SeaStar
116	`vsel init` failed

Code	**Meaning**
117	RCA channel not open
118	Write to RCA channel failed
119	Event is too big to go across RCA channel
120	Bulk transfer request is too big
121	Unsupported ui event
122	Internal power manager failure
123	Power sequence is already in progress
124	Power sequence aborted
125	Power sequence timeout
126	Bulk transfer address must be aligned on a 32-bit boundary
127	bulk transfer datalen must be a multiple of 4
128	Unable to start the SIC processor
129	Unable to halt the SIC processor
130	Diag generic error
131	Software error
132	Diag hw error
133	Diag init error
134	Diag system call failure
135	Failed to allocate memory
136	Invalid diag option or argument
137	Invalid NULL pointer
138	Diag linked function error
139	Unable to remove file
140	Unable to close file
141	`seacheck` generic error
142	`seacheck` init error
143	`seacheck` sw error
144	`seacheck` hw error
145	`memtest` init error
146	`memtest` sw error
147	`memtest` hw error
148	`cpuburn` init error
149	`cpuburn` sw error

Code	Meaning
150	`cpuburn` hw error
151	Invalid state for requested power command
152	Item removed from power sequence due to upstream fault or state
153	SM failed clear flag request by UI
154	SM failed set flag request by UI
155	SM failed set enable state request by UI
156	SM failed set empty state request by UI
157	SM failed set disable state request by UI
158	Cray SeaStar invalid state for routing
159	System interconnection network link invalid state for routing
160	No matching ID found in State or Trans request
161	CDR Tree Node contained null id
162	Portals code not found
163	Portals code failed to run
164	Request list id has invalid type
165	Power sequence does not apply to this item
166	System interconnection network boot failed
167	Boot manager timeout
168	Node is not in bootable state
169	Node is not in haltable state
170	Boot manager internal error
171	Unable to seek to specified file position
172	Boot manager memory error
173	Boot manager CPI/O package error
174	Boot node daemon initialization error
175	Boot node daemon unknown error
176	Item state 'error' is invalid for requested command
177	Item state 'off' is invalid for requested command
178	Item state 'on' is invalid for requested command
179	Item state 'standby' is invalid for requested command
180	Item state 'disable' is invalid for requested command
181	Item state 'ready' is invalid for requested command

Code	Meaning
182	Item state 'diag' is invalid for requested command
183	Item state 'halt' is invalid for requested command
184	Item state 'NA' is invalid for requested command
185	Item state 'empty' is invalid for requested command
186	Item state 'unknown' is invalid for requested command
187	Alert flag set for one or more Cray SeaStar chips, cannot route
188	Invalid request
189	Alert flag is set
190	Cabinet Inlet Air Under Temp Fault
191	The Event has too many ids
192	Unable to scrub SeaStar memory
193	Diagmanager is running another diagnostic session
194	Diagmanager did not start this diagnostic
195	No diag scheduled
196	Diagnostic was running when session terminated
197	Diagmanager timeout triggered before diag exited
198	Diagnostic exited with warning
199	Diagnostic exited with fail
200	Diagnostic exited without sending termination event
201	Diagmanager could not parse ui request event
202	Diagmanager failed to get the lock for the components requested for this session
203	Memory comparison failed
204	Node heartbeat fault
205	Cray SeaStar chip heartbeat fault
206	SM was not the target of the event
207	Node voltage fault
208	Node temperature fault
209	Node health check fault
210	Cray SeaStar chip voltage fault
211	Cray SeaStar chip temperature fault
212	Cray SeaStar chip health check fault
213	Previous diagnostic failed on this or parent component

Code	Meaning
214	Excessive SeaStar memory SBE count
215	SeaStar Memory MBE fault
216	VERTY health check fault
217	Invalid partition id in id list
218	Invalid state for this operation
219	Id lookup failed
220	Invalid parameter or id found
221	Generating SM data failed
222	Id is not in the partition
223	SM partition config update failed
224	Unable to obtain state report from this target
225	Received state report from a previously failed target
226	Mismatch in the target state report and our state information
227	Generating partition data failed
228	Locking components failed
229	Failed to process received event
230	SS Powered OFF while CPU still running
231	Alert set on component from UI
232	Alert on component as SS is in alert
233	Alert received from Valere module
234	Cabinet door security breach
235	Cabinet doors secure
236	Item state 'enable' is invalid for requested command
237	Power manager failed to get the lock for the components requested for this session
238	Session aborted by user request
239	Opteron Built-In Self Test failed
240	Boot/SDB node lookup failed
241	Boot/SDB node has invalid state
242	Boot/SDB node is not a member of this partition
243	One of the partition member id is already in other partition
244	Invalid partition state
245	Partition is not configured

Code	Meaning
246	Invalid id found in Boot/SDB list
247	Partition member lookup failed
248	Invalid partition member state found
249	Invalid id found in partition request id list
250	Invalid partition state: partition is not active
251	Requested ids spanning multiple partitions
252	L1 cage VRM fault
253	PIC Flash operation already in progress
254	PIC Flash attempted with write protect enabled
255	L0 hotswap lever activated
256	Loadable library not found
257	Symbol not found
258	Requested diagnostic is incompatible with this hardware
259	Invalid command in attribute event
260	Invalid module type
261	Failed to set an attribute
262	`i2c` open failed
263	Sending `ec_ssdc_req` to L0 failed
264	Parsing ssdc config file failed
265	Parsing `ec_ui_ssdc_req` failed
266	Invalid ssdc config in L0 request
267	No register config found in SSDC conf
268	Sending `ec_sedc_req` to L0 failed
269	Parsing SEDC config file failed
270	Parsing `ec_ui_sedc_req` failed
271	Invalid SEDC config in L0/L1 request
272	No register config found in SEDC conf
273	Generating SEDC data event failed
274	SEDC UI registration failed
275	Error in `pthread_create()`
276	Error in `pthread_join()`
277	Error in component name
278	`hss_sysd` executed not on the controller

Code	**Meaning**
279	Error in allocation of memory
280	Boot pthread canceled due to timeout
281	Cabinet power up pthread canceled due to timeout
282	Cabinet power down pthread canceled due to timeout
283	Slot power up pthread canceled due to timeout
284	Slot power down pthread canceled due to timeout
285	Module power up pthread canceled due to timeout
286	Module power down pthread canceled due to timeout
287	Module power up failed on blades
288	Module power down failed on blades
289	`hwinit` pthread canceled due to timeout (`bbinit` on `ct_sgBlade`)
290	`hwinit` pthread canceled due to timeout (`hwinit` on `ct_bwBlade`)
291	`bbinit` failed on `ct_sgBlade`
292	`hwinit` failed on `ct_bwBlade`
293	MMR/MEMORY transfer failure in `do_hss_rw_work()`
294	MMR/MEMORY transfer failed due to invalid command in the event
295	`ec_route_phase3` failed
296	Invalid configuration specification
297	JTAG write failed
298	JTAG read failed
299	JTAG lock failed
300	JTAG failed
301	LCB Link active, is this a live system?
302	Portals firmware did not respond to a mailbox command
303	Portals firmware ignored a mailbox command
304	Portals firmware responded unexpectedly to a mailbox command
305	Invalid subcommand
306	Lock operation failed
307	Operation not permitted, lock in effect
308	PCIX voltage fault

Code	Meaning
309	PCIX health check fault
310	L1 micro flash read failed
311	L1 micro flash write failed
312	L1 micro flash erase failed
313	L1 micro flash verification failed
314	L1 micro in a bad state for flash operation
315	L1 micro in unknown state
316	L1 micro cannot be flashed, no bootloader present
317	Cabinet fan VFD failure
318	Cabinet fan underload
319	Cabinet over-current condition
320	Cabinet under-voltage condition
321	Node does not accept shutdown events
322	L0 quiesce is already active
323	L0 quiesce is not active
324	Node does not accept quiesce events
325	Node not running for quiesce/unquiesce
326	Node timed out waiting for quiesce
327	Node timed out waiting for unquiesce
328	Cabinet power controller communication fault
329	Gemini BIST failure
330	Gemini CCLK/LCLK PLL lock timeout
331	Gemini SerDes PLL lock timeout
332	Gemini SMS timeout
333	Gemini SMS failure
334	CPU Model Mismatch
335	CPU Speed Mismatch
336	Memory Speed Mismatch
337	Memory Configuration Mismatch
338	Mezzanine Configuration Mismatch
339	Role not changed: node on service blade (HW)
340	Role not changed: invalid node state
341	Role not changed: DB node not updated

Code	Meaning
342	Database update failed
343	Database open failed
344	Memory G34 DIMM Mismatch
345	Memory G34 DIMM SPD Data Mismatch
346	SM failed set enable. Parent(s) not enabled.
347	Warning: SM state change successful, but forced (`-f`).
348	Component state not disabled
349	Component state not enabled
350	Component state not empty
351	Gemini: state not enabled
352	SeaStar: state not enabled

Remote Access to the SMW [D]

Virtual Network Computing (VNC) software enables you to view and interact with the SMW from another computer. The Cray system provides a VNC server, `Xvnc`; you must download a VNC client to connect to it. See RealVNC (http://www.realvnc.com/) or TightVNC (http://www.tightvnc.com/) for more information.

> **Note:** The VNC software requires a TCP/IP connection between the server and the viewer. Some firewalls and site security do not allow this connection.

Cray supplies a VNC account `cray-vnc`.

Procedure 84. Starting the VNC server

1. Log on to the SMW as root user.

2. Use the `chkconfig` command to check the current status of the server:

   ```
   smw:~ # chkconfig vnc
   vnc  off
   ```

3. Disable `xinetd` startup of `Xvnc`.

   If the `chkconfig` command you executed in step 2 reports that `Xvnc` was started by INET services (`xinetd`):

   ```
   smw:~ # chkconfig vnc
   vnc xinetd
   ```

   execute the following commands to disable `xinetd` startup of `Xvnc` (`xinetd` startup of `Xvnc` is the SLES 11 default, but it usually is disabled by `chkconfig`):

   ```
   smw:~ # chkconfig vnc off
   smw:~ # /etc/init.d/xinetd reload
   Reload INET services (xinetd).                    done
   ```

   If no other `xinetd` services have been enabled, the `reload` command will return `failed` instead of `done`. If the `reload` command returns `failed`, this is normal and you can ignore the `failed` notification.

4. Use the `chkconfig` command to start `Xvnc` at boot time:

   ```
   smw:~ # chkconfig vnc on
   ```

5. Start the `Xvnc` server immediately:

   ```
   smw:~ # /etc/init.d/vnc start
   ```

If the password for `cray-vnc` has not already been established, the system prompts you for one. You must enter a password to access the server.

```
Password: ********
Verify:
Would you like to enter a view-only password (y/n)? n
xauth:  creating new authority file /home/cray-vnc/.Xauthority

New 'X' desktop is smw-xt:1

Creating default startup script /home/cray-vnc/.vnc/xstartup
Starting applications specified in /home/cray-vnc/.vnc/xstartup
Log file is /home/cray-vnc/.vnc/smw-xt:1.log

smw:~ # ps -eda | grep vnc
1839 pts/0    00:00:00 Xvnc
```

Note: The startup script starts the `Xvnc` server for display `:1`.

To access the `Xvnc` server, use a VNC client, such as `vncviewer`, `tight_VNC`, `vnc4`, or a web browser. Direct it to the SMW that is running `Xvnc`. Many clients allow you to specify whether you want to connect in view-only or in an active mode. If you choose active participation, every mouse movement and keystroke made in your client is sent to the server. If more than one client is active at the same time, your typing and mouse movements are intermixed.

Note: Commands entered through the VNC client affect the system as if they were entered from the SMW. However, the main SMW window and the VNC clients cannot detect each other. It is a good idea for the administrator who is sitting at the SMW to access the system through a VNC client.

Procedure 85. For workstation or laptop running Linux or Mac OS: Connecting to the VNC server via ssh tunnel

- If you are connecting from a workstation or laptop running Linux or Mac OS, enter the `vncviewer` command shown below.

  The first password you enter is for `crayadm` on the SMW. The second password you enter is for the VNC server on the SMW chosen when `/etc/init.d/vnc` is run for the first time on the SMW.

  ```
  /home/mary> vncviewer -via crayadm@smw localhost:1
  Password: ********
  VNC server supports protocol version 3.130 (viewer 3.3)
  Password: ********
  VNC authentication succeeded
  Desktop name "cray-vnc's X desktop (smw:1)"
  Connected to VNC server, using protocol version 3.3
  ```

Procedure 86. For workstation or laptop running Windows: Connecting to the VNC server via ssh tunnel

- If you are connecting from a computer running Windows, then both a VNC client program such as TightVNC and an SSH program, such as PuTTY, SecureCRT, or OpenSSH are recommended.

  Although TightVNC encrypts VNC passwords sent over the network, the rest of the traffic is sent unencrypted. To avoid a security risk, install and configure an SSH program that creates an SSH tunnel between TightVNC on the local computer and the remote VNC server.

  After installing TightVNC, double-click on the TightVNC icon, enter the hostname and VNC screen number, `smw:1`, and then click on the **Connect** button.

Updating the Time Zone [E]

When you install the Cray Linux Environment (CLE) operating system, the Cray system time is set at US/Central Standard Time (CST), which is six hours behind Greenwich Mean Time (GMT). You can change this time.

> **Note:** When a Cray system is initially installed, the time zone set on the SMW is copied to the boot root, shared root and CNL boot images.

To change the time zone on the SMW, L0 controller, L1 controller, boot root, shared root or for a CNL image, follow the appropriate procedure below.

Procedure 87. Changing the time zone for the SMW and the L1 and L0 controllers

> **Warning:** Perform this procedure while the Cray system is shut down; do not flash L0 and L1 controllers while the Cray system is booted.

You must be logged on as `root`. In this example, the time zone is changed from `"America/Chicago"` to `"America/New_York"`.

1. Ensure the L0 and L1 controllers are responding.

   ```
   smw:~ # xtalive -a l0sysd s0
   ```

2. Check the current time zone setting for the SMW and controllers.

   ```
   smw:~ # date
   Wed May 26 21:30:06 CDT 2010

   smw:~ # xtrsh -l root -s /bin/date s0
   c0-0c0s2 : Wed May 26 21:30:51 CDT 2010
   c0-0c0s5 : Wed May 26 21:30:51 CDT 2010
   c0-0c0s7 : Wed May 26 21:30:51 CDT 2010
   c0-0c1s1 : Wed May 26 21:30:51 CDT 2010
   .
   .
   .
   c0-0 : Wed May 26 21:30:52 CDT 2010
   ```

3. Verify that the `zone.tab` file in the `/usr/share/zoneinfo` directory contains the time zone you want to set.

   ```
   smw:~ # grep America/New_York /usr/share/zoneinfo/zone.tab
   US      +404251-0740023 America/New_York      Eastern Time
   ```

4. Create the time conversion information files.

```
smw:~ # date
Wed May 26 21:32:52 CDT 2010
smw:~ # /usr/sbin/zic -l America/New_York
smw:~ # date
Wed May 26 22:33:05 EDT 2010
```

5. Modify the `clock` file in the `/etc/sysconfig` directory to set the `DEFAULT_TIMEZONE` and the `TIMEZONE` variables to the new time zone.

```
smw:/etc/sysconfig # grep TIMEZONE /etc/sysconfig/clock
TIMEZONE="America/Chicago"
DEFAULT_TIMEZONE="US/Eastern"
smw:~ # vi /etc/sysconfig/clock
make changes
smw:~ # grep TIMEZONE /etc/sysconfig/clock
TIMEZONE="America/New_York"
DEFAULT_TIMEZONE="US/Eastern"
```

6. Copy the `/etc/localtime` directory to `/opt/tfptboot` and restart `rsms`.

```
smw:~ # cp /etc/localtime /opt/tftpboot
smw:~ # /etc/init.d/rsms restart
```

7. Exit from the `root` login.

```
smw:~ # exit
```

8. Erase the flash memory of the L1s and flash the updated time zone.

```
crayadm@smw:~> fm -w -t l1
crayadm@smw:~> xtflash -t l1
```

9. Erase the flash memory of the L0s and flash the updated time zone.

```
crayadm@smw:~> fm -w -t l0
crayadm@smw:~> xtflash -t l0
```

10. Check the current time zone setting for the SMW and controllers.

```
crayadm@smw:~> date
Wed May 26 23:07:07 EDT 2010
crayadm@smw:~> xtrsh -l root -s /bin/date s0
c0-0c1s1 : Wed May 26 23:07:16 EDT 2010
c0-0c0s7 : Wed May 26 23:07:16 EDT 2010
c0-0c1s3 : Wed May 26 23:07:16 EDT 2010
.
.
.
c0-0 : Wed May 26 23:07:15 EDT 2010
```

11. Bounce the system.

```
crayadm@smw:~> xtbounce s0
```

Procedure 88. Changing the time zone on the boot root and shared root

Perform the following steps to change the time zone. You must be logged on as root. In this example, the time zone is changed from `"America/Chicago"` to `"Europe/London"`.

1. Confirm the time zone setting on the SMW.

   ```
   smw:~ # cd /etc/sysconfig
   smw:~ # grep TIMEZONE clock
   TIMEZONE="Europe/London"
   DEFAULT_TIMEZONE="Europe/London"
   ```

2. Log on to the boot node.

   ```
   smw:~ # ssh root@boot
   boot:~ #
   ```

3. Verify that the `zone.tab` file in the `/user/share/zoneinfo` directory contains the time zone you want to set.

   ```
   boot:~ # cd /usr/share/zoneinfo
   boot:~ # grep Europe/London zone.tab
   GB +512830-0001845 Europe/London Great Britain
   ```

4. Create the time conversion information files.

   ```
   boot:~ # date
   Fri Mar 10 05:19:38 CST 2007
   boot:~ # /usr/sbin/zic -l Europe/London
   boot:~ # date
   Fri Mar 10 11:21:31 GMT 2007
   ```

5. Modify the `clock` file in the `/etc/sysconfig` directory to set the `DEFAULT_TIMEZONE` and the `TIMEZONE` variables to the new time zone.

   ```
   boot:~ # cd /etc/sysconfig
   boot:~ # grep TIMEZONE clock
   TIMEZONE="America/Chicago"
   DEFAULT_TIMEZONE="America/Chicago"
   boot:~ # vi clock
   make changes
   boot:~ # grep TIMEZONE clock
   TIMEZONE="Europe/London"
   DEFAULT_TIMEZONE="Europe/London"
   ```

6. Switch to the default view by using `xtopview`.

   Note: If the SDB node has not been started, you must include the `-x /etc/opt/cray/sdb/node_classes` option when you invoke the `xtopview` command.

   ```
   boot:~ # xtopview
   default/:/ #
   ```

7. Verify that the `zone.tab` file in the `/user/share/zoneinfo` directory contains the time zone you want to set.

   ```
   default/:/ # cd /usr/share/zoneinfo
   default/:/ # grep Europe/London zone.tab
   GB +512830-0001845 Europe/London Great Britain
   ```

8. Create the time conversion information files.

   ```
   default/:/ # date
   Fri Mar 10 05:22:38 CST 2007
   default/:/ # /usr/sbin/zic -l Europe/London
   default/:/ # date
   Fri Mar 10 11:24:31 GMT 2007
   ```

9. Modify the `clock` file in the `/etc/sysconfig` directory to set the `DEFAULT_TIMEZONE` and the `TIMEZONE` variables to the new time zone.

   ```
   default/:/ # cd /etc/sysconfig
   default/:/ # grep TIMEZONE clock
   TIMEZONE="America/Chicago"
   DEFAULT_TIMEZONE="America/Chicago"
   default/:/ # vi clock
   make changes
   default/:/ # grep TIMEZONE clock
   TIMEZONE="Europe/London"
   DEFAULT_TIMEZONE="Europe/London"
   ```

10. Exit `xtopview`.

    ```
    default/:/ # exit
    boot:~ #
    ```

Procedure 89. Changing the time zone for compute nodes

The time zone for a CNL compute node can be changed by running the `xtpackage` command to copy the `/etc/localtime` file from the SMW to the CNL load file which is used to create a new boot image with `xtbootimg`. For example, with a source of `/opt/xt-images/hostname-3.1.20`.

1. Confirm the time zone setting on the SMW.

   ```
   smw:~ # cd /etc/sysconfig
   smw:~ # grep TIMEZONE clock
   TIMEZONE="America/Chicago"
   DEFAULT_TIMEZONE="America/Chicago"
   ```

2. Update the boot image to include these changes; follow the steps in Procedure 2 on page 68.

   The time zone is not changed until you boot the compute nodes with the updated boot image.

Creating Modulefiles [F]

This appendix provides a template and an example of a modulefile that you can use as you construct modulefiles for your site.

F.1 Modulefile Template

The following listing provides a template of the elements required in a modulefile. Use this as your guide when creating your own modulefiles.

```
#%Module########################################################################
#
# Generic modulefile template
#

###
# Add your verbiage into ModulesHelp area. This information
# will be seen by those invoking
# module help [my_product]
###

proc ModulesHelp { } {
puts stderr "This modulefile defines the library paths and"
puts stderr "include paths needed to use "
puts stderr "[my_product]."
puts stderr ""
}

###
# [my_product] is the name consistently used in the modulefile
# to set environment variables. It may be the same name as
# the modulefile and the rpm, however the modulefile and rpm
# will be named in a lower case name while [my_product] should
# be upper case, i.e. "module load acml" and ACML_DIR.
###

set is_module_rm [module-info mode remove]

###
# If [my_product] will not be versioned, then set
# [my_product]_CURPATH to the location of [my_product].
# If you use versions, then you only need to change one
# number as you create a module for another product version.
###

set [my_product]_LEVEL [product-version]
set [my_product]_CURPATH /opt/[installed-product-name]/$[my_product]_LEVEL
```

```
setenv [my_product]_DIR $[my_product]_CURPATH

###
# Add your executable to PATH.
###
#prepend-path PATH       $[my_product]_CURPATH/bin

###
# Add your dynamic library path. This is *NOT* for statically built
# libraries. For those use [my_product]_POST_LINK_OPTS below.
###
#prepend-path LD_LIBRARY_PATH  $[my_product]_CURPATH/lib

###
# Add MANPATH and INFOPATH
###
if { [file isdirectory $[my_product]_CURPATH/info] == 1} {
 prepend-path INFOPATH $[my_product]_CURPATH/info
}

if { [file isdirectory $[my_product]_CURPATH/man] == 1} {
 prepend-path MANPATH $[my_product]_CURPATH/man]
}

###
# To make our product work in commandline generation, you must
# add [my_product] to the PE_PRODUCT_LIST.
###
append-path  PE_PRODUCT_LIST  [my_product]

###
# The following 5 *_OPTS environment variables allow placement of compiler
# commandline options. The PRE and POST in the names refers to
# the location before or after the user-specified arguments.
# Remember that, in general, the linker evaluates its commandline from left
# to right, but the compiler generally uses the last argument in the list.
# The commandline is created for you in this order:
# cc [PRE_COMPILE_OPTS] [PRE_LINK_OPTS] user_args [POST_COMPILE_OPTS] \
#   [POST_LINK_OPTS] [INCLUDE_OPTS]
###

###
# Compiler options. The first character in this list must be a
# space and the list must be double quoted.
#
# You can define a fortran modules path for pgi-compiled files by adding it
# as a "-I' options to [my_product]_PRE_COMPILE_OPTS.

#setenv [my_product]_PRE_COMPILE_OPTS
#setenv [my_product]_POST_LINK_OPTS

###
# Options passed to the linker, including
# -L paths and -l library names. The -L and -l are used for statically built
# libraries. The first character in the list must be a space and the list
# must be double quoted. The -L and -l arguments should be added to
# [my_product]_POST_LINK_OPTS.
```

```
#setenv [my_product]_PRE_LINK_OPTS
#setenv [my_product]_POST_COMPILE_OPTS

#
# Include search path
#

#setenv [my_product]_INCLUDE_OPTS
```

Example 114. Module file example

This example shows a product, `kate`, with library files `libkate.a` and `libkit.a`, which were built with 64-bit PGI. Naming directories `pgi64` helps keep track of library formats. You can create whatever directory structure works for you. Likewise, naming the modulefile `kate-pgi` tells a potential user that this would be loaded when compiling using PGI.

```
#%Module######################################################################
#
# kate-pgi modulefile
#

proc ModulesHelp { } {
puts stderr "This modulefile defines the library paths and"
puts stderr "include paths needed to use the pgi-compiled kate."
puts stderr "Libraries -libkate.a, libkit.a, libkate.so and compiler"
puts stderr "option, -Mprof=mpi, are added. The utility run-kate"
puts stderr "is added to PATH."
}

###
# The modulefile kate-gnu could load gnu-built kate libraries,
# which are defined at $KATE_CURPATH/gnu64/lib
###

set is_module_rm [module-info mode remove]

set KATE_LEVEL 2.0
set KATE_CURPATH /opt/kate/$KATE_LEVEL

prepend-path PATH       $KATE_CURPATH/bin
prepend-path LD_LIBRARY_PATH  $KATE_CURPATH/pgi64/lib
prepend-path MANPATH      $KATE_CURPATH/man

append-path  PE_PRODUCT_LIST  KATE

###
# Definitions for these must begin with a space.
# Remember that in general the linker evaluates its command-line
# options left to right, while the compiler takes the last one
# it detects. You can define a Fortran modules path for pgi compiler
# by adding it as a "-I" option to *_POST_COMPILE_OPTS.
###
setenv KATE_PRE_COMPILE_OPTS  " -Mprof=mpi"
setenv KATE_POST_LINK_OPTS  " -L $KATE_CURPATH/lib -lkate -lkit"
setenv KATE_POST_COMPILE_OPTS  " -I $KATE_CURPATH/fortran_modules_dir"
setenv KATE_INCLUDE_OPTS  " -I $KATE_CURPATH/include"
```

F.2 Sharing Your Modulefile

Add your modulefile to `/opt/modulefiles` or to another directory. If you use another directory, you must add the path to your environment by using a `module use` command; for example, `module use /my/module/path`. To make the new modulefile path available to all users, edit the file `/opt/modules/init/.modulespath`.

F.3 Modulefile Help

Using the `module` command, you can get online help about any module in your system:

```
# module help modulefile
```

PBS Professional Licensing for Cray Systems [G]

G.1 Introduction

PBS Professional uses a licensing scheme based on FLEXnet with a central license server that allows licenses to float between servers. This reduces the complexity of managing environments with multiple, independent PBS installations and simplifies configuration when you run other software packages that use FLEXnet licensing.

The PBS server and scheduler run on the Cray service database (SDB) node. By default, the SDB node is only connected to the Cray system high-speed network (HSN) and cannot access an external FLEXnet license server. Various options to set up network connectivity between the FLEXnet server and the SDB node are detailed below. Determine which option is best suited to your needs and implement that solution prior to installing the PBS Professional software from Altair.

Note: Regardless of the option chosen, you must run a PBS Professional MOM daemon on each login node where users may launch jobs.

PBS Professional configuration options on a Cray system include:

- **Running the PBS Professional server and scheduler on a Cray system service node.** If you choose to run the PBS Professional scheduler and server on a login node, you should be aware that these daemons consume processor and memory resources and have the potential to impact other processes running on the login node. In addition, any service running on a node where users are allowed to run processes increases the potential for interruption of that service. While these risks are generally low, it is important that you consider them before selecting this option. Refer to Migrating the PBS Professional Server and Scheduler on page 360 to configure PBS Professional using this strategy.
- **Moving the PBS Professional server and scheduler external to the Cray system.** The PBS Professional scheduler requests MPP data from one of the MOM daemons running on the Cray system login nodes. The volume of this data is dependent upon the size and utilization of the Cray system. If you run the PBS Professional scheduler outside of the Cray system, the scheduler cycle time could increase due to decreased bandwidth and increased latency in network communication. In most cases, the difference in cycle time is negligible. However, if your system has larger node counts (> 8192), you may want to avoid this option. To configure PBS Professional for this strategy, refer to Migrating the PBS Professional Server and Scheduler on page 360.

- **Configuring the SDB node as an RSIP client.** This options allows you to leave the PBS Professional scheduler and server on the SDB node. If you are already running RSIP, this may be an attractive option. Cray recommends a dedicated network node for the RSIP server, which may not be desirable if you are not already running RSIP. Follow the appropriate procedure in Configuring RSIP to the SDB Node on page 362 to configure the SDB node as an RSIP client.
- **Configuring Network Address Translation (NAT) to forward IP packets to and from the SDB node.** This may be the best choice if you intend to use packet forwarding exclusively for PBS Professional licensing and do not mind running NAT services on a login node. The steps to configure NAT IP forwarding to the SDB node are described in Network Address Translation (NAT) IP Forwarding on page 365.
- **Installing a network card in the SDB node to connect it to the external network.** With this option you do not need to configure RSIP or NAT, but you must purchase a PCIe network interface card (NIC) for a modest cost. This is an attractive option if you want to access the SDB node directly from your external network. This procedure does not require connection via another node on the Cray system. The steps to configure this option are covered in Installing and Configuring a NIC on page 367.

Cray recommends that system administrators consult their local networking and security staff prior to selecting one of these options. Once you have chosen and configured a method for accessing the FLEXnet server, complete the PBS Professional FLEXnet configuration as described in the *Altair License Manager Installation Guide*. For additional information about using the `qmgr` command to set up the `pbs_license_file_location` resource, see the *PBS Professional Installation and Upgrade Guide* from Altair Engineering, Inc. For more information, see: http://www.altair.com/.

G.2 Migrating the PBS Professional Server and Scheduler

Before migrating the PBS Professional server and scheduler off of the SDB node you must first select the target host. PBS Professional versions 9.2 and beyond are MPP aware, meaning they are capable of scheduling jobs to Cray systems. If you already have a central PBS Professional server and scheduler, simply add the Cray system to the list of nodes.

The first step is to install PBS Professional on the Cray system as described in the *PBS Professional Installation and Upgrade Guide*. The install procedure configures the SDB node as the PBS Professional server and scheduler host. You must modify the default configuration to ensure that the PBS Professional scheduler and server do not start automatically on the SDB node.

Procedure 90. Migrating PBS off the SDB node

1. If the PBS scheduler and server are running on the SDB node, log on to the SDB and stop the services.

   ```
   sdb:~ # /etc/init.d/pbs stop
   ```

2. Log on to the Cray system boot node as root and unspecialize the PBS Professional configuration file for the SDB node. For example, your SDB is node 3, type the following commands:

   ```
   boot:~ # xtopview -m "Unspecialize pbs.conf on the SDB" -n 3
   node/3:/ # xtunspec /etc/pbs.conf
   node/3:/ # exit
   boot:~ #
   ```

3. Edit the PBS Professional configuration file for the login nodes to point to the new server. The new server may be one of the login nodes or a host external to the Cray system. Set PBS_SERVER in `/etc/pbs.conf` to the new PBS Professional server host. For example, if your server is named *myserver*, type the following commands:

   ```
   boot:~ # xtopview -m "Update pbs.conf for new server" -c login
   class/login/: # vi /etc/pbs.conf
   PBS_SERVER=myserver.domain.com
   class/login/: exit
   boot:~#
   ```

4. To migrate the server and scheduler to a login node and start PBS Professional automatically at boot time, specialize the `/etc/pbs.conf` file for that node. If the services are being moved to an external host, skip this step. For example, if the node ID of the login node is 4, type the following commands:

   ```
   boot:~ # xtopview -m "Specialize pbs.conf for new server" -n 4
   node/4:/ # xtspec /etc/pbs.conf
   ```

5. Modify the `/etc/pbs.conf` file to start all of the PBS Professional services; for example:

   ```
   node/4:/ # vi /etc/pbs.conf
   PBS_START_SERVER=1
   PBS_START_SCHED=1
   PBS_START_MOM=1

   node/4:/ # exit
   boot:~ #
   ```

6. Log on to each of the login nodes as root and modify the PBS Professional MOM configuration file `/var/spool/PBS/mom_priv/config`. Change the `$clienthost` value to the name of the new PBS Professional server. For example, if your server is named *myserver*, type the following commands:

   ```
   login2:~ # vi /var/spool/PBS/mom_priv/config
   $clienthost myserver.domain.com
   ```

7. After the configuration file has been updated, restart PBS Professional on each login node.

   ```
   login2:~ # /etc/init.d/pbs restart
   ```

   Note: This command starts the PBS Professional scheduler and server if you have migrated them to a login node.

8. Log on to the new PBS Professional server host and add a host entry for each of the login nodes.

   ```
   myserver:~ # qmgr
   Qmgr: create node mycrayxt1
   Qmgr: set node mycrayxt1 resources_available.mpphost=xthostname
   Qmgr: create node mycrayxt2
   Qmgr: set node mycrayxt2 resources_available.mpphost=xthostname
   Qmgr: exit
   myserver:~
   ```

   At this point, the login nodes should be visible to the PBS Professional server.

G.3 Configuring RSIP to the SDB Node

Follow the instructions in this section to configure the SDB node as an RSIP client. Once the SDB node is configured as an RSIP client, refer to the *Altair License Manager Installation Guide* for detailed instructions about obtaining and installing the appropriate license manager components.

If you have not configured RSIP on your system, follow Procedure 91 on page 362 to generate a simple RSIP configuration with a single server and only the SDB node as a client.

Cray XT System Software Installation and Configuration Guide includes procedures to configure RSIP on a Cray system using the `CLEinstall` installation program. If you have already configured RSIP using these procedures during your Cray Linux Environment (CLE) installation or upgrade, follow Procedure 92 on page 364 to add the SDB node as an RSIP client for one of your existing RSIP servers.

For additional information on configuring RSIP services, see Configuring Realm-Specific IP Addressing (RSIP) on page 200.

Procedure 91. Creating a simple RSIP configuration with the SDB node as a client

1. Boot the system as normal. Ensure all the service nodes are available, and ensure that the system is setup to allow password-less `ssh` access for the root user.

2. Select a service node to run the RSIP server. The RSIP server node must have external Ethernet connectivity and must not be a login node. In this example the physical ID for the RSIP server is `c0-0c0s7n0`.

3. Specialize the `rsipd.conf` file by node ID and install the `rsip.conf` file to the shared root. Additionally, tune the RSIP servers by updating the associated `sysctl.conf` file. Invoke the following steps for the RSIP server node.

   a. Log on to the boot node and invoke `xtopview` in the node view.

   ```
   boot:~ # xtopview -n c0-0c0s7n0
   node/c0-0c0s7n0:/ #
   ```

   b. Specialize `/etc/opt/cray/rsipd/rsipd.conf` for the specified node.

   ```
   node/c0-0c0s7n0:/ # xtspec /etc/opt/cray/rsipd/rsipd.conf
   ```

   c. Copy the `rsip.conf` template file from the SMW to the shared root.

```
node/c0-0c0s7n0:/ # scp crayadm@smw:/opt/cray-xt-rsipd/default/etc/rsipd.conf.example \
/etc/opt/cray/rsipd/rsipd.conf
```

   d. Modify the `port_range`, `ext_if` and `max_clients` parameters in the `rsipd.conf` file as follows:

   ```
   node/c0-0c0s7n0:/ # vi /etc/opt/cray/rsipd/rsipd.conf
   port_range 8192-60000
   max_clients 2
   Uncomment:
   ext_if eth0
   ```

   Note: If your external Ethernet interface is not `eth0`, modify `ext_if` accordingly. For example,

   ```
   ext_if eth1
   ```

   e. Specialize the `/etc/sysctl.conf` file and modify the OS port range so that it does not conflict with the RSIP server.

   ```
   node/c0-0c0s7n0:/ # xtspec /etc/sysctl.conf
   node/c0-0c0s7n0:/ # vi /etc/sysctl.conf
   net.ipv4.ip_local_port_range = 60001 61000
   ```

   f. If the specified RSIP server is using a 10GbE interface, update the default socket buffer settings by modifying the following lines in the `sysctl.conf` file.

   ```
   net.ipv4.tcp_timestamps = 0
   net.ipv4.tcp_sack = 0
   net.core.rmem_max = 524287
   net.core.wmem_max = 524287
   net.core.rmem_default = 131072
   net.core.wmem_default = 131072
   net.ipv4.tcp_rmem = 131072 1000880 9291456
   net.ipv4.tcp_wmem = 131072 1000880 9291456
   net.ipv4.tcp_mem = 131072 1000880 9291456
   ```

g. Update the `udev` rules to skip the `ifup` of the `rsip` interfaces as they are created. Add `rsip*` to the list of interface names for `GOTO="skip_ifup"`.

```
node/c0-0c0s7n0:/ # xtspec /etc/udev/rules.d/31-network.rules
node/c0-0c0s7n0:/ # vi /etc/udev/rules.d/31-network.rules
SUBSYSTEM=="net", ENV{INTERFACE}=="rsip*|ppp*|ippp*|isdn*|plip*|lo*|irda*| \
dummy*|ipsec*|tun*|tap*|bond*|vlan*|modem*|dsl*", GOTO="skip_ifup"
```

h. Exit the `xtopview` session.

```
node/c0-0c0s7n0:/ # exit
```

4. Update the auto boot script to start the RSIP server. This is done from the SMW. Place the new lines towards the end of the file, immediately before any `'motd'` or `'ip route add'` lines. Ensure that `rsipd` is started prior to starting ALPS and PBS. In our example, the RSIP server is *nid00016*.

```
crayadm@smw:~> vi /opt/cray/etc/auto.xthostname
# RSIP server node startup
lappend actions { crms_exec_via_bootnode
"nid00016" "root" "/opt/cray/rsipd/default/sbin/rsipd" }
```

5. Update the auto boot script to start the RSIP client on the SDB node. Do this after the above line that started the RSIP server. This line is simply a `modprobe` of the `krsip` module with the IP argument pointing to the HSN IP address of the RSIP server node. For example, if the SeaStar IP address of the RSIP server is `192.168.0.29`, type the following commands.

```
crayadm@smw:~> vi /opt/cray/etc/auto.xthostname
# RSIP client startup
lappend actions { crms_exec_via_bootnode "sdb" "root" "modprobe krsip ip=192.168.0.29" }
```

Procedure 92. Adding the SDB node as an RSIP client to an existing RSIP configuration

1. Select one of your RSIP servers to provide RSIP access for the SDB node. In this example, we have chosen the RSIP server with the physical ID `c0-0c0s7n0`.

2. Log on to the boot node and invoke `xtopview` in the node view for the RSIP server you have selected.

```
boot:~ # xtopview -n c0-0c0s7n0
node/c0-0c0s7n0:/ #
```

3. Modify the `max_clients` parameters in the `rsipd.conf` file; Add 2 more clients to make room for the new SDB node. For example, if you configured 300 RSIP clients (compute nodes), type the following:

```
node/c0-0c0s7n0:/ # vi /etc/opt/cray/rsipd/rsipd.conf
max_clients 302
```

4. Update the auto boot script to start the RSIP client on the SDB node. Do this after the line that starts the RSIP server. This line is simply a `modprobe` of the `krsip` module with the IP argument pointing to the HSN IP address of the

RSIP server node. For example, if the SeaStar IP address of the RSIP server is `192.168.0.29`, type the following commands.

```
crayadm@smw:~> vi /opt/cray/etc/auto.xthostname
# RSIP client startup
lappend actions { crms_exec_via_bootnode "sdb" "root" "modprobe krsip ip=192.168.0.29" }
```

G.4 Network Address Translation (NAT) IP Forwarding

Follow Procedure 93 on page 365 to configure NAT IP forwarding to the SDB node.

Procedure 93. Configuring NAT IP forwarding for the SDB node

1. Select a login node to act as the NAT router. Cray recommends that you select the node with the lowest load or network latency. For this example the login node is named `login2`.

2. Login to the node you have selected and invoke the `ifconfig` command to obtain the SeaStar network interface data for the node. For example:

   ```
   login2:/ # ifconfig ss
   ss        Link encap:Ethernet  HWaddr 00:00:00:07:00:00
             inet addr:192.168.0.8  Mask:255.255.0.0
             inet6 addr: fe80::200:ff:fe07:0/64 Scope:Link
             UP RUNNING NOARP  MTU:16000  Metric:1
             RX packets:2960668 errors:0 dropped:0 overruns:0 frame:0
             TX packets:2860775 errors:0 dropped:0 overruns:0 carrier:0
             collisions:0 txqueuelen:1000
             RX bytes:8088280748 (7713.5Mb) TX
   bytes:2732093573 (2605.5Mb)
   ```

   Note the value of the interface IP address (*192.168.0.8* in this case). This is the IP address of the routing node.

3. Record the Ethernet interface used on this login node. For example:

   ```
   login2:/ # netstat -r  | grep default
   default    cfgw-12-hsrp.us 0.0.0.0     UG      0 0        0 eth0
   ```

   Following this example, the Ethernet interface `eth0` should be used in the NAT startup script created in the next step.

4. Edit `/etc/hosts` on the shared root to include the external FLEXnet license server(s). Add these entries prior to the first local Cray IP addresses; that is, before the `192.168.x.y` entries. For example:

   ```
   boot:~# xtopview
   default/:/ # vi /etc/hosts
   10.0.0.55    tic tic.domain.com
   10.0.0.56    tac tac.domain.com
   10.0.0.57    toe toe.domain.com

   default/:/ # exit
   boot:~#
   ```

5. In the same manner, edit `/etc/hosts` on the boot root to include entries for the external FLEXnet license server(s).

```
boot:~# vi /etc/hosts
10.0.0.55    tic tic.domain.com
10.0.0.56    tac tac.domain.com
10.0.0.57    toe toe.domain.com
```

6. Create a `/etc/init.d/local.start-nat` file on the shared root.

```
boot:~# xtopview
default/:/ # cd /etc/init.d
default/:/ # vi local.start-nat
```

   Add the following content to the new file:

```
echo "Setting up NAT IP forwarding."
echo 1 > /proc/sys/net/ipv4/ip_forward
iptables -t nat -F
iptables -A FORWARD -i eth0 -o ss -m state --state ESTABLISHED,RELATED -j ACCEPT
iptables -A FORWARD -i ss -o eth0 -j ACCEPT
iptables -A FORWARD -j LOG
iptables -t nat -A POSTROUTING -o eth0 -j MASQUERADE
```

7. Specialize the file and exit `xtopview`.

```
default/:/ # xtspec local.start-nat
default/:/ # exit
boot:~#
```

8. Log on as root to the selected router node and start the NAT service. Use the `iptables` command to verify that forwarding is active.

```
login2:~ # /etc/init.d/local.start-nat
login2:~ # iptables -L -n
Chain INPUT (policy ACCEPT)
target     prot opt source               destination

Chain FORWARD (policy ACCEPT)
target     prot opt source               destination

Chain OUTPUT (policy ACCEPT)
target     prot opt source               destination
login2:~ #
```

9. Log on to the SDB node and add a new default route. Note that this route should not currently exist. Use the selected login node SeaStar interface IP identified in step 2.

```
nid00003:~ # /sbin/route add default gw 192.168.0.8
```

10. Test the new route by invoking the `ping` command and ensuring the SDB node can access external servers by name.

11. Edit the auto boot script to Configure NAT services.

```
smw:~# vi /opt/cray/etc/auto.xthostname
```
   Add the following lines just prior to the ALPS/PBS startup:
```
lappend actions { crms_exec_via_bootnode "login2" "root" \
"/etc/init.d/local.start-nat" }
lappend actions { crms_exec_via_bootnode "sdb" "root" \
"/sbin/route add default gw 192.168.0.8" }
```

NAT services should now restart automatically upon the next reboot of the Cray system.

G.5 Installing and Configuring a NIC

Obtain a PCIe compliant NIC. Intel 82546 based cards have been verified with Cray system SDB nodes. Follow Procedure 94 on page 367 to install the network card in the SDB node and connect it to the external network. Note that you are required to reboot your system as part of this procedure.

Procedure 94. Installing and configuring a NIC on the SDB node

1. Prior to shutting the system down, perform the following steps on the boot node to ensure the new NIC is configured upon the ensuing reboot. Invoke `xtopview` in the node view for the SDB node. For example, if your SDB is node *3*, the IP address to assign on the external network is *172.30.10.100*, the appropriate `netmask` is *255.255.0.0*, and the default gateway IP is *172.30.10.1*, type these commands.

```
boot:~# xtopview -m "add eth0 interface" -n 3
node/3:/ # cd /etc/sysconfig/network
node/3:/ # vi ifcfg-eth0
Add the following content to the ifcfg-eth0 file:
DEVICE="eth0"
BOOTPROTO="static"
STARTMODE="onboot"
IPADDR=172.30.10.100
NETMASK=255.255.0.0

node/3:/ # xtspec ifcfg-eth0
node/3:/ # echo 'default 172.30.10.1 - -' >routes
node/3:/ # xtspec routes
node/3:/ # exit
boot:~ #
```

2. Edit the `/etc/hosts` file on the shared root and add entries for the external FLEXnet license server(s). For example:

```
boot:~# xtopview
default/:/ # vi /etc/hosts
Add these entries prior to the first local Cray system IP addresses; that is, before the 192.168.x.y entries.
10.0.0.55    tic tic.domain.com
10.0.0.56    tac tac.domain.com
10.0.0.57    toe toe.domain.com

default/:/ # exit
boot:~# exit
```

3. Shut down the system.

   ```
   smw:~# xtshutdown
   ```

4. Power down the slot where the SDB node is installed. For example:

   ```
   smw:~# xtcli power down_slot -f c0-0c0s0
   ```

5. Pull the blade, physically insert the new NIC into the PCIe slot of the SDB node and reinsert the blade into the slot.

6. Power up the slot where the SDB node is installed. For example:

   ```
   smw:~# xtcli power up_slot -f c0-0c0s0
   ```

7. Connect the NIC to the Ethernet network on which the FLEXnet server is accessible.

8. Boot the Cray system.

9. Log on to the SDB node and invoke the `ifconfig` command to confirm that the SDB shows the new `eth0` interface.

```
nid00003:~ #  /sbin/ifconfig eth0
eth0      Link encap:Ethernet  HWaddr 00:04:23:DF:4C:56
          inet addr:172.30.10.100  Bcast:172.30.10.1 Mask:255.255.0.0
          inet6 addr: 2001:408:4000:40c:204:23ff:fedf:4c56/64 Scope:Global
          inet6 addr: 2600:805:100:40c:204:23ff:fedf:4c56/64 Scope:Global
          inet6 addr: fe80::204:23ff:fedf:4c56/64 Scope:Link
          UP BROADCAST RUNNING MULTICAST  MTU:1500  Metric:1
          RX packets:428807 errors:0 dropped:0 overruns:0 frame:0
          TX packets:10400 errors:0 dropped:0 overruns:0 carrier:0
          collisions:0 txqueuelen:1000
          RX bytes:34426088 (32.8 Mb)  TX bytes:1292332 (1.2 Mb)
          Base address:0x2fc0 Memory:fece0000-fed00000
```

10. Confirm that you can ping the license server from the SDB node.

    ```
    nid00003:~ #  ping tic.domain.com
    ```

Glossary

blade

1) A field-replaceable physical entity. A service blade consists of AMD Opteron sockets, memory, Cray network application-specific integrated circuit (ASIC) chips, PCI cards, and a blade control processor. A compute blade consists of AMD Opteron sockets, memory, Cray network application-specific integrated circuit (ASIC) chips, and a blade control processor. 2) From a system management perspective, a logical grouping of nodes and blade control processor that monitors the nodes on that blade.

blade control processor

A microprocessor on a blade that communicates with a cabinet control processor through the HSS network to monitor and control the nodes on the blade. See also *blade*, *L0 controller*, *Hardware Supervisory System (HSS)*.

cabinet control processor

A microprocessor in the cabinet that communicates with the HSS via the HSS network to monitor and control the devices in a system cabinet. See also *Hardware Supervisory System (HSS)*.

cage

A chassis in a cabinet of a Cray system. See *chassis*.

chassis

The hardware component of a Cray cabinet that houses blades. Each cabinet contains three vertically stacked chassis, and each chassis contains eight vertically mounted blades. See also *cage*.

class

A group of service nodes of a particular type, such as login or I/O. See also *specialization*.

CLE

The operating system for Cray XE and Cray XT systems.

CNL

The CLE compute node kernel. CNL provides a set of supported system calls. CNL provides many of the operating system functions available through the service nodes, although some functionality has been removed to improve performance and reduce memory usage by the system.

compute blade

See *blade*.

compute node

A node that runs application programs. A compute node performs only computation; system services cannot run on compute nodes. Compute nodes run a specified kernel to support either scalar or vector applications. See also *node*; *service node*.

compute node root

The runtime environment available to compute nodes for use in dynamic compiling, linking and execution of programs.

compute node root server

A Data Virtualization Services (DVS) server that projects the shared root to compute nodes for use with dynamic shared objects.

compute processing element

See *processing element*.

Cray DVS

The Cray Data Virtualization Service (Cray DVS) is a distributed network service that provides compute nodes with transparent access to file systems on the service partition using the Cray high-speed network.

deferred implementation

The label used to introduce information about a feature that will not be implemented until a later release.

Hardware Supervisory System (HSS)

Hardware and software that monitors the hardware components of the system and proactively manages the health of the system. It communicates with nodes and with the management processors over the private Ethernet network. See also *system interconnection network*.

heartbeat

A signal sent at regular intervals by software to show that it is still active.

L0 controller

See *blade control processor*.

L1 controller

See *cabinet control processor*.

logical machine

An administrator-defined portion of a physical Cray system, operating as an independent computing resource.

login node

The service node that provides a user interface and services for compiling and running applications.

metadata server (MDS)

The component of the Lustre file system that manages Metadata Targets (MDT) and handles requests for access to file system metadata residing on those targets.

module

See *blade*.

module file

A metafile that defines information specific to an application, a collection of applications, or a library. This term is not related to the Fortran language MODULE statement, but is related to setting up the Cray programming environment. The Modules utility uses module files to define the paths, command names, and other environment variables used by the application or library, including the version to be used.

multicore

A processor that combines multiple independent execution engines ("cores"), each with its own cache and cache controller.

node

For CLE systems, the logical group of processor(s), memory, and network components acting as a network end point on the system interconnection network.

node ID

A decimal number used to reference each individual node. The node ID (NID) can be mapped to a physical location.

NUMA node

A multicore processor and its local memory. Multisocket compute nodes have two or more NUMA nodes.

object storage target (OST)

The Lustre system component that represents an I/O device containing file data as file system objects. This can be any LUN, RAID array, disk, disk partition, etc.

parallel processing

Processing in which multiple processors work on a single application simultaneously.

processing element

A processing element is one instance of an executable propagated by the Application Level Placement Scheduler (ALPS).

resiliency communication agent (RCA)

A communications interface between the operating environment and the HSS. Each RCA provides an interface between the HSS and the processes running on a node and supports event notification, informational messages, information requests, and probes. See also *Hardware Supervisory System (HSS)*.

service blade

See *blade*.

service database (SDB)

The database that maintains the global system state.

service node

A node that performs support functions for applications and system services. Service nodes run a version of SLES and perform specialized functions. There are six types of predefined service nodes: login, IO, network, boot, database, and syslog.

specialization

The process of setting files on the shared-root file system so that unique files can exist for a node or for a class of nodes.

system interconnection network

The high-speed network that handles all node-to-node data transfers.

System Management Workstation (SMW)

The workstation that is the single point of control for system administration. See also *Hardware Supervisory System (HSS)*.

system set

A group of partitions on the BootRAID (boot root, boot node swap, shared root, boot image, SDB, syslog, UFS, etc.) that make a complete, bootable system.