Intel® Enterprise Edition for Lustre* Software Installation Guide

Partner Guide
High Performance Data Division

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About this Document

Document Purpose

This document provides detailed instructions for installing Intel® Enterprise Edition for Lustre* software. This document:

- Introduces Intel® Enterprise Edition for Lustre* software and its capabilities
- Introduces Intel® Manager for Lustre* software and its capabilities to configure and support real-time management of Lustre file systems, using a GUI-based dashboard
- Provides detailed instructions about how to configure the components to create a file system that meets the High Availability Configuration Specification (discussed herein). Conformance with this specification permits configuration, monitoring, and management of the Lustre file system using the Intel® Manager for Lustre* software.
- Describes the pre-installation tasks such as configuring servers, establishing yum repositories, configuring LNET, and also discusses Linux* kernel considerations
- Describes how to install Intel® Enterprise Edition for Lustre* software
- Describes how to configure Intel® Manager for Lustre* software
- Describes how to add storage servers to the Lustre file system
- Provides troubleshooting information

Intended Audience

This guide is intended for partners who are designing storage solutions based on Intel® Enterprise Edition for Lustre* software. Readers are assumed to be full-time Linux system administrators or equivalent who have:

- experience administering file systems and are familiar with storage components such as block storage, SAN, and LVM
- Proficiency in setting up, administering and maintaining networks. Knowledge of LNET is required. Knowledge of InfiniBand* is required if InfiniBand is to be used.
- Detailed knowledge of the overall configuration of the storage system and the ability to verify that the configuration matches the configuration requirements as defined in this guide.

This document is *not intended for end users* of storage solutions implemented using the Intel® Enterprise Edition for Lustre* software.

Conventions Used

Conventions used in this document include:

- # preceding a command indicates the command is to be entered as root

- $ indicates a command is to be entered as a user
- *<variable_name>* indicates the placeholder text that appears between the angle brackets is to be replaced with an appropriate value

Related Documentation

- *Intel® Enterprise Edition for Lustre* Software, Version 3.1.0.0 Release Notes*
- *Intel® Manager for Lustre* Software User Guide*
- *Lustre* Installation and Configuration using Intel® EE for Lustre* Software and OpenZFS*
- *Configuring LNet Routers for File Systems based on Intel® EE for Lustre* Software*
- *Multi-Rail LNet Configuration Guide*
- *Installing Hadoop, the Hadoop Adapter for Intel® EE for Lustre*, and the Job Scheduler Integration*
- *Creating an HBase Cluster and Integrating Hive on an Intel® EE for Lustre® File System*
- *Hierarchical Storage Management Configuration Guide*
- *Configuring SELinux for File Systems based on Intel* EE for Lustre* Software*
- *Configuring Snapshots for File Systems based on Intel® EE for Lustre* Software*
- *Upgrading a Lustre file system to Intel® Enterprise Edition for Lustre* software (Lustre only)*
- *Creating a Scalable File Service for Windows Networks using Intel® EE for Lustre* Software*
- *Intel® EE for Lustre* Hierarchical Storage Management Framework White Paper*
- *Architecting a High-Performance Storage System White Paper*

Introducing the Intel® Enterprise Edition for Lustre* Software

Intel® Enterprise Edition for Lustre* software, when integrated with Linux, aggregates a range of storage hardware into a single Lustre* file system that is well proven for delivering fast IO to applications across high-speed network fabrics, such as InfiniBand* and Ethernet.

Lustre* is a global, single-namespace file system architecture that allows parallel access by many clients to all the data in the file system across many servers and storage devices. Designed to take advantage of the reliability features of enterprise-class storage hardware, Intel® EE for Lustre* software provides high availability features including redundant servers with storage failover. Metadata and data are stored on separate servers to allow each system to be optimized for different workloads.

What is Intel® Manager for Lustre* Software?

Intel® EE for Lustre* software includes the Intel® Manager for Lustre* software, which greatly simplifies configuring, creating, monitoring, and managing one or more Lustre file systems from either the manager GUI, or the associated command line interface (CLI).

RestAPI plugins can further extend the functionality of IML. Such plugins might include real-time storage monitoring that let you track Lustre file system usage, performance metrics, events, and errors at the Lustre level. Please contact Intel® for more information.

Intel® Manager for Lustre* software is a part of the Intel® EE for Lustre* software product.

What is Management Mode?

The Intel® Manager for Lustre* software lets you create and manage new high-availability (HA) Lustre file systems from its GUI. For each HA file system, the GUI and dashboard let you create, monitor, and manage all servers and their respective targets. The software lets you define failover servers to support HA. RAID-based fault tolerance for storage devices is implemented independent of Intel® Manager for Lustre* software. Software RAID (MDRAID) disk discovery is not supported.

To provide robust HA support, Intel® Manager for Lustre* software automatically configures Corosync and Pacemaker, and takes advantage of IPMI or PDUs to support server failover. Note that Logical Volume Manager (LVM) is not supported in Management mode, but is supported in Monitor mode.

Note: Managed HA support *requires* that your entire storage system configuration and all interfaces be compliant with a *known configuration*. See the High Availability Configuration Specification herein for more information.

What is Monitor-only Mode?

Monitor-only mode allows you to "discover" a working Lustre file system. Using Intel® Manager for Lustre* software, you can then monitor the file system at the Intel® Manager for Lustre* dashboard. All of the charts presented on the manager dashboard to monitor performance and statistics, are also available in monitor-only mode.

Monitor-only mode is for file systems that do not fully conform to the High Availability Configuration Specification. In this situation, the Corosync and Pacemaker configuration modules provided with Intel® Manager for Lustre* software are not automatically deployed. This means that Intel® Manager for Lustre* software cannot configure the file system for server failover. Note that Logical Volume Manager (LVM) is not supported in Management mode, but is supported in Monitor mode.

The Configuration Page in Monitor-only mode

The Configuration page presented by Intel® Manager for Lustre* software is designed primarily to enable designers to create Lustre file systems with server failover capability, but this capability is not supported in monitor-only mode. However, many of the features provided on the Configuration page are also directly useful for monitor-only file systems.

Building a Lustre Storage Solution over a ZFS File System

If your intent is to build a high-availability, Lustre storage solution over an existing ZFS, Intel® EE for Lustre* software supports this configuration. However, the installation and configuration of such a system is not described in this guide. Please see the document: *Lustre* Installation and Configuration using Intel® EE for Lustre* Software and OpenZFS*.

Building the System – The High Availability Configuration Spec

This section presents the High Availability Configuration Specification. This specification defines how a file system you create using Intel® Manager for Lustre* software, must be assembled and configured to support a high-availability Lustre file system that is also managed by Intel® Manager for Lustre* software.

In addition to the specification presented next, please contact your Intel® technical support representative for the latest information regarding the configuration and interconnect requirements to achieve the maximum benefits of an HA file system managed by Intel® EE for Lustre* software.

Overall System Configuration

The high-level configuration of an HA file system managed by Intel® EE for Lustre* software consists of the following. See Figure 1.

- A **dedicated manager server** hosts the Intel® Manager for Lustre* software and dashboard.
- **Management server** (MGS): The MGS provides access to the management target (MGT) storage. To support failover, the management server is also configured as the backup for the metadata server.
- **Metadata server** (MDS): The MDS provides access to the metadata target storage. To support failover, the metadata server is also configured as the backup management server.
- **Object storage server** (OSS): At least two servers provide access to the object storage targets, which store the file system's data. OSSs are configured in failover pairs sharing access to the same data storage, so that if an OSS fails, service is automatically failed over to its peer server.
- **Management target** (MGT): The MGT stores configuration information for all the Lustre file systems in a cluster and provides this information to other Lustre components. The MGT is accessed by the primary MGS and, if the MGS fails, by the MDS operating in failover mode. The MGT should *not* be larger than 10 Gbyte in capacity.
- **Metadata target** (MDT): The MDT stores metadata (such as file names, directories, permissions, and file layout) for attached storage and makes them available to clients. The MDT is accessed by the primary MDS and, if the MDS fails, by the MGS operating in failover mode.
- **Object storage targets** (OSTs): Client file system data is stored in one or more objects that are located on separate OSTs. The number of objects per file is configurable by the user and can be tuned to optimize performance for a given workload. RAID 6 is recommended for OSTs. RAID is implemented independent of Intel® Manager for Lustre* software. Note that Logical Volume Manager (LVM) *is not* supported in Management mode, but *is* supported in Monitor mode. Software RAID (MDRAID) disk discovery is not supported.
- **Failover/High Availability ring 1 network**: This network supports Pacemaker and Corosync and requires an IP address block within the 10/8 RFC-1918 private IP address space. Should you choose to utilize the 10/8 address block for the management/ring0 network as well, then the largest permissible network size that may be used for the management network (ring0) is /9, since the High Availability ring1 network must co-exist within the 10/8 address space as well. Additionally, because the 10/8 network is used for the High Availability ring1 network and it must be of equal size to the management/ring0 network, the largest management/ring0 network you can define is a /9. Sizes larger than /9 are unsupported. Given those restrictions, if you require a /8 address block for your management network, you will be unable to utilize

the RFC 1918 private IP addressing space (i.e. 10/8) and must choose another /8 network.

- **Management network**: The Management network is 1-gigabit Ethernet, connecting every server in the file system. This network is used with ssh, to install and update Intel® Manager for Lustre* software on each server. It is also used to manage the servers and make separate connections to an IPMI port installed on each managed server.

- **Lustre network**: Generally, the Lustre network (LNET) is either 10-gigabit Ethernet or Infiniband and provides high-speed file system access for each client. The required data rate of this network is generally driven by the file system size, the number of clients, and the average throughput requirements for each client.

Note: After you have completely configured the system and installed Intel® EE for Lustre* software on the manager server, you will be ready to create the Lustre file system using the Intel® Manager for Lustre* software. **Note that installation consists of installing Intel® EE for Lustre* software on the manager server only**. For HA file systems, the software automatically installs required packages on the file system's servers to support HA. This avoids the need to manually install the Intel® EE for Lustre* software on storage servers and avoids possible errors.

During this physical configuration of your file system hardware, be sure to write down how servers and storage are configured so you can later assign primary and failover servers to each volume (using the Intel® Manager for Lustre* software GUI). Also, keep records of how failover power control has been implemented (IPMI or PDUs) as this will be needed later.

Figure 1 shows the high-level HA system configuration.

Figure 1. Lustre* High-Availability File System Configuration

Note: All references herein to the *manager GUI* refer to the Intel® Manager for Lustre* graphical user interface.

Manager Server Requirements

The *manager server* is a dedicated server on which the Intel® Manager for Lustre* software is installed. This is unique from the *management server*. Requirements for the manager server are listed next.

Note: Before using the Red Hat or RHEL software referenced herein, please refer to Red Hat's website for more information, including without limitation, information regarding the mitigation of potential security vulnerabilities in the Red Hat software.

- X86 CPU
- At *least* 4 GB of RAM

- Storage on the server large enough to accommodate:
  - 24 GB for the operating system and additional packages
  - Swap space equal to twice the available RAM present
  - a base OS installation that provides **at least a 500-GB /var partition**
- A one gigabit Ethernet port to connect to the management network.
- RAID 1 is a minimum recommendation. RAID 10 may be optimal for heavy workloads. Software RAID (MDRAID) disk discovery is not supported.
- Red Hat Enterprise Linux or CentOS Linux, version 7.3 must be installed on all servers. All Lustre servers should be running the same OS and version. CentOS must have access to the base repositories and update repositories. Red Hat must have the following channels registered and enabled:
  - rhel-x86_64-server-supplementary-7
  - rhel-x86_64-server-optional-7
  - rhel-x86_64-server-ha-7
  - rhel-x86_64-server-7
- `yum` needs to be functional (with any needed proxies) and default yum repositories must be fully configured. Run `yum update` to verify that yum updates occur successfully.

Intel® Manager for Lustre* software is supported on:

- Latest released Google Chrome browser.
- Latest released Mozilla Foundation Firefox browser.

Management Server and Metadata Server Requirements

The management server (MGS) is configured as a failover server with the metadata server (MDS), and vice-versa, so the MGS and MDS share the same configuration requirements.

Note: The MGS is separate from the independent server running Intel® Manager for Lustre* software.

Figure 2 depicts the configuration, interconnect requirements and targets for the MGS and MDS.

Figure 2. Management and Metadata Server and Target Configuration

The MDS and MGS, both independent servers, share the following requirements.

- X86 CPU
- MDS and MGS memory requirements are determined by factors such as the number of clients, the sizes of directories, and the load placed on the server. See the *Lustre* 2.X File System Operations Manual, Chapter 5, Determining Hardware Configuration Requirements and Formatting Options* for more information.
- Red Hat Enterprise Linux or CentOS Linux version 7.3 must be installed. All Lustre servers should be running the same OS and version. CentOS must have access to the base repositories and update repositories. Red Hat must have the following channels registered and enabled:

  - rhel-x86_64-server-supplementary-7
  - rhel-x86_64-server-optional-7
  - rhel-x86_64-server-ha-7
  - rhel-x86_64-server-7

- A dedicated Ethernet port capable of one gigabit/sec. This port connects to the Management network.
- `yum` needs to be functional, with any needed proxies, and default yum repositories must be fully configured. Run `yum update` to verify that yum updates occur successfully.
- HA servers are configured in pairs, with a primary server and a failover server.
- Crossover cable – Each HA server (excluding the manager server) is connected to its peer HA server by a private crossover link. This is an Ethernet connection.
- All required multipath configuration between each storage server controller and its physical storage devices must be complete.
- Storage controllers and drives must already be installed and LUNs must already be configured and present.
- Each server of a failover pair must have access to exactly the same LUNs as its peer. Each LUN is visible only to its two, paired failover servers.
- For proper failover functionality, paired servers must be able to access the other's power control device. This can be implemented either using power distribution units (PDUs) or IPMI. Recommended PDUs are from American Power Conversion Corp., models AP7900, AP7901, AP7902, AP7920, AP7921, AP7930, AP7931, AP7932, AP7960, AP7990, and AP8941. Each server should be supplied with two power supply sources, for redundancy.

Management Target

- For comparatively small file systems, the typical management target capacity might be 100 MB. See the *Lustre* 2.X File System Operations Manual, Chapter 5, Setting up a Lustre File System* for more information.
- Intel® Manager for Lustre* software does *not* support an MGT larger than 10 Gbytes.
- RAID 1 is recommended. Software RAID (MDRAID) disk discovery is not supported.
- As described above, the MGS and MDS servers are connected to the management storage in a primary/failover configuration.
- All required multipath configuration between each storage server controller and its physical storage devices must be complete.

Metadata Target

- Storage capacity for the metadata target should be 2K bytes per storage system file. Multiply the anticipated number of files the file system will contain by 2K to determine the required capacity of the target. See the *Lustre* 2.X File System Operations Manual, Chapter 5, Setting up a Lustre File System* for more information.
- RAID 10 is recommended for metadata targets. Software RAID (MDRAID) disk discovery is not supported.
- As described above, the MGS and MDS servers are connected to metadata storage in a primary/failover configuration.
- All required multipath configuration between each storage server controller and its physical storage devices must be complete.

Object Storage Server and Target Requirements

The object storage server (OSS) provides access to the object storage target(s) (OST). There is no specific limit to the number of OSSs. For HA, each OSS must have a failover twin. This means that OSSs are paired. Each OSS pair can provide access for to up to 8 targets or LUNS. The maximum capacity for an OST is 128 terabytes. Figure 3 depicts the configuration and interconnect requirements for HA OSSs and OSTs. See the *Lustre* 2.X File System Operations Manual, Chapter 5, Setting up a Lustre File System* for more information.

Figure 3. Object Storage Server(s) and Target(s) Configuration

Requirements for HA object storage servers and targets are as follows:

- Red Hat Enterprise Linux or CentOS Linux version 7.3 must be installed. All Lustre servers should be running the same OS and version. CentOS must have access to the base repositories and update repositories. Red Hat must have the following channels registered and enabled:

  - rhel-x86_64-server-supplementary-7
  - rhel-x86_64-server-optional-7
  - rhel-x86_64-server-ha-7
  - rhel-x86_64-server-7

- A storage device of at least 6 GB on each server to store the operating system and additional packages. Generally, OSS and OST space requirements are driven by the total size of the file system, the number of servers and OST, the number of files in the file system and the file size. See the Lustre* 2.X File System Operations Manual, Chapter 5, Setting up a Lustre File System for more information.
- A dedicated Ethernet port capable of one gigabit/sec. This port connects to the Management network.
- yum needs to be functional, with any needed proxies, and default yum repositories must be fully configured. Run yum update to verify that yum updates occur successfully.
- HA servers are configured in pairs, with a primary server and a failover server.
- Crossover cable – Each HA server (excluding the manager server) is connected to its peer HA server by a private crossover link. This is an Ethernet connection.
- Any required multipath configuration between each storage server controller and its physical storage devices must be complete.
- Storage controllers and drives must already be installed and LUNs must already be configured and present.
- Each server of a failover pair must have access to exactly the same LUNs as its peer. Each LUN is visible only to its two, paired failover servers.
- For proper failover functionality, paired servers must be able to access the other's power control device. This can be implemented using power distribution units (PDUs) or by using IPMI. Recommended PDUs are from American Power Conversion Corp., models AP7900, AP7901, AP7902, AP7920, AP7921, AP7930, AP7931, AP7932, AP7960, and AP7990. Each server should be supplied with two power supply sources, for redundancy.
- RAID 6, n+2 is recommended for object storage targets. For optimal write performance, n should be a power of 2 (e.g. 4, 8, or 16). This helps to ensure that a full stripe write of 1 MB can be spread evenly across all disks in the volume, with no "read, modify, write" penalty. Note that Logical Volume Manager (LVM) is not supported in Management mode, but is supported in Monitor mode. Software RAID (MDRAID) disk discovery is not supported.

- There is no specific limit to the number of object storage servers, but each OSS should support no more than eight target storage devices.

Power Control to Support Failover

High availability requires the ability to shut down a failing server so that it will not interfere with file system operations, allowing the backup (failover) server to assume its role. This control can be provided by using power distribution units (PDUs) or IPMI. To comply with this High Availability Configuration Specification, you must use either PDU control or IPMI, but not both.

Intelligent Platform Management Interface

High availability requires that you configure IPMI *or* power distribution units to support failover. The Intelligent Platform Management Interface (IPMI) enables server failover support. For this configuration, each managed server requires an IPMI controller that connects directly to the management network via a dedicated Ethernet port. A failing HA server is automatically power-cycled and access to its target storage devices is provided by the backup server. Power-cycling the failed server forces it to relinquish control of its resources and allows administrators to troubleshoot it.

After the failed server is repaired and ready for return-to-service, it is *not* automatically brought back online as the primary server (failed-back). Fail-back is performed manually, by the administrator at the Intel® Manager for Lustre* software GUI.

Note: See Issues Regarding Power Loss to the BMC or PDU

After you have connected and configured IPMI, see Appendix A, IPMI Checks.

Power Distribution Units

High availability requires that you configure IPMI *or* power distribution units to support failover. Power distribution units (PDUs) can be used to give control over the power supplied to a HA server to its peer server. If one server of an HA pair detects the failure of its peer server, the detecting server turns off power to the PDU outlets connected to the failing server. If you chose to use PDUs for power control, be sure to note which PDUs and outlets are connected to which servers. Also, for redundancy, be sure that the primary and backup power outlets connected to each server reside on different PDUs. After configuring PDUs and noting PDU/server assignments, you will later configure these assignments on the Intel® Manager for Lustre* Power Control tab.

Note: See Issues Regarding Power Loss to the BMC or PDU

Issues Regarding Power Loss to the BMC or PDU

Regarding failover, if the method of power control is not functioning (e.g., loss of power to the fencing device, misconfiguration, etc.), HA will be unable to fail the targets from the failed server to its failover server. This is because in order to complete failover, the failover server must be able to guarantee that the failed server can no longer access targets running on it. The only way to be sure this is true is to remove power from the failed server. Thus, the failover server must be able to communicate with the fencing device of the failed server for failover to occur successfully.

With IPMI, the power for each HA server and its fencing device is coupled together. Accordingly, there are more scenarios where both may lose power at once (chassis power failure, motherboard failure, etc.). If a server suffers chassis power failure such that the BMC is not operational, HA will be unable to fail the targets over. The remedy in this situation is to restore power to the chassis of the failed server to restore the functionality of your file system. If HA coverage for the scenarios just described is important to you, we strongly recommend using smart PDUs, rather than IPMI as your fencing device.

Power loss to a PDU will mean that HA will be unable to fail the targets over. As in the above situation, the remedy is to restore power to the PDU to restore the functionality of your file system. We recommend redundant PDUs if availability is critical.

Pre-Installation Tasks

What Not to Do

Please do *not* perform the following tasks, as these tasks (among others) are performed automatically, or will conflict with the software:

- Do **not** configure IP addresses for the crossover cable interfaces (server to target).
- Do **not** install or configure Lustre, Corosync, or Pacemaker. Install Intel® EE for Lustre* software only as described in this guide.
- Do **not** configure NTP on storage servers.
- When installing Red Hat Enterprise Linux or CentOS Linux, do **not** use the EPEL repositories. Uninstall EPEL-release on all systems if it is installed.
- Do **not** install CMAN (Cluster Manager) or other packages that use the Red Hat fence agents. Intel® Manager for Lustre* software will have package conflicts. Remove all such packages from all systems.

LNET Configuration

LNET provides the client network infrastructure required by the Lustre file system. It supports many commonly used network types such as InfiniBand and Ethernet.

Basic LNET configuration can be performed using the Intel® Manager for Lustre* GUI. This is done before creating the Lustre file system. In this early version of GUI-based LNET configuration, it is intended that the file system will exist on a *single* LNET and that all servers and clients are on this LNET. In this case, you can perform LNET configuration from the GUI and the configuration information is saved in a reserved file called /etc/modprobe.d/iml_lnet_module_parameters.conf. Do not manually edit this file. Simply follow the instructions in the Intel® Manager for Lustre* Help.

If you wish to configure more advanced features (such as routes and IP networks), then you should do this manually, in a separate file contained in the /etc/modprobe.d directory. Please see the configuration guide *Configuring LNet Routers for File Systems based on Intel® EE for Lustre* Software* and also see the *Lustre Operations Manual, Chapter 9 - Configuring Lustre Networking*: https://build.hpdd.intel.com/job/lustre-manual/lastSuccessfulBuild/artifact/lustre_manual.xhtml#configuringlnet

Server Configuration

The following are pre-installation configuration requirements for servers. These requirements apply to ALL servers unless specifically noted.

Note: If you are installing Lustre on servers that have been previously configured as ZFS file system servers, first re-provision all servers with the correct, supported operating system. Then install Lustre as described herein. *Any existing file system data will be lost*.

1. Red Hat Enterprise Linux or CentOS Linux version 7.3 must be installed. All servers should be running the same OS and version.
   - **Do not** use the EPEL repositories. Uninstall EPEL-release on all systems if it is installed.
   - Do **not** install CMAN (Cluster Manager) or other packages that use the Red Hat fence agents. Intel® Manager for Lustre* software will have package conflicts. Remove all such packages from all systems.
2. For servers running Red Hat Linux, each server must be registered with RHN (Red Hat Network) and have the optional channel installed. Following is one example of how to accomplish this. Please reference your site instructions for more information.

   ```
   subscription-manager register --autosubscribe
   --username=$redhat_register_user
   --password=$redhat_register_password
   ```

   ```
   yum -y install yum-utils
   ```

   ```
   yum-config-manager --enable rhel-7-server-optional-rpms
   ```
3. Next, you will need to configure hostname resolution of all Lustre nodes, on each Lustre node. Dynamic hostname resolution (DNS) can be used to perform this step. If DNS is not being used, you can perform this manually as follows:

Set useful hostnames and ensure you have a functioning /etc/hosts file. Give each server a unique name, such as manager, mds1, mds2, oss1 and oss2. You should be able to "ping <hostname>" and ssh freely between systems (dependent on a functional /etc/hosts file).

An /etc/hosts file might have something like this in it when complete:

```
"
10.0.0.101 manager
10.0.0.102  ost1
10.0.0.103  mds1
10.0.0.104  mds2
10.0.0.105  ost2
"
```

Copy your /etc/hosts file to all servers.

4. Use ssh-copy-id to copy your ssh public key to each server so that your servers are able to ssh into each other without having to enter a password.
5. Yum needs to be functional, with any needed proxies, and default yum repositories must be fully configured. Run yum update to verify that yum updates occur successfully. "yum search vim" will reveal if you cannot connect to your configured repositories.
6. Ensure that NTP is not running on any system. Intel® EE for Lustre* software will manage NTP.
7. Ensure that ssh root access "ssh -l root <hostname>" works from the server that will be hosting the Intel® Manager for Lustre* dashboard, to all other file system servers.
8. Properly configure the firewall to allow access to your distribution's yum repositories and any external NTP service. You should also be able to ssh between the Lustre servers and the manager server without having to enter a password.

Note: If a storage node (a Lustre server) is to be used as a metadata server (MDS), to properly enforce Lustre file permissions, the MDS *must have access* to the same UID/GID database as the Lustre clients. For example, if the Lustre clients are using LDAP to provide network-wide user account information, the MDS must be configured to check LDAP for user account information. If a pair of nodes has been configured as HA peers for an MDT, LDAP must be configured on both nodes to ensure proper functionality in the event of a failover.

Note: Non-root users should be prevented from logging into storage nodes.

Client Requirements

A client accessing your Lustre file system (created with Intel® Manager for Lustre* software) must be running Intel® EE for Lustre* 3.1.0.0 client software. See Configuring Clients for instructions on installing software and configuring clients.

LNET provides the client network infrastructure required by the Lustre file system and LNET must be configured for each client. See LNET Configuration.

Linux* Kernel Rebuilds and Patches

The installation of Intel® EE for Lustre* software will replace your existing Linux* kernel on all servers. If you require other kernel patches for your environment please contact Intel® for further assistance with this issue. For those who may need to rebuild a kernel, first contact Intel® support as rebuilding will over-write the kernel installed with Intel® EE for Lustre* software.

Firewall Considerations

Intel® Manager for Lustre* software runs on servers running RHEL or CentOS, version 7.3. The *firewalld* package needs to be installed and configured for *all file system servers before* installing Intel® EE for Lustre* software. The Intel® EE for Lustre* software installation process will then modify the firewall configuration as needed for Intel® EE for Lustre* software to operate.

Intel® EE for Lustre* Software Installation

This section describes how to install the Intel® EE for Lustre* software and the Intel® Manager for Lustre* software on the *manager server.*

After Intel® EE for Lustre* and Intel® Manager for Lustre* software is installed, point your web browser to the Intel® Manager for Lustre* dashboard. Use Chrome* or Firefox*. A display monitor with a minimum resolution of 1024 X 768 pixels is recommended, to adequately display the Intel® Manager for Lustre* software GUI.

Note: Later, when adding storage servers to your Lustre file system, the Intel® Manager for Lustre* agent, Intel® EE for Lustre* software, and specific dependencies (e.g.: for Corosync and Pacemaker) are automatically deployed to the storage server. This avoids the need to manually install the Intel® EE for Lustre* software on storage servers and avoids possible errors.

Note: Some installations may opt to deploy and configure a Lustre file system manually, without Intel® Manager for Lustre* software. Other installations may opt to deploy and configure a Lustre file system and then later install Intel® Manager for Lustre* software to be

used in Monitor-only mode. The overall release tarball is ee-3.1.0.0.tar.gz. To deploy and configure Lustre manually, see Installing and Configuring Lustre Manually.

For information regarding installing and configuring Lustre, see Part II of the *Lustre Operations Manual*. This information is available at the following URL. If this page does not load, copy and paste it into your browser.

https://build.hpdd.intel.com/job/lustre-manual/lastSuccessfulBuild/artifact/lustre_manual.xhtml#part.installconfig

Installing Intel® EE for Lustre* software

You will need the following information to perform this installation:

- The name, email address, and password you wish to use for the first Intel® Manager for Lustre* software superuser. The email address must use an FQDN.
- (Optional) The fully qualified domain name (FQDN) of the NTP server (internal or external) used for your site. If no NTP server is set, the Intel® Manager for Lustre* server's clock will act as the time source for the entire storage cluster.

To install the software, complete these steps:

1. Download the installation archive to a directory on the manager server (e.g. /tmp).
2. Unpack the installation archive using tar: ee-3.1.0.0.tar.gz
   ```
   # cd /tmp; mkdir install
   # tar –C install –xzf ee-3.1.0.0.tar.gz
   ```
3. To install the Intel® EE for Lustre* software, run:
   ```
   # cd /tmp/install/ ee-3.1.0.0
   # ./install
   ```
4. When the prompts below appear, enter your parameters for the first superuser of Intel® Manager for Lustre*:

   Username: *<Enter the name of the superuser>*

   Password: *<Enter a password>*

   Confirm password: *<Enter the password again>*

   Email: *<Enter an email address for the superuser>*

   Note: Additional Intel® Manager for Lustre* software superusers as well as file system administrators and users can be created in the manager GUI.

   When configuration is complete, a message is displayed indicating the installation was successful.

5. When the prompt **NTP Server [localhost]** appears, respond with *one of these options*:
   - *Option 1:* To designate the NTP server (internal or external) used for your site, enter the FQDN or IP address of the NTP server and press the **<Enter>** key.
   - *Option 2:* To use the Intel® Manager for Lustre* software server's clock as the time source, press the **<Enter>** key.
6. Using `ifconfig`, obtain the IP address of the administrative network interface for the server hosting Intel® Manager for Lustre* software. The default network interface for Intel® Manager for Lustre* software is `eth0`.
7. Open a web browser and access the Intel® Manager for Lustre* software GUI using the server IP address obtained in the previous step. Enter in the address field of your browser:

   `https://<command_center_server_IP_address>/`

   Note: If the IP address of the server has an associated FQDN, you can connect to the Intel® Manager for Lustre* GUI user interface using:

   `https://< command_center_server_fqdn>/`

Note: The GUI uses a self-signed SSL certificate to secure communications between the browser and the server. You will need to accept this certificate in order to connect to the Intel® Manager for Lustre* GUI. A certificate can be downloaded from (example only):
https://<manager-addr>/certificate/

After Intel® EE for Lustre* software is installed, point your web browser to the Intel® Manager for Lustre* dashboard. Use Chrome* or Firefox*.

Configuring Intel® Manager for Lustre* software

The Intel® Manager for Lustre* software configuration settings shown in the following table can be modified.

Configuration Setting	***Default***	***Description***
`ALLOW_ANONYMOUS_READ`	`True` (upper case first letter is required)	Allows anonymous (unauthenticated) users to view statistics, logs and status of a system in the Intel® Manager for Lustre* GUI but not to make any changes. If set to `False`, anonymous users will be presented with a login prompt and no data.
`EMAIL_HOST`	`None`	SMTP server hostname (Example: `'server1.test.com'`)
`EMAIL_PORT`	`25`	SMTP server port number
`EMAIL_HOST_USER`	`''`	SMTP server username (or `''`)
`EMAIL_HOST_PASSWORD`	`''`	SMTP server password (or `''`)
`EMAIL_USE_TLS`	`False` (upper case first letter is required)	`True` indicates that TLS/SSL is to be used. `False` indicates it is not to be used.
`EMAIL_SENDER`	`'noreply@<command_center server_fqdn>'`	Address that appears in the *From* field on alert emails

To change these configuration settings:

1. Use a text editor to create or modify a file `local_settings.py` in the directory `/usr/share/chroma-manager/`

   For example, add the following setting to the `local_settings.py` file to restrict view of system statistics, logs, and status to only users who are logged in:

   ```
   ALLOW_ANONYMOUS_READ=False
   ```

   In this example, the first letter of `False` must be capitalized.

   Note: Entries must follow Python* syntax rules. For example, all strings must be enclosed in single or double quotes (double quotes must be used if the string includes a single quote). For example, `EMAIL_HOST=server1.test.com` will result in an error, while `EMAIL_HOST='server1.test.com'` is a valid entry.

   Warning: If you edit the file `settings.py` instead of creating a `local_settings.py` file, your changes will be overwritten without warning when the Intel® Manager for Lustre* software is updated.

2. To configure email alerts, complete one of the options below. By default, email alerts from the Intel® Manager for Lustre* software are disabled (`EMAIL_HOST` set to `None`).
   - *Option 1: Set up an external mail server.* Create or modify the file `/usr/share/chroma-manager/local_settings.py` to provide appropriate values for these settings:
     a. Set `EMAIL_SENDER` to an address suitable for your site.
     b. Modify `EMAIL_HOST` (and other server settings if necessary) to point to an existing SMTP server on your network.
   - *Option 2: Use a local mail server.* If a suitable SMTP server is not available, you can configure the Intel® Manager for Lustre* software server to act as an SMTP server:
     a. Set `EMAIL_SENDER` to an address suitable for your site.
     b. Set up a local mail daemon using standard procedures for Red Hat Enterprise Linux or CentOS such as those described in the Red Hat documentation at: https://access.redhat.com/site/documentation/en-US/Red_Hat_Enterprise_Linux/6/html/Deployment_Guide/
     c. Set `EMAIL_HOST` to `'localhost'`
3. Run the chroma configuration tool in order to effect changes made to `local_settings.py`.

   ```
   # chroma-config restart
   ```

For configuring user accounts, see the online Help in the Intel® Manager for Lustre* software. The online Help also provides instructions for creating, monitoring, and managing your Lustre file systems.

Creating a Managed Lustre File System

After Intel® EE for Lustre* software is installed, point your web browser to the Intel® Manager for Lustre* dashboard. Use Chrome* or Firefox*.

For complete instructions on adding servers, configuring LNET, assigning primary and failover servers, configuring PDUs or IPMI, and creating a Lustre file system, see the Intel® Manager for Lustre* online Help.

Adding Storage Servers to a Lustre File System

Adding a storage server consists of identifying that server to Intel® Manager for Lustre* software, using either the manager GUI or the Intel® Manager for Lustre* command line interface. A server can be added to an existing file system that was previously discovered and

is visible to Intel® Manager for Lustre* software in monitor-only mode, or a server can be added to a managed, HA file system created using Intel® Manager for Lustre* software.

For managed, HA file systems, when the server is identified, the Intel® Manager for Lustre* agent, Intel® EE for Lustre* software, and specific dependencies (e.g. for Corosync and Pacemaker) are automatically deployed to the new storage server. This simplifies software installation and avoids possible errors.

When the above software is automatically installed on a server, the server becomes capable of running Lustre services for attached storage targets like the MGT, MDT, and OSTs, thereby acting as a gateway between these targets and the network.

The Lustre file system on the storage servers is configured from the Intel® Manager for Lustre* software GUI, or the supported command line interface.

Storage servers are typically deployed in a high availability (HA) configuration with shared storage. When a server becomes unavailable, Lustre services for targets that were running on that server are started on another server attached to the same storage (known as "failover").

For complete instructions on adding servers, assigning primary and failover servers, configuring PDUs or IPMI, and creating a Lustre file system, see the Intel® Manager for Lustre* online Help.

Note: Installing Intel® EE for Lustre* software automatically disables SELinux on all storage servers, because the Lustre file system software is not compatible with SELinux. Installation also configures firewalls on the manager and storage servers.

Administering a Lustre File System

WARNING: *To manage Lustre file systems from the command line, you must use the Intel® Manager for Lustre* command line interface (CLI).*

WARNING*: Modifying a file system manually from a shell on a storage server will interfere with the ability of the Intel® Manager for Lustre* software to manage and monitor the file system.*

Storage servers created in the manager GUI can be managed using the manager GUI or the command line interface. For information about using the CLI, see the Intel® Manager for Lustre* online Help topic*, Using the command line interface*.

Configuring Clients

A client (compute node) accessing a storage appliance must be running Intel® EE for Lustre* 3.1.0.0 client software. The Lustre file system must first be created or discovered at the Intel® Manager for Lustre* dashboard (see the Intel® Manager for Lustre* Online Help to do this). The Lustre client software must be installed on the client, and then the Lustre file system can be mounted on the client as described on the Online Help.

Client Requirements

Each file system client must be running Red Hat Enterprise Linux (RHEL) or CentOS Linux, version 6.8 or 7.3.

Notes:

- Before using the Red Hat or RHEL software referenced herein, please refer to Red Hat's website for more information, including without limitation, information regarding the mitigation of potential security vulnerabilities in the Red Hat software.
- Client support for el6 is distributed in the ee-contrib-3.1.0.0/el6/lustre-client-<lu-version>-bundle.tar.gz tarball.

Intel® EE for Lustre* software may be installed on file system *servers and clients* running SUSE Linux Enterprise version 11 with SP4, and on clients-only running SLES12 with SP1. However, for SLES installations, Intel® Manager for Lustre* software is *not supported or installed.* As a result, automatic configuration and/or monitoring of high availability is not supported by Intel® Manager for Lustre* software on installations running SUSE.

For information about clients running SUSE, see Installing Lustre on SUSE Linux Enterprise Server.

LNET provides the client network infrastructure required by the Lustre file system and LNET must be configured for each client. See LNET Configuration.

Installing Intel® EE for Lustre* software on Clients Running RHEL or CentOS

The following instructions detail how to install and configure client software.

The following Lustre packages are installed on clients:

`lustre-client-modules-<ver>`	Lustre module RPM for clients.
`lustre-client-<ver>`	Lustre utilities for clients.

To configure a Lustre client running RHEL or CentOS version 6.8, perform these steps:

1. Download the Lustre client RPMs for your platform from the Lustre* Releases repository. See Table 8.3, "Packages Installed on Lustre Clients" for a list of required packages. (You may need to paste the URL in a browser.)
2. Install the Lustre client packages on all Lustre clients.

Note: The version of the kernel running on a Lustre client must be the same as the version of the `lustre-client-modules-ver` package being installed. If not, a compatible kernel must be installed on the client before the Lustre client packages are installed.

   a. Log onto a Lustre client as the root user.
   b. Use the yum command to install the packages:

      ```
      # yum --nogpgcheck install pkg1.rpm pkg2.rpm …
      ```

   c. Verify the packages were installed correctly:

      ```
      # rpm -qa|egrep "lustre|kernel"|sort
      ```

   d. Reboot the client.
   e. Repeat these steps on each Lustre client.

3. Configure LNET on the client.
4. Launch Intel® Manager for Lustre* software and login as administrator. Go to the manager GUI to obtain mount point information:
   a. Go to **Configuration** > **File Systems.**
   b. In the table listing available file systems, click the name of the file system to be accessed by the client. A page showing file system details will be displayed.
   c. Click **View Client Mount Information**. The mount command to be used to mount the file system will be displayed as shown in this example:

      ```
      mount -t lustre 10.214.13.245@tcp0:/test /mnt/test
      ```

5. On the client, enter the mount command provided.

To configure a Lustre client running RHEL or CentOS version 7.3, perform these steps:

1. For clients running RHEL or CentOS version 7.3, add a client repository with the following command.
   ```
   # yum-config-manager --add-repo=
   https://<command_center_server>/client/7
   ```
2. This will create a file in /etc/yum.repos.d named `<server.fqdn>_client.repo` (e.g. foo.bar.baz_client.repo)
3. Edit the generated file `<server.fqdn>_client.repo` and add the following lines at the end of the file:
   ```
   sslverify = 0
   gpgcheck = 0
   ```
   Then save and close.
4. Install the required Lustre packages on each client:
   a. Enter (on one line):

      ```
      # yum install lustre-client-modules-<ver>.<arch>.rpm
      ```

b. Update the bootloader (`grub.conf` or `lilo.conf`) configuration file as needed.

   Note: Verify that the bootloader configuration file has been updated with an entry for the new kernel. Before you can boot to a kernel, an entry for it must be included in the bootloader configuration file. Often it is added automatically when the kernel RPM is installed.

5. Launch Intel® Manager for Lustre* software and login as administrator. Go to the manager GUI to obtain mount point information:

   d. Go to **Configuration** > **File Systems.**

   e. In the table listing available file systems, click the name of the file system to be accessed by the client. A page showing file system details will be displayed.

   f. Click **View Client Mount Information**. The mount command to be used to mount the file system will be displayed as shown in this example:

   ```
   mount -t lustre 10.214.13.245@tcp0:/test /mnt/test
   ```

6. On the client, enter the mount command provided.

Installing Lustre on SUSE Linux Enterprise Server

Intel® EE for Lustre* software may be installed on file system servers and clients running SUSE Linux Enterprise version 11 with SP4, and on clients only running SLES12 with SP1. Note that for SLES, the Intel® Manager for Lustre* software *is not supported or installed*. Automatic configuration or monitoring of Lustre file systems using the Intel® Manager for Lustre* dashboard is not supported.

The overall release tarball is ee-contrib-3.1.0.0.tar.gz. To install Lustre manually on SUSE Linux Enterprise, use these packages:

- SLES e2fsprogs packages: ee-contrib-3.1.0.0/sles11/ sles11-e2fsprogs-1.42.13.wc5-bundle.tar.gz
- SLES Lustre server packages: ee-contrib-3.1.0.0/ sles11/sles11-lustre-server-2.7.19.6-bundle.tar.gz
- SLES Lustre client packages: ee-contrib-3.1.0.0/ sles11/ sles11-lustre-client-2.7.19.6-bundle.tar.gz

To install Lustre manually on clients, running SLES version 12, install this package:

- SLES Lustre client packages: ee-contrib-3.1.0.0/ sles12/sles12-lustre-client-2.7.19.6-bundle.tar.gz

For information regarding installing and configuring Lustre, see Part II of the Lustre Operations Manual. This is available at the following URL. If this page does not load, copy and paste it into your browser.

https://build.hpdd.intel.com/job/lustre-manual/lastSuccessfulBuild/artifact/lustre_manual.xhtml#part.installconfig

Installing and Configuring Lustre Manually

Some installations may opt to deploy and configure a Lustre file system manually, without Intel® Manager for Lustre* software. Other installations may opt to deploy and configure a Lustre file system and then later install Intel® Manager for Lustre* software to be used in Monitor-only- mode.

The overall release tarball is ee-3.1.0.0.tar.gz. To deploy and configure Lustre manually, use these packages:

- Lustre server packages:lustre-2.7.19.6-bundle.tar.gz
- Lustre client packages:lustre-client-2.7.19.6-bundle.tar.gz
- e2fsprogs packages: e2fsprogs-1.42.13.wc5-bundle.tar.gz

For information regarding installing and configuring Lustre, see Part II of the Lustre Operations Manual. This is available at the following URL. If this page does not load, copy and paste it into your browser.

https://build.hpdd.intel.com/job/lustre-manual/lastSuccessfulBuild/artifact/lustre_manual.xhtml#part.installconfig

Installing Intel® EE for Lustre* software on Intel® Xeon Phi™ Coprocessors

Install Lustre* client on an Intel® Xeon Phi™ Coprocessor

To install Lustre, install the following two RPMs on the Intel® Xeon Phi™ coprocessor (not on the host).

```
# rpm –ivh lustre-client-mic-<version>.x86_64.rpm
# lustre-client-mic-modules-<version>.x86_64.rpm
```

In case of issues with dependencies, add the –nodeps option.

After restarting the MPSS service, the Lustre client will appear on the coprocessor card.

Configure Lustre for the Intel® Xeon Phi™ Coprocessor

Configuring Lustre for the Xeon Phi Coprocessor is easy. You only need to specify the LNET configuration in /etc/modprobe.d/lustre.conf file.

To check configuration, enter the following commands.

```
# ssh mic0
# echo “options lnet networks=\"o2ib0(ib0)\"”
>/etc/modprobe.d/lustre.conf
# modprobe lustre
# mkdir -p /mnt/lustre
# mount.lustre <MGS_IP>@o2ib0:/<lustre_FS_name> /mnt/lustre
```

To make this configuration persistent across re-boots, enter the following commands (where “X” is the card number).

```
# mkdir -p /var/mpss/micX/mnt/lustrefs
# echo 'dir /mnt/lustrefs 0755 0 0' >> /var/mpss/micX.filelist
# mkdir -p /var/mpss/micX/etc/modprobe.d
# cp /etc/modprobe.d/lustre.conf /var/mpss/micX/etc/modprobe.d/
(or just create it in /var/mpss/micX/etc/modprobe.d/)
# echo 'file /etc/modprobe.d/lustre.conf etc/modprobe.d/lustre.conf
0644 0 0' >> /var/mpss/micX.filelist
```

General Troubleshooting

Consider the following tips before contacting technical support as you may find this information useful when debugging an issue:

- Locate the logs in `/var/log/chroma`.
- If an issue is encountered in the user interface and you have access to a JavaScript* debug console, open the console.
- If a command has failed, go to *Notifications* > *Commands* and click on the command that failed to display a detailed message.

Troubleshooting information for known issues you may encounter is provided below. Also, see Getting Help.

***Problem:* When you run `chroma-config`, a message is displayed that includes the following: “*Please correct the hostname resolution.*”**

Solution: Verify that hostname resolution is set up correctly using these commands:

1. Obtain the IP address for the network interface. The default network interface is `eth0`. Enter (on one line):

   ```
   # ifconfig <network_interface_name> | grep "inet addr" |
    awk -F" " {'print $2'}
   ```

   Use the output of this step in the next step.

2. Obtain the hostname of the server by entering:

   ```
   # getent hosts <network_interface_ip_address>
   ```

   Use the output of this step in the next step.

3. Obtain the IP address of the server by entering:

   ```
   # getent hosts <hostname>
   ```

If all these commands return the same *hostname* and *IP address*, your hostname server is set up correctly.

Problem: **An error message is displayed after you have modified the Command Center configuration file `local_settings.py`.**

Solution: To find the error, look for a line containing "local_settings.py" and check the following text for clues to the error. In the example below, the value of the configuration setting `ALLOW_ANONYMOUS_READ` starts with a lower case letter.

```
File "/usr/share/chroma-manager/local_settings.py", line 1, in
<module>
  ALLOW_ANONYMOUS_READ=true
NameError: name 'true' is not defined
```

The correct value `True` starts with an upper case letter as shown below:

```
ALLOW_ANONYMOUS_READ=True
```

Python syntax rules must be followed for configuration settings. For example, strings must be enclosed in single or double quotes (use double quotes if the string includes a single quote). For example, the value of the SMTP server host name defined for `EMAIL_HOST` must be enclosed in single quotes as shown below:

```
EMAIL_HOST='server1.test.com'
```

Problem: **The time displayed in the Command Center is not correct.**

Solution: Check the time zone settings of the server and your browser. The local time displayed in the Command Center user interface is based on UTC and the time zone settings on both the server and the browser host.

Problem: **You are unable to manage a storage server from the Command Center after entering a Lustre command (such as `umount/mkfs`) on the server command line.**

Solution: A storage server cannot be managed using Lustre commands on the storage server command line. For recovery assistance, contact your Intel® technical support representative.

Problem: **You need to take a server out of service temporarily for a repair that may involve starting and stopping the server several times.**

Solution: When you take the server out of service in a system configured for HA, the Command Center will failover the targets on that server to its failover server.

After completing the repair and putting the server back in service, force a manual failback of a target to its primary server, by completing these steps in the Command Center Manager user interface:

1. Go to **Configuration** > **File Systems** and select the file system to be modified.
2. In the entry for the target to be failed back, click **Actions** menu **Failback** button.

For more details about manually performing failover and failback operations, see the Intel® Manager for Lustre* online Help topic, *Managing storage*.

Problem: **You need to restart cleanly after a power outage to some, or all, of your cluster.**

Solution: Start the targets that lost power and monitor the alert next to each target in the Command Center for completion of the recovery process. Check that failover and failback operations have restored the original cluster configuration.

Problem: **The Command Center is displaying an alert *"NIDS changed on server <hostname>"* and your file system won't start.**

Solution: File system targets use a network address or network ID (NID) to refer to the server they are associated with. A storage server NID may change if the network connecting the Lustre servers and clients is modified. If a Lustre server NID changes, the server NID record in the Command Center must be updated.

For a procedure to update server NIDS, see the Intel® Manager for Lustre* online Help topic, *Handling network address changes*.

Problem: **You are unable to create or read a file from a client and a "*Permission denied*" message is displayed.**

Solution: To properly enforce Lustre file permissions, the MDS must have access to the same UID/GID database as the Lustre clients. For example, if the Lustre clients are using LDAP to provide network-wide user account information, the MDS must be configured to check LDAP for user account information. If a pair of nodes has been configured as HA peers for an MDT, then LDAP must be configured on both nodes to ensure proper functionality in the event of a failover.

Updating the Operating System

Intel® EE for Lustre* software release 3.1.0.0 runs on servers and clients running RHEL or CentOS, version 7.3; client only support is available on version 6.8. To update the OS, see the software documentation provided by the OS vendor. All Lustre servers must be running the same OS and version.

Installing Updates to Intel® EE for Lustre* software

Note: Perform any OS update prior to updating the Intel® EE for Lustre* software.

Note: Updates are only supported for official releases. Updates from, or to, test releases are not specifically supported.

Upgrading Intel® EE for Lustre* software and restarting the manager server will overwrite any changes previously made to the chroma-manager.conf template in /etc/httpd/conf.d/. Before upgrading your installation or restarting your manager node, make sure you backup any modifications to this file first.

Due to a dependency in the update process in previous releases, please take note of the following update path. Please perform the following update in the order listed, based on your currently installed version of Intel® EE for Lustre* software.

1. If your currently installed software version is 2.0.0.0 , update to version 2.0.1.1 first. Then perform the following consecutive updates in the remaining steps.
2. If your currently installed software version is 2.0.1.1, update to version 2.2.0.2 first. Then perform the following consecutive updates in the remaining steps.
3. If your currently installed software version is 2.2.0.2 or later, update directly to version 3.1.0.0.

Performing a version downgrade or rollback is not supported.

To install an update of Intel® EE for Lustre* software on the manager server and then all file system managed servers, do the following:

1. Stop the file system. To do this, click **Configuration** > **File Systems**. Then under **Actions**, click **Stop**.
2. Some servers may belong to multiple file systems. This means that if you stop one file system, such a server is still running in support of the other file system(s). Be sure to stop all file systems that share a server with your candidate file system.
3. Perform the installation procedure herein: Installing Intel® EE for Lustre* software. The installation will detect that this is an update and install the appropriate files. Use that procedure to verify successful installation.
4. After the updated Intel® EE for Lustre* software is installed, point your web browser to the Intel® Manager for Lustre* dashboard. Use Chrome* or Firefox*. Be sure to refresh the browser cache, i.e., force a fresh reload of the updated dashboard.
5. With the updated release of Intel® Manager for Lustre* software installed at the manager server, a notification is displayed on the Servers page that an update is available for installation on managed servers. On the **Servers** page, click **Install Updates**.
6. Each server row in the table will contain a **Selected** toggle button in its corresponding **Select Server** column. Select all servers that you wish to update and click the Install Updates button. This completes the update process for the manager server and all managed servers.
7. When all servers have been updated, restart the file system(s) that were stopped for this update.

Appendix A - IPMI Checks

Procedures provided in this appendix can be used to establish a level of confidence that your IPMI implementation is functional. Note that IPMI implementations can be problematic, and while these procedures can provide a level of confidence, absolute assurance from Intel® that your particular IPMI implementation will operate error-free is not possible.

IPMI Platform Check

Perform the following steps:

1. Identify the BMC model number on all servers.
2. Identify the BMC firmware revision on all servers.
3. Ensure that the BMC model number and firmware revision are the same on all servers.
4. Using the fence_ipmilan utility provided by the fence-agents RPM on Red Hat/CentOS, verify that the following commands complete successfully:
   a. fence_ipmilan -a <BMC ADDRESS> -l <BMC USERNAME> -p <BMC PASSWORD> -o monitor
   b. fence_ipmilan -a <BMC ADDRESS> -l <BMC USERNAME> -p <BMC PASSWORD> -o status
   c. fence_ipmilan -a <BMC ADDRESS> -l <BMC USERNAME> -p <BMC PASSWORD> -o reboot
   d. fence_ipmilan -a <BMC ADDRESS> -l <BMC USERNAME> -p <BMC PASSWORD> -o off
   e. fence_ipmilan -a <BMC ADDRESS> -l <BMC USERNAME> -p <BMC PASSWORD> -o on

This process could run some combination of these commands over an extended period (e.g., monitor every 30 seconds or so with periodic power commands), for each BMC.

Appendix B - Backing up and Restoring Intel® Manager for Lustre* Server Software

An effective system recovery strategy requires that the administrator maintains a current backup of critical files and implements a reliable and repeatable method for restoring the platform to working condition.

This chapter provides guidance on how to conduct a full recovery of the Intel® Manager for Lustre* server from a combination of the original installation media and a backup manifest of the Intel® Manager for Lustre* software. The manifest will describe the essential files required in order to restore Intel® Manager for Lustre* software (referred to herein as “manager software”) and its management of existing file systems to the point of the last successful backup. From these instructions, administrators can define a recovery process that is compatible with their own environment.

This chapter discusses backup and recovery of the manager software, including the configuration information for Lustre file systems being managed and/or monitored by the manager software. Backup and restoration of data held on any Lustre file system is not within the scope of this document.

While no specific recommendations for backup technologies, server provisioning tools, or infrastructure are made, system managers should consider investment in an automated OS provisioning system for the consistent deployment and recovery of the base operating platform for any computer. Several options exist for server provisioning systems; these include template-driven installations such as Kickstart (which is used by Red Hat Enterprise Linux and derivative platforms such as CentOS and Fedora). Systems such as Symantec Ghost and the open source PING project install servers from a "golden" binary image. For larger enterprises, there are comprehensive network operations management software suites that cover management for the entire production life-cycle of IT assets.

The processes described herein assume that the operating system can be redeployed in a consistent and repeatable manner, so that repeated installations have a known outcome. The following instructions assume the server’s operating system has been fully installed. From there, this section describes how to fully restore the manager software, including the configuration information for Lustre file systems being managed and/or monitored by the manager software, from the last complete backup made of the manager software backup manifest.

Backup Overview

Backup and recovery of the IML server software platform involves the following components:

- Operating system installation and configuration, to include:
    - File system layout

  - Core packages
  - Boot loader
  - Date, time and language
  - Network configuration
  - Name service (`/etc/resolv.conf`) and hosts table (`/etc/hosts`)
  - Package Update management environment (RPM & YUM)
  - Identity configuration
    - User databases (`/etc/passwd`, `/etc/shadow`, `/etc/group`, `/etc/gshadow`)
    - Name service switch (`/etc/nsswitch.conf`)
    - Superuser privilege management (Sudo)
  - Security configuration
    - IPTables
    - SELinux
    - PAM
    - SSH keys (host and user)
- Intel® Manager for Lustre* software installation and configuration
  - Additional packages required by IML (installation will attempt to automatically resolve package dependencies via YUM)
  - Messaging services
  - NTP configuration
  - SSL Certificates
  - Data Storage Management (PostgreSQL RDBMS)

Rather than rely upon a standard backup of the operating platform root disks, an alternative strategy of creating a repeatable build procedure from first principals will deliver a more predictable mechanism in the long term. Building servers to a recipe makes it easier to audit installations for correctness by being able to compare the manifest (recipe) to the deployed instance, as well as making it easier to track and deploy changes. This also reduces reliance on backup infrastructure for recovery, allowing one to concentrate backup efforts on those critical data sets that cannot be reproduced. This will generally reduce overall recovery times by reducing the amount of data that must be restored from the backup infrastructure (which is often tape-based and bandwidth-constrained).

Example Backup Checklist

The following is an example checklist of high-level tasks to perform in executing a backup. Perform these tasks before restoring the Intel® Manager for Lustre* service.

- Save the Kickstart Template from OS Installation (or create one)
- Save OS network configuration (can be included in Kickstart template)
- Save YUM configuration
- Save user configuration
- Save SSH host keys [optional]
- Save SSH root user keys [optional]
- Run IML Installer
- Save NTP configuration
- Save Intel® Manager for Lustre* server SSL Certificates
- Execute PostgreSQL Backup (execute on a regular schedule)

Operating System

The operating system that hosts the IML software must be deployed in a consistent and repeatable manner. For Red Hat Enterprise Linux and derivative operating systems, template-driven provisioning using Kickstart has proven to be reliable and straightforward to audit. RHEL-based operating systems generate a Kickstart template during the normal, media-based installation process and this can be a very effective starting point for developing a fully automated installation process.

An alternative to template-driven OS provisioning is to develop a binary image that is ready to be written directly to bare storage on the server. Image-based platforms can be more difficult to maintain and audit, but are often faster to deploy and are especially effective when the underlying hardware platform is guaranteed to be consistent over the operational life-span of the service.

Regardless of the mechanism, the operating system installation and recovery is usually driven from a description of the end-state, rather than from a backup in the purest sense. It is assumed that the core operating system changes infrequently and that any changes are automatically incorporated into the provisioning platform (either by editing the template or updating the "golden" image). It is further assumed that there is nothing in the data held by the core OS that requires routine archival. If this is not the case, additional procedures may be required to ensure that relevant data is persistently and reliably backed up

Operating system requirements are covered in this guide under Manager Server Requirements. The following example Kickstart template describes a basic platform with a

small set of packages and two network interfaces: one for provisioning the OS and connection to external infrastructure, and the other for connection to the Intel® EE for Lustre* management network.

An example Kickstart template:

```
install
text
reboot
url --url=http://10.0.1.1/CS6.4/
lang en_US.UTF-8
keyboard us
network --hostname ee-iml --onboot yes --device eth0 --bootproto
static --ip 10.0.2.1 --netmask 255.255.0.0 --gateway 10.0.0.1 --
noipv6 --nameserver 8.8.8.8
network --onboot yes --device eth1 --bootproto static --ip 10.1.0.1
--netmask 255.255.0.0 --noipv6
rootpw  --iscrypted xyzzy
firewall --disabled
selinux --disabled
authconfig --enableshadow --passalgo=sha512
timezone --utc America/New_York
bootloader --location=mbr --driveorder=vda --
append="crashkernel=auto console=ttyS0,115200 rd_NO_PLYMOUTH"
zerombr
clearpart --all --initlabel --drives=vda
autopart
repo --name="CentOS" --baseurl=http://10.0.1.1/CS6.8/ --cost=100

%packages
@core
@base
%end
```

Kickstart templates are flexible and powerful, and can be extended with the addition of pre- and post-install scripts. With a modest amount of effort, the entire operating system installation can be fully automated.

Host Name Resolution

The hosts database `/etc/hosts` often contains the names and IP addresses of all of the assets managed by the manager software; include a copy of this file in the operating system manifest. The file `/etc/resolv.conf` contains the list of DNS name servers in use on the network; include a copy of this file in the manifest as well.

Package Update management environment (RPM & YUM)

The YUM configuration file `/etc/yum.conf` and files located at `/etc/yum.repos.d/*` must be configured so that package dependencies for Intel® Manager for Lustre* software can be automatically installed.

Identity configuration

Ensure that any local user information is appropriately accounted for, including:

- User databases (i.e., `/etc/passwd`, `/etc/shadow`, `/etc/group`, `/etc/gshadow`)
- Superuser privilege management (Sudo)
- Name service switch (`/etc/nsswitch.conf`)

Security configuration

Include the security configuration in the operating system's provisioning or backup manifest, including firewall rules (IPTables), Security Enhanced Linux (must be disabled), pluggable authentication modules (PAMs) and SSH (including Host and User keys).

Intel® Manager for Lustre* software

The Intel® Manager for Lustre* software is distributed with an installation program that makes deployment straightforward, predictable, and repeatable. The installer works to automatically resolve any software package dependencies, and also initializes the platform and configures essential services, such as the PostgreSQL database used for recording information, and the RabbitMQ messaging system.

To support the restoration of the Intel® Manager for Lustre* software, be sure to regularly back-up of the PostgresSQL database. This is necessary because the database persistently records Intel® Manager for Lustre* software configuration information.

Also, be sure to archive the SSL certificates generated during the installation process. With these two items, along with the original software distribution, one can reliably recover a manager server instance to working condition after data loss, or replace an irrevocably damaged manager server with a new platform, quickly and with minimal disruption.

To minimize data loss due to loss of a manager server instance, database backups must be run on a regular schedule and be captured to a persistent storage target that is external to the Intel® Manager for Lustre* server itself. The interval between backups determines the level of risk of data loss. We strongly recommend that a point-in-time backup is taken directly after completing any major change management activity, such as adding new servers or file systems.

Creating a Backup Manifest for the Intel® Manager for Lustre* Server

This section provides a subset of the information required to rebuild a server from the base operating system install. We do not cover OS installation here. Instructions in this section are executed as the root superuser on an example server configuration, for the purposes of demonstration. Procedures for copying the resulting data off the manager server to a reliable medium are not given, but can be achieved with a simple secure copy (e.g., scp) from the source to a destination system or an integrated enterprise backup platform.

Network Configuration Files

```
mkdir -p $HOME/backup/etc/sysconfig
cp -a /etc/sysconfig/network /etc/sysconfig/network-scripts/ifcfg-*
$HOME/backup/etc/sysconfig/.
cp -p /etc/hosts $HOME/backup/etc/.
cp -p /etc/resolv.conf $HOME/backup/etc/.
cp -p /etc/nsswitch.conf $HOME/backup/etc/.
```

YUM Configuration

```
mkdir -p $HOME/backup/etc
cp /etc/yum.conf $HOME/backup/etc/.
cp -a /etc/yum.repos.d/* $HOME/backup/etc/.
```

User Configuration

```
mkdir -p $HOME/backup/etc
cp -p /etc/passwd $HOME/backup/etc/.
cp -p /etc/shadow $HOME/backup/etc/.
cp -p /etc/group $HOME/backup/etc/.
cp -p /etc/gshadow $HOME/backup/etc/.
cp -p /etc/sudoers $HOME/backup/etc/.
```

SSH Host keys (Optional)

SSH creates a set of host keys to identify computers. These are automatically generated the first time that the OpenSSH service is started on a computer and change every time that the operating system is re-installed or if the original host keys, stored in the /etc/ssh directory, are deleted. Changing the host key effectively changes the identity of the computer and breaks any trust that has already been established between other computers on the network. In general, this is a desirable feature and can protect systems from server spoofing attacks (e.g. man-in-the-middle attacks). However, when restoring a server to production, consider restoring the original credentials of the host as well. Keep in mind that the backup must be protected from compromise in order to prevent the SSH key pair from being misappropriated.

Accordingly, this step is optional, but it can be useful if one wants to re-create the original server as closely as possible.

```
mkdir -p $HOME/backup/etc/ssh
cp -p /etc/ssh/ssh_host*key* $HOME/backup/etc/ssh/.
```

SSH user keys (Optional)

Intel® Manager for Lustre* software has several mechanisms available for establishing trust between itself and the servers that it manages. One of the most common mechanisms used during server discovery, is to create a passphrase-less SSH public/private key pair for the root super-user account and distribute the public key to the root user account on all of the servers that will be managed by the manager software. Loss of the private key stored on the manager server means that the SSH key-pair will need to be regenerated and the public key redistributed to all hosts.

For RSA keys:

```
mkdir -m 0700 -p $HOME/backup/root/.ssh
cp -p /root/.ssh/id_rsa* $HOME/backup/root/.ssh/.
```

For DSA keys:

```
mkdir -m 0700 -p $HOME/backup/root/.ssh
cp /root/.ssh/id_dsa* $HOME/backup/etc/root/.ssh/.
```

As with the SSH host keys, this practice is not generally recommended because the backup must be protected from compromise in order to prevent the SSH key pair from being misappropriated. In any case, be aware that if the IML server is lost, the SSH keys will need to be either recovered or regenerated and the public keys redistributed to all targets.

NTP Configuration

The Intel® Manager for Lustre* software installation program will generate an NTP configuration file. After installation completes, create a backup of the resulting file:

```
mkdir -p $HOME/backup/etc
cp /etc/ntp.conf $HOME/backup/etc/.
```

Intel® Manager for Lustre* SSL Certificates

Intel® Manager for Lustre* software uses SSL certificates to establish trusted communications between the manager server (running the Intel® Manager for Lustre* software GUI) and the agents running Intel® EE for Lustre* software, including the metadata servers, object storage servers, etc. Without these certificates, trust cannot be established and the Intel® Manager for

Lustre* software will not be able to manage or receive monitoring telemetry from those agents.

The SSL certificates are generated by the Intel® Manager for Lustre* installation program and are re-generated each time the installer is run. The SSL certificates are randomly generated, so no two sets of keys are the same. To support successfully restoring Intel® Manager for Lustre* software and restoring communication with the agents, create a backup of the following certificate files located on the manager server.

```
mkdir -p $HOME/backup/var/lib/chroma
cp /var/lib/chroma/authority.crt ~/backup/var/lib/chroma/.
cp /var/lib/chroma/authority.pem ~/backup/var/lib/chroma/.
cp /var/lib/chroma/authority.srl ~/backup/var/lib/chroma/.
cp /var/lib/chroma/manager.crt ~/backup/var/lib/chroma/.
cp /var/lib/chroma/manager.pem ~/backup/var/lib/chroma/.
```

Intel® Manager for Lustre* Database

Intel® Manager for Lustre* software employs a PostgreSQL RDBMS to record configuration data and file system telemetry for all Lustre servers connected to the manager server. Data collection is continuous and regular backups of the database are required in order to be able to exact a point-in-time recovery of the manager server with minimal loss of data. The interval between backups represents the potential risk in terms of lost data.

The PostgreSQL project offers detailed information on different backup strategies. Presented here is the simplest and in many ways most reliable mechanism for capturing a consistent backup of the databases managed by PostgreSQL. The approximate command, when executed as the root superuser on a RHEL or CentOS based operating system is:

```
mkdir -p $HOME/backup
su - postgres -c "/usr/bin/pg_dumpall --clean" | /bin/gzip >
$HOME/backup/pgbackup-`date +\%Y-\%m-\%d-\%H:\%M:\%S`.sql.gz
```

Note that while the command is executed as root, the database backup program is in fact run as the PostgreSQL superuser, called postgres. The `/bin/su` command creates a sub-shell that is owned by the `postgres` user and is then used to run `/usr/bin/pg_dumpall`. The `pg_dumpall` command creates a complete backup of the structure and content of every PostgreSQL database on the server and records the output as a set of SQL commands. The resulting text file can be compressed for more efficient storage. Note that the `--clean` flag supplied to the `pg_dumpall` command will add instructions to drop any existing structures in the target PostgreSQL instance upon restore. In other words, the PostgreSQL instance will be completely over-written during a restore of the database from this backup.

Caution: It may be tempting to omit the `--clean` flag from the backup process, but this will complicate the restore process and *may lead to an inadvertent corruption of the target*.

Therefore, always use the `--clean` flag when taking a full backup of the Intel® Manager for Lustre* database.

The above command can be added to `cron` so that it runs on a regular schedule. Each backup copy will have a unique date and time stamp, down to the resolution of one second.

Over time, the backup file can get large and may eventually exceed the single file size limit for the underlying file system. One can work around this limitation by feeding the output into the `split` command.

For other database backup strategies and discussions on the merits of the different approaches, refer to the PostgreSQL project documentation.

Restoring the Intel® Manager for Lustre* Service

Most of the effort expended in developing a recovery strategy for IT services is focused on the backup procedure described previously.

Note: It is important to identify all of the configuration items and data sets that need to be backed up and to develop a robust infrastructure and processes to support the backup. It is also important to test these processes and routinely audit the methods and mechanisms for correctness.

If all is well with the backup mechanism, then the recovery of a given service is a relatively straightforward proposition. The easier one can make the process of recovering a service into production, the more effective and reliable that process is likely to be. As much as is possible, one wants to streamline the server provisioning and recovery steps so that manual interaction is reduced to the minimum required for success. The goal is to reduce time required to restore, reduce non-conformance and error, and increase reliability.

If the backup mechanism is reliable and complete, the recovery process should be straightforward.

Re-install OS and Restore System Configuration

This process is essentially the same as that used to originally provision the manager server, with additional steps to recover the database and SSL certificates. The server hardware and operating system should conform closely to the requirements under Manager Server Requirements. Network connections, localization, user accounts, etc., should all be established as before the server/services failure. It is essential to ensure that the manager server is functionally identical to the original instance. As discussed in Operating System, template-driven automated provisioning platforms such as Kickstart are very effective ways to implement consistent operating system deployment.

Re-install Intel® Manager for Lustre* software

There is no automated installer for the Intel® Manager for Lustre* software but it is fortunately straightforward to re-run the installation program. This has the added benefit of guaranteeing that the core infrastructure is correctly installed and configured and that all package dependencies are appropriately satisfied. Re-running the installation program creates a new, unpopulated, instance of the Intel® Manager for Lustre* software. Note that it does not matter what answer you provide to the questions asked by the installation program; this information will be overwritten when the database backup is restored.

When installation completes, shutdown the Intel® Manager for Lustre* software and its related services immediately, but keep the PostgreSQL database server running:

```
service rabbitmq-server stop
service chroma-supervisor stop
service httpd stop
```

Caution: Do not conduct any further configuration of Intel® Manager for Lustre* software. Do not attempt to re-discover Intel® EE for Lustre* assets or add any servers or storage to the instance until the recovery is complete and the Intel® Manager for Lustre* software installation is verified as working to your satisfaction.

Restore the NTP Configuration

Restore the backup of /etc/ntp.conf and restart NTP:

```
cp $HOME/backup/etc/ntp.conf /etc/ntp.conf
service ntpd restart
```

Restore the Intel® Manager for Lustre* SSL certificates

The following commands must be run after the initial installation program has been run; otherwise, the SSL certificates will be overwritten.

```
/bin/cp ~/backup/var/lib/chroma/authority.crt /var/lib/chroma/.
/bin/cp ~/backup/var/lib/chroma/authority.pem /var/lib/chroma/.
/bin/cp ~/backup/var/lib/chroma/authority.srl /var/lib/chroma/.
/bin/cp ~/backup/var/lib/chroma/manager.crt /var/lib/chroma/.
/bin/cp ~/backup/var/lib/chroma/manager.pem /var/lib/chroma/.
```

Restore the PostgresSQL Database

Run the restore command for PostgresSQL, assuming that the backup was created using the `pg_dumpall` command as described in "Creating a Backup Manifest – Intel® Manager for Lustre* Database". Warning, this command will erase all existing database content:

```
zcat ~/backup/pgbackup-*.sql.gz | su - postgres -c "psql postgres"
```

The following errors, usually encountered at the beginning of the restore output, can be ignored:

```
ERROR: current user cannot be dropped
...
ERROR: role "postgres" already exists
```

Restart Intel® Manager for Lustre* software

When the PostgreSQL database restore has completed, restart the services that were shut down:

```
service rabbitmq-server start
service httpd start
service chroma-supervisor start
```

Alternatively, reboot the Intel® Manager for Lustre* server. The service will restart automatically.

Potential Issues

Internal Server Error Reported by Browser on Connection to the Intel® Manager for Lustre GUI*

After the restore is complete and the services have been started, the Intel® Manager for Lustre* software may report the following error when an attempt is made to connect through the client browser:

> **Internal Server Error**
>
> The server encountered an internal error or misconfiguration and was unable to complete your request.
>
> Please contact the server administrator, root@localhost and inform them of the time the error occurred, and anything you might have done that may have caused the error.
>
> More information about this error may be available in the server error log.
>
> **Apache/2.2.15 (CentOS) Server at localhost Port 8001**

If this occurs, log into the IML server and remove the following file:

```
/var/log/chroma/client_errors.log
```

The browser interface should now return to normal after refreshing the page.

Graph Data Missing After Restore

It has been noticed that occasionally, after a complete restore of the Intel® Manager for Lustre* server, some of the data points may not be updated. One of the obvious symptoms of this is the graphs on the Intel® Manager for Lustre* dashboard may display as blank, without data, even when the file system is known to be busy. Similarly, OST capacity may be incorrectly reported.

This is caused by one or more of the Intel® Manager for Lustre* client agents losing contact with the manager and refusing to reconnect after the service has been restored. To restore the connection, log into the affected Intel® EE for Lustre* asset (e.g., the MDS or OSS) and restart the client agent service as follows. This is a one-time fix.

```
service chroma-agent restart
```

Appendix C - Backup and Recovery of Servers Managed by Intel® Manager for Lustre* Software

Note: This appendix is outdated and in revision. Procedures in this appendix were developed for servers running RHEL 6.7. The process for servers running RHEL 7.3 is very similar, but *this appendix has not yet been revised or tested for RHEL 7.3*.

Introduction

This appendix provides guidance on how to conduct bare-metal recovery of a Lustre server from a combination of the original installation media and a backup manifest for the servers. This content describes the essential files required to recover the service to the point of the last successful backup. From this, readers can create processes that are compatible with their own environments.

Note: Backup and restoration of file system data is beyond the scope of this procedure.

Intel® Manager for Lustre* software provides a way to configure Lustre servers as metadata and object storage servers. Such servers are configured into high availability cluster pairs as defined in this section: Building the System – The High Availability Configuration Spec.

For a high-availability Lustre file system configured and managed by Intel® Manager for Lustre* software, there must be at least one cluster pair hosting the Management Server (MGS) and a Metadata Server (MDS) for the file system. With the introduction of Distributed Namespace (DNE), there may be additional metadata server pairs, hosting further MDS resources.

In such an HA file system, there must also be at least one Object Storage Server (OSS) high availability cluster pair. There may be a large number of OSS pairs in a single Lustre file system.

The process described herein assumes that Intel® Manager for Lustre* software has provisioned Lustre servers and that a Lustre file system has been successfully created. This process is restricted to coverage of managed servers and applies equally to Metadata and Object Storage servers.

Backup Overview

Just as for any critical server infrastructure, it is essential to maintain a comprehensive and consistent backup of the system configuration for all of the servers managed by Intel® EE Lustre server software, and to maintain a repeatable and reliable method for recovering file system services in the event of a failure.

Backup and recovery of Intel® EE Lustre MDS and OSS server software involves the following components:

- Operating system installation and configuration, to include:
  - File system layout
  - Core packages
  - Boot loader
  - Date, time and language
  - Network configuration
  - Name service (`/etc/resolv.conf`) and hosts table (`/etc/hosts`)
  - Package Update management environment (RPM & YUM configuration)
  - Identity configuration
    - User databases (/etc/passwd, /etc/shadow, /etc/group, /etc/gshadow)
    - Name service switch (/etc/nsswitch.conf)
    - Superuser privilege management (Sudo)
  - Security configuration
    - IPTables
    - SELinux
    - PAM
    - SSH keys (host and user)
- Intel® EE for Lustre* software installation and configuration
  - Additional packages required by Lustre
  - NTP configuration
  - SSL Certificates
  - High availability software configuration

Rather than rely upon a standard backup of the operating platform root disks, an alternative strategy of creating a repeatable build procedure from first principals will deliver a more predictable mechanism in the long term. Building servers to a recipe makes it easier to audit installations for correctness by being able to compare the manifest (recipe) to the deployed instance, as well as making it easier to track and deploy changes. This also reduces reliance on backup infrastructure for recovery, allowing one to concentrate backup efforts on those critical data sets that cannot be reproduced. This will generally reduce overall recovery times by reducing the amount of data that must be restored from the backup infrastructure (which is often tape-based and bandwidth-constrained).

Example Backup Checklist

The following is an example checklist of high level tasks to perform in executing a backup. Perform these tasks after creating an Intel® EE for Lustre* file system using the Intel® Manager for Lustre* dashboard.

- Save Kickstart Template from OS Installation (or create one)
- Save OS network configuration (can be included in Kickstart template)
- Save YUM configuration
- Save user configuration
- Save SSH host keys [optional]
- Save SSH root user keys [optional]
- Save NTP configuration
- Save Intel® Manager for Lustre* agent configuration
- Save the LNET configuration
- Save the Pacemaker + Corosync configuration

Operating System

Note: This appendix is outdated and in revision. Procedures in this appendix were developed for servers running RHEL 6.7. The process for servers running RHEL 7.3 is very similar, but this appendix has not yet been revised or tested for RHEL 7.3.

Red Hat Enterprise Linux or CentOS Linux, version 6.7 or 7.2 must be installed on all Lustre servers. The OS must be deployed in a consistent and repeatable manner. All servers should be running the same OS and version. For Red Hat Enterprise Linux and CentOS Linux, template-driven provisioning using Kickstart has proven to be reliable and straightforward to audit. RHEL-based operating systems generate a Kickstart template during the normal, media-based installation process and this can be an effective starting point for developing an automated installation process.

An alternative to template-driven OS provisioning is to develop a binary image that is ready to be written directly to bare storage on the server. Image-based platforms can be more difficult to maintain and audit, but are often faster to deploy and are especially effective when the underlying hardware platform is guaranteed to be consistent over the operational life-span of the service.

Regardless of the mechanism, the operating system installation and recovery is usually driven from a description of the end-state, rather than from a backup in the purest sense. It is assumed that the core operating system changes infrequently and that any changes are

automatically incorporated into the provisioning platform (either by editing the template or updating the "golden" image). It is further assumed that there is nothing in the data held by the core OS that requires routine archival. If this is not the case, additional procedures may be required to ensure that relevant data is persistently and reliably backed up

The following example Kickstart template describes a basic platform with a small set of packages and two network interfaces: one for provisioning the OS and connection to the Intel® EE for Lustre* management network, the other might be used for Lustre communications traffic (if Ethernet is being used for Lustre networking).

An example Kickstart template:

```
install
text
reboot
url --url=http://10.0.1.1/CS6.4/
lang en_US.UTF-8
keyboard us
network --hostname ee-iml --onboot yes --device eth0 --bootproto
static --ip 10.0.2.1 --netmask 255.255.0.0 --gateway 10.0.0.1 --
noipv6 --nameserver 8.8.8.8
network --onboot yes --device eth1 --bootproto static --ip 10.1.0.1
--netmask 255.255.0.0 --noipv6
rootpw  --iscrypted xyzzy
firewall --disabled
selinux --disabled
authconfig --enableshadow --passalgo=sha512
timezone --utc America/New_York
bootloader --location=mbr --driveorder=vda --
append="crashkernel=auto console=ttyS0,115200 rd_NO_PLYMOUTH"
zerombr
clearpart --all --initlabel --drives=vda
autopart
repo --name="CentOS" --baseurl=http://10.0.1.1/CS6.4/ --cost=100

%packages
@core
@base
%end
```

Kickstart templates are flexible and powerful, and can be extended with the addition of pre- and post-install scripts. With a modest amount of effort, the entire operating system installation can be fully automated.

Host Name Resolution

The hosts database `/etc/hosts` often contains the names and IP addresses for all of the members of the Lustre server infrastructure; include a copy of this file in the operating system manifest. The file `/etc/resolv.conf` contains the list of DNS name servers in use on the network; include a copy of this file in the manifest as well.

Package Update management environment (RPM & YUM)

The YUM configuration file `/etc/yum.conf` and files located at `/etc/yum.repos.d/*` must be configured so that package dependencies for Intel® Manager for Lustre* software can be automatically installed.

Identity configuration

Ensure that any local user information is appropriately accounted for, including:

- User databases (i.e., `/etc/passwd`, `/etc/shadow`, `/etc/group`, `/etc/gshadow`)
- Superuser privilege management (Sudo)
- Name service switch (`/etc/nsswitch.conf`)

Security configuration

Include the security configuration in the operating system's provisioning or backup manifest, including firewall rules (IPTables), Security Enhanced Linux (must be disabled), pluggable authentication modules (PAMs) and SSH (including Host and User keys).

Creating a Backup Manifest for a Metadata Server or Object Storage Server

The following sections describe how to rebuild a server from the base operating system install. It does not include information on OS installation itself. Instructions are executed as the root superuser on an example server configuration, for the purpose of demonstration. Procedures for copying the resulting data off the server to a reliable medium are not covered here, but can be a simple secure copy (e.g. scp) from the source to a destination system (such as the server running the Intel® Manager for Lustre* GUI), or an integrated enterprise backup platform.

Backups must be run for each server in the file system and, minimally, must be run each time a configuration change is made.

Chroma Agent Configuration

The Intel® Manager for Lustre* client agent, called chroma-agent, keeps a set of configuration files in /var/lib/chroma. It is essential that all files in this directory are saved. In addition to SSL authentication keys, the directory contains configuration information pertinent to the server's

purpose and supplemental information regarding the storage configuration used to manage the resources in Pacemaker.

```
# SSL Certificates and Chroma Settings:
/var/lib/chroma/*
```

Intel® Manager for Lustre* YUM Repository Configuration

Intel® EE for Lustre* software is distributed as RPM packages. These are hosted in YUM repositories on the manager server running the Intel® Manager for Lustre* software and GUI.

```
# YUM Configuration for IML Repositories:
/etc/yum.repos.d/Intel-Lustre-Agent.repo
```

Network Configuration

Copy the network configuration, if it is not already part of an installation process for the server.

```
# Network Configuration:
/etc/sysconfig/network-scripts/ifcfg-*
/etc/sysconfig/system-config-firewall
/etc/rsyslog.conf
/etc/ntp.conf
```

SELinux Configuration

Either copy the SELinux configuration file, or make sure to disable SELinux during provisioning of the server. For RHEL and CentOS systems, there is a configuration setting for disabling SELinux in the file: `/etc/selinux/config`

Lustre LNET Configuration

This is normally set by the Intel® Manager for Lustre, but can be recovered by making a copy of the following file.

```
# Lustre LNet Configuration:
/etc/modprobe.d/iml_lnet_module_parameters.conf
```

Pacemaker and Corosync High Availability Framework

The Corosync configuration is held in a plain text file, but the Pacemaker configuration is more complex and must be exported from the running cluster resource manager service. Fortunately, there is a simple command to export the Pacemaker configuration.

```
# Corosync Configuration:
/etc/corosync/corosync.conf
```

```
# Pacemaker Configuration:
cibadmin --query > $HOME/cluster-cfg-$HOSTNAME.xml
```

System Services Startup Scripts (rc.sysinit)

The following awk script parses the output from the chkconfig command and creates a shell script that can be executed to re-apply the runlevels for each of the installed services.

```
# RC.Sysinit Services Configuration:
chkconfig --list | awk '{
on="";
off="";
for (i=2;i<=8;i++) {
  if ($i ~ /on$/){
    on=sprintf("%s%s",on,substr($i,1,1))
  }
  else {
    off=sprintf("%s%s",off,substr($i,1,1))
  }
}
if (length(off)>0)
  printf("/sbin/chkconfig --levels %s %s off\n",off,$1);
if (length(on)>0)
  printf("/sbin/chkconfig --levels %s %s on\n",on,$1)
}' > $HOME/chkconfig-output-$HOSTNAME.sh
```

Sample Automated Backup Script for Intel® EE Lustre Servers

For a server managed by Intel® EE for Lustre* software, this script can be used as the basis for automating the backup of server configuration information.

```
#!/bin/sh
BCKNAME=bck-$HOSTNAME-`date +%Y%m%d-%H%M%S`
BCKROOT=$HOME/$BCKNAME
mkdir -p $BCKROOT
tar cf - \
/var/lib/chroma \
/etc/yum.repos.d/Intel-Lustre-Agent.repo \
/etc/sysconfig/network-scripts/ifcfg-* \
/etc/sysconfig/system-config-firewall \
/etc/rsyslog.conf \
/etc/ntp.conf \
/etc/selinux/config \
/etc/modprobe.d/iml_lnet_module_parameters.conf \
/etc/corosync/corosync.conf \
| (cd $BCKROOT && tar xf -)
```

```
# Pacemaker Configuration:
cibadmin --query > $BCKROOT/cluster-cfg-$HOSTNAME.xml

# RC.Sysinit Services Configuration:
chkconfig --list | awk '{
on="";
off="";
for (i=2;i<=8;i++) {
  if ($i ~ /on$/){
    on=sprintf("%s%s",on,substr($i,1,1))
  }
  else {
    off=sprintf("%s%s",off,substr($i,1,1))
  }
}
if (length(off)>0)
  printf("/sbin/chkconfig --levels %s %s off\n",off,$1);
if (length(on)>0)
  printf("/sbin/chkconfig --levels %s %s on\n",on,$1)
}' > $BCKROOT/chkconfig-output-$HOSTNAME.sh
cd `dirname $BCKROOT`
tar zcf $BCKROOT.tgz `basename $BCKROOT`
```

Restoring a Server from Backup

The following process restores a server managed by Intel® EE for Lustre* software to production state. This is done using backup resources created as described in the previous sections. This process is for a single server, but can be repeated for each storage server in a cluster. When a pair of servers must both be restored, it is recommended to reinstall the servers one-at-a-time.

The following command line examples assume that the server configuration has been extracted in to a directory referenced by the variable $BACKUP_ROOT. It is also assumed that basic network connectivity has been restored, sufficient to allow access to the operating system YUM repositories, as well as the repositories of the manager server running the Intel® EE for Lustre* GUI.

Restore Process

1. Restore the SELinux configuration.

   ```
   cp $BACKUP_ROOT/etc/selinux/config /etc/selinux/.
   ```

2. Restore the contents of /var/lib/chroma, which includes the SSL certificates and the chroma-agent configuration.

```
cp -a $BACKUP_ROOT/var/lib/chroma /var/lib/.
```

3. Restore the YUM repository definition:

```
cp $BACKUP_ROOT/etc/yum.repos.d/Intel-Lustre-Agent.repo
/etc/yum.repos.d/.
```

4. Restore the network interface configuration:

```
cp $BACKUP_ROOT/etc/sysconfig/network-scripts/ifcfg-*
/etc/sysconfig/network-scripts/.
cp $BACKUP_ROOT/etc/sysconfig/system-config-firewall
/etc/sysconfig/.
```

   Restart network interfaces, if required for the server to make the connection to the IML server.

5. Re-install the Intel® EE Lustre server packages:

```
yum -y install --enablerepo=lustre,iml-agent,e2fsprogs \
lustre \
kernel- 3.10.0-514.el7_lustre.x86_64.rpm


yum -y install --enablerepo=iml-agent \
chroma-agent \
chroma-agent-management \
chroma-diagnostics
```

6. Restore the RSyslog configuration and NTP Configuration:

```
cp $BACKUP_ROOT/etc/rsyslog.conf $BACKUP_ROOT/etc/ntp.conf /etc/.
```

7. Restore the LNET Configuration:

```
cp $BACKUP_ROOT/etc/modprobe.d/iml_lnet_module_parameters.conf
/etc/modprobe.d/.
```

8. Restore the Corosync configuration:

```
cp $BACKUP_ROOT/etc/corosync/corosync.conf /etc/corosync/.
```

   Note: Do not restore the Pacemaker configuration at this time.

9. Restore the system services startup configuration (rc.sysinit run levels):

```
 sh $BACKUP_ROOT/chkconfig-output-$HOSTNAME.sh
```

10. Create the directories for the Lustre storage mount points. For example, the following script extracts the directory paths for the Lustre storage from the chroma-agent configuration, and creates the directories:

    ```
    for i in /var/lib/chroma/targets/* ; do
    cat $i | python -c 'import sys,json; obj=json.load(sys.stdin); print
    obj["mntpt"]';
    done | xargs mkdir -p
    ```

    This method is not officially sanctioned because the format of the JSON configuration is not part of a public API and may change over time. Nevertheless, it's a convenient way to recreate mount points, if they are not already in the build manifest for the server.

11. Reboot.

12. When the system has completed booting, verify that the server is running the Intel® EE Lustre* software Linux kernel, and that LNET is properly configured. For example:

    ```
    [root@ee-mds1 ~]# uname -r
    3.10.0-514.el7_lustre.x86_64.rpm [root@ee-mds1 ~]# modprobe -v lnet
    [root@ee-mds1 ~]# lctl network up
    LNET configured
    [root@ee-mds1 ~]# lctl list_nids
    10.70.73.11@tcp
    ```

13. Verify that the basic cluster framework is also running:

    ```
    pcs status
    ```

    a. If the other server in the HA pair is already running, then the Pacemaker configuration should have been copied over when Pacemaker started on the node being recovered. The cluster status will show the resources.

    b. If both servers in the HA pair have been re-installed, then the Pacemaker configuration will need to be restored from the backup as well. For example:

    ```
    cibadmin --replace --xml-file $BACKUP_ROOT/ee-cluster-cfg-
    $HOSTNAME.xml
    ```

    This command will fail if a pre-existing configuration is detected. If the configuration from the backup is absolutely required, then include the --force flag on the command line. Be very careful that this is the correct configuration before proceeding.

14. The newly restored server may not yet be able to manage resources in the cluster, so clear out any historical error conditions and force the cluster to re-detect the current state. For example:

    ```
    [root@ee-mds1 ~]# pcs resource show
    ```

```
MGS_7dec26    (ocf::chroma:Target): Started
demo-MDT0000_ae5915(ocf::chroma:Target): Started
[root@ee-mds1 ~]# pcs resource cleanup MGS_7dec26
Resource: MGS_7dec26 successfully cleaned up
[root@ee-mds1 ~]# pcs resource cleanup demo-MDT0000_ae5915
Resource: demo-MDT0000_ae5915 successfully cleaned up
```

15. If the resources are running on their non-preferred servers (i.e., on the failover hosts), then use the following commands to force a failback (or use Intel® Manager for Lustre* GUI to manage the resources):

    ```
    pcs resource move <resource name>
    pcs resource clear <resource name>
    ```

    The `resource clear` command removes any constraints imposed by the move, so that the resource can be moved back again in the event of a subsequent failover trigger.

16. It may be useful during the initial stages of the recovery process for Pacemaker to disable the constraints around the fencing agents. This can make it easier to restore services to a running condition on one server while still working to rebuild the second. However, Intel® does not support Intel® EE Lustre software installations that do not have fencing agents configured, so only use this process with caution, and only if required to support an emergency recovery. Once full service is restored, this configuration change must be reversed.

    ```
    pcs property set stonith-enabled=false
    ```

The cluster configuration has now been recovered to the running state based on the last backup taken. Note that this process assumes that the Lustre storage for the MGT, MDTs and OSTs remains intact during the outage and throughout the server recovery.

Getting Help

For partners: If you encounter a problem with Intel® EE for Lustre* software, Intel® Manager for Lustre* software, or storage, and you require support from your Intel® technical support representative, then to help expedite resolution of the problem, please do the following:

1. Run chroma diagnostics.
2. Submit a ticket.

Run chroma diagnostics

Run chroma-diagnostics on any of the servers that you suspect may be having problems, and on the server hosting the Intel® Manager for Lustre* software dashboard. Chroma-Diagnostics generates a compressed tar.lzma file that you should attach to your JIRA ticket when you create it.

To run chroma-diagnostics:

1. Log into the server in question as Admin. Admin login is required in order to collect all desired data.
2. Enter the following command at the prompt:

   ```
   # chroma-diagnostics
   ```

   Following are the displayed results of running this command. (The resulting tar.lzma file will have a different file name.)

   ```
   Collecting diagnostic files

   Detected devices
   Devices monitored
   Listed installed packages
   Listed cibadmin --query
   Listed: pcs config show
   Listed: crm_mon -1r
   Finger printed Intel® Manager for Lustre* software installation
   Listed running processes
   listed PCI devices
   listed file system disk space.
   listed cat /proc/cpuinfo
   listed cat /proc/meminfo
   listed cat /proc/mounts
   listed cat /proc/partitions
   Listed hosts
   Copied 1 log files.
   Compressing diagnostics into LZMA (archive)
   ```

```
Diagnostic collection is completed.
Size:  16K      /var/log/diagnostics_20151006T160338_lotus-
4vm15.iml.intel.com.tar.lzma
```

3. You can also decompress the file and examine the results. To unpack and extract the files, use this command:

   ```
   # tar --lzma -xvpf <file_name>.tar.lzma
   ```

4. If desired, the following command returns help for chroma diagnostics:

   ```
   # chroma-diagnostics -h
   ```

Submit a ticket

You can submit a ticket using the Jira issue tracking system. Attach the chroma diagnostics log report to the ticket.

1. Log in to the Jira dashboard at: https://jira.hpdd.intel.com/secure/Dashboard.jspa
2. In the upper right corner, select **+ Create Issue**.
3. Select the project that was issued by your Intel® account manager.

For any other issues, contact your product manager or sales representative.

For end-users: For assistance with this product, contact your storage solution provider.