Pillar AxiomONE™ Path Manager 3.2

Installation Guide and Release Notes

for Oracle Enterprise Linux 4.8
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Pillar Data Systems, Inc., 2840 Junction Avenue, San Jose, CA 95134-1922

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Preface

Audience

This document is intended for individuals who install and maintain Pillar AxiomONE Path Manager (APM) software.

Expected experience includes:
- Understanding of storage area networks (SANs) and disk storage systems.
- Understanding of Fibre Channel or iSCSI technology
- Practical knowledge of Pillar Axiom storage systems.
- Basic Linux administration skills.
- Experience installing software packages on Oracle Enterprise Linux systems.

Before You Read This Document

Being familiar with certain other Pillar Axiom technical documentation helps you succeed in the use of this document.

Review the late-breaking information described in the Pillar Axiom Customer Release Notes for the particular version and model of the Pillar Axiom storage system that you are using. The Release Notes document includes important information about the installation and operation of the Pillar Axiom software that was not available at the time this guide was published, including:
- System enhancements
- Changes to how certain components work
- Software update procedure
- System limits
- Network requirements
- Known issues
- Errata for technical documents

We also recommend that you be familiar with the Pillar Axiom Administrator’s Guide, which provides detailed information on creating and managing storage resources.
How this Document is Organized

This document provides instructions for installing and using the AxiomONE Path Manager (APM) for Oracle Enterprise Linux 4.8 (OEL 4.8) software.

The document is divided into three chapters:

• Chapter 1 provides an introduction to APM, a description of the features of the APM for OEL 4.8 software.
• Chapter 2 describes the requirements for installing APM for OEL 4.8 and lists supported hardware, software and configurations. This chapter provides detailed instructions for downloading and installing the APM for OEL 4.8 software on your host system.
• Chapter 3 provides specific information about this release, including features introduced in this release, known issues, and resolved issues.

Access Documentation

Pillar Data Systems technical documentation (including installation, service, cabling, integration, and administration guides) are available from several sources.

Pillar Axiom GUI

After logging in to the AxiomONE Storage Services Manager on the Pilot, navigate to Support > Technical Documentation and click on the document of interest.

Web sites

◦ Technical documents (http://www.pillardata.com/techdocs)
◦ Customer support portal (https://support.pillardata.com/login.do)

After logging in to the web site, click on Documents in the left navigation pane, and then click the appropriate category in the expanded list. Click on the document of interest.

Product CD-ROM

Insert the Technical Documentation CD-ROM that came with your Pillar Axiom storage system into the CD player in a computer. Open the DocMenu PDF and click on the document of interest.
Tip: To search all technical documents on the CD-ROM, click the Search all PDFs icon in the top right corner. In the Search dialog, enter the word or phrase for which you would like to search.

Pillar Welcomes Your Comments

Pillar is interested in improving its documentation and welcomes your comments and suggestions. You can submit your comments by emailing us at docs@pillardata.com. Please include the title and part number of your document with your feedback:

Pillar AxiomONE™ Path Manager 3.2 Installation Guide and Release Notes for RHEL 4.8

Part number 4420-00046-0300

Pillar Contacts

Table 1 Contacts at Pillar Data Systems

<table>
<thead>
<tr>
<th>For help with...</th>
<th>Contact...</th>
</tr>
</thead>
<tbody>
<tr>
<td>Error messages, usage questions, and other support issues</td>
<td>US and Canada: 877-4PILLAR (1-877-474-5527)</td>
</tr>
<tr>
<td></td>
<td>Europe: +800 PILLAR FS (+800 74 55 27 37)</td>
</tr>
<tr>
<td></td>
<td>Asia Pacific: +1-408-518-4515</td>
</tr>
<tr>
<td></td>
<td>South Africa: +0 800 980 400</td>
</tr>
<tr>
<td></td>
<td>Have your system serial number ready.</td>
</tr>
<tr>
<td></td>
<td><a href="mailto:support@pillardata.com">support@pillardata.com</a></td>
</tr>
<tr>
<td></td>
<td>Customer support portal (<a href="https://support.pillardata.com/login.do">https://support.pillardata.com/login.do</a>)</td>
</tr>
<tr>
<td>Training (custom or packaged)</td>
<td>Training and Education (<a href="http://www.pillardata.com/support-education/training/">http://www.pillardata.com/support-education/training/</a>)</td>
</tr>
</tbody>
</table>
Table 1 Contacts at Pillar Data Systems (continued)

<table>
<thead>
<tr>
<th>For help with...</th>
<th>Contact...</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sales and general contact information</td>
<td>Company contacts (<a href="http://www.pillardata.com/company/contact">http://www.pillardata.com/company/contact</a>)</td>
</tr>
</tbody>
</table>
Introduction to AxiomONE Path Manager

AxiomONE Path Manager 3.2 Requirements

Pillar Axiom storage systems presenting LUNs to Oracle Enterprise Linux 4.8 (OEL 4.8) hosts using AxiomONE Path Manager 3.2 must be running release 3.3.15 or higher of the Pillar Axiom software.
AxiomONE Path Manager (APM) manages the Linux multipath framework and communicates with Pillar Axiom servers on a control path, which is separate from the data path. The Linux multipath framework manages the LUN data access paths themselves.

Figure 1: APM interaction with a Pillar Axiom server illustrates how the APM software installed on a storage area network (SAN) host interacts with a Pillar Axiom storage system. Refer to the table below to determine the significance of the lines and colors in the figure.

Table 2 Line and color key for APM interaction diagram

<table>
<thead>
<tr>
<th>Graphic element</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Data path</td>
</tr>
<tr>
<td></td>
<td>Control path</td>
</tr>
<tr>
<td><img src="image" alt="Pillar-supplied hardware and software" /></td>
<td>Pillar-supplied hardware and software</td>
</tr>
<tr>
<td><img src="image" alt="Non-Pillar hardware and software" /></td>
<td>Non-Pillar hardware and software</td>
</tr>
<tr>
<td><img src="image" alt="SAN host kernel space" /></td>
<td>SAN host kernel space</td>
</tr>
<tr>
<td><img src="image" alt="SAN host user space" /></td>
<td>SAN host user space</td>
</tr>
</tbody>
</table>
Chapter 1 Introduction to AxiomONE Path Manager

Figure 1 APM interaction with a Pillar Axiom server

Legend

1. User
2. User application
3. SAN host
4. APM daemon
5. Control paths (all dashed lines)
6. Pillar Axiom administrator
7. Pillar Axiom command line interface (CLI) or graphical user interface (GUI)
8. Encrypted XML over TCP/IP
9. Network card
10. Linux multipath framework
11. iSCSI software initiator (iSCSI)
12. TCP/IP driver (iSCSI)
13. HBA driver (FC) or NIC driver (iSCSI)
14. HBA (FC) or NIC (iSCSI)
15. SCSI over Fibre Channel (FC) or iSCSI over IP (iSCSI)
16. Data path (all solid lines)
17. Pillar Axiom server
18. Brick storage enclosure pool

AxiomONE Path Manager Architecture

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About the AxiomONE Path Manager Control Path

The AxiomONE Path Manager (APM) control path provides a path separate from the data path to manage multipathing and communication.

The APM software uses a daemon running in the background to control multipathing and communication. The APM daemon uses the control path to:

- Get path information from the HBA drivers.
- Configure the Linux multipath framework.
- Send information such as host attributes and statistics to the Pilot management controller, and collect logs from the host on request.

The APM daemon sends a description of the host to the Pilot on each connected Pillar Axiom storage system. This description creates a definition for the host in the AxiomONE Storage Services Manager. The definition includes any Fibre Channel (FC) ports in the host, and the name of the host's iSCSI initiator, if Internet Small Computer System Interface (iSCSI) is configured. The graphical user interface (GUI) and command line interface (CLI) list the port World Wide Names (WWNs) of the FC ports in the host and the Internet Protocol (IP) addresses that are used to make iSCSI connections to the Pillar Axiom system.

If you use iSCSI on the host to connect to a FC Slammer storage controller through an iSCSI-to-FC router, these connections are described as FC. The connections will appear to originate from the FC ports that are assigned on the switch to the host's iSCSI initiator. The WWNs of these ports are displayed as Fibre Channel HBA ports on the host. The HBA model associated with these ports is reported as iSCSI-FC router.

About the AxiomONE Path Manager Data Path

AxiomONE Path Manager (APM) uses the Linux device-mapper to provide paths for reading and writing data to LUNs on the Pillar Axiom storage system.

See Figure 1: APM interaction with a Pillar Axiom server for an illustration of how data flows from the host to the Pillar Axiom storage system.

The Linux multipath framework:

- Controls and manages all data paths to Pillar Axiom LUNs.
- Groups multiple data paths to a Pillar Axiom LUN and presents this group to the operating system as a single LUN or disk drive.
- Identifies and uses optimized data paths when possible. An optimized path provides the best performance and is the preferred path for data transfer.
• Determines which data paths to use.
• Handles data path failover.
• Manages data path errors.

About Multipathing and Device Mapper Automation

AxiomONE Path Manager (APM) uses the standard Linux 2.6 device-mapper functionality to provide multipathing services. APM consists of a daemon that monitors the state of the device-mapper and communicates with the Pillar Axiom software. APM presents the multipathed LUNs as virtual block devices in the Linux 2.6 device-mapper framework.

**Note:** You can use device-mapper and multipath-tools for many purposes other than managing multipathing for Pillar Axiom storage systems.

Pillar Data Systems provides a package containing an updated version of the multipath-tools component of device-mapper, along with additional bug fixes, as part of APM.

**Important!** You must use this Pillar Data Systems version of multipath-tools instead of the one supplied as part of the operating system in order to use APM. See Install (or Update) the AxiomONE Path Manager Software.

In addition, APM provides installation and start up scripts that automate several of the manual integration and configuration tasks usually required by device-mapper. The automation includes:

• Correcting functional deficiencies in the HBA driver installers.
• Bringing partitions on multipath devices online automatically.
• Reordering startup scripts for optimum operation.

**Note:** To determine how the Linux startup scripts have been altered, refer to the comments in the following Pillar-provided files:

• /etc/init.d/multipathd
• /etc/init.d/axiompmd
AxiomONE Path Manager 3.2 Features

APM is defined as:

Optional software installed on a storage area network (SAN) host to manage multiple paths to the Pillar Axiom storage system.

APM performs the following primary functions:

- Routes I/O to Pillar Axiom LUNs using only the best available data paths.
- Shares traffic among the available paths and ensures that access to the LUNs is not interrupted if some paths fail.
- Automatically configures the host into the AxiomONE Storage Services Manager and updates the configuration if the host information changes.

The function described in the last bullet enables the AxiomONE Storage Services Manager to report information about APM running on the host, such as the number of working paths, and, in some environments, to configure features such as load balancing.

Each APM release provides different features, and the features provided for each platform may vary. Refer to the following table for descriptions of the specific features implemented in this release.

Table 3 APM 3.2 for OEL 4.8 features

<table>
<thead>
<tr>
<th>Feature</th>
<th>Benefit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Automatic data path failover</td>
<td>Automatically switches to the highest priority optimized path available after a path failure or fail back.</td>
</tr>
<tr>
<td>Automatic recognition of storage attached network (SAN) hosts by the AxiomONE Storage Services Manager</td>
<td>Sends a description of the host to each Pilot management controller on connected Pillar Axiom systems, allowing the AxiomONE Storage Services Manager and command line interface (CLI) tools to create a definition for the host. This definition includes such information as the World Wide Names (WWNs) for each of the host's Fibre Channel ports, the Internet protocol (IP) addresses for any Internet Small Computer System Interface (iSCSI) ports, and the version of APM running on the host.</td>
</tr>
<tr>
<td>Call-Home log collection</td>
<td>When a Pillar Axiom administrator uses the AxiomONE Storage Services Manager to collect system information (refer to the Pillar Axiom Administrator's Guide for details), the Pillar Axiom storage system sends a request to each</td>
</tr>
</tbody>
</table>
Table 3 APM 3.2 for OEL 4.8 features (continued)

<table>
<thead>
<tr>
<th>Feature</th>
<th>Benefit</th>
</tr>
</thead>
</table>
| connected APM host. The APM hosts collect useful diagnostic information and send it to the Pillar Axiom system, where it is bundled with any other requested information. The Pillar Axiom system can then transmit this information to the Pillar World Wide Customer Support Center. The information collected from each APM host includes:  
  • Logs from the APM components.  
  • Configuration and status information from the operating system.  
  • System and error logs from the operating system.  
  No customer data is transmitted. | |
| Support for Fibre Channel (FC) connections to FC Slammer storage controllers | Makes connections to Pillar Axiom storage arrays over high-speed FC network infrastructure. |
| Support for iSCSI connections to both Fibre Channel (FC) and iSCSI Slammers | Makes connections to Pillar Axiom storage arrays over long distances using IP network infrastructure.  
  **Note:** iSCSI connections to FC Slammers require iSCSI-to-FC routers. |
| Support for Fibre Channel (FC) clustering | Makes connections to clustered systems operating in an FC-based SAN. |
About AxiomONE Path Manager and Clustering

The AxiomONE Path Manager (APM) for Oracle Enterprise Linux 4.8 (OEL 4.8) can be used in a clustered environment.

The APM software must be installed and working before you set up clustering.

If the cluster function fails on the nodes, but the nodes are still running at the operating system level, data consistency can be affected. The leftover write operations from failed database instances reach the storage system after the recovery process starts. Because these write operations are no longer in the proper serial order, they can damage the consistency of the stored data. To avoid damaging the data consistency, when a cluster node fails, fence the failed node off from all the shared disk devices or disk groups.

This I/O fencing process is sometimes called *I/O fencing-exclusion*, *disk fencing*, or *failure fencing*. The purpose of I/O fencing is to:

- Prevent updates by failed instances.
- Detect failures.
- Prevent the *split-brain* effect in the cluster.

*Note:* The split-brain effect occurs when failure of a single cluster causes reconfiguration of the cluster into multiple partitions, each of which assumes ownership of the same exclusive resources, usually resulting in data corruption.

Oracle Clusterware, in association with the shared storage unit, and the Oracle Clustering File System (OCFS), are required to prevent the failed nodes from accessing shared devices.

If you experience reboot or hang problems, we recommend setting O2CB parameters to values that are higher than Oracle’s suggested minimums. For example, we found the following settings effective for our test cluster configuration:

```bash
# O2CB_ENABLED: 'true' means to load the driver on boot.
O2CB_ENABLED=true
# O2CB_BOOTCLUSTER: If not empty, the name of a cluster to start.
O2CB_BOOTCLUSTER=ocfs2
# O2CB_HEARTBEAT_THRESHOLD: Iterations before a node is considered dead.
O2CB_HEARTBEAT_THRESHOLD=901
# O2CB_IDLE_TIMEOUT_MS: Time in ms before a network connection is considered dead.
O2CB_IDLE_TIMEOUT_MS=100000
# O2CB_KEEPALIVE_DELAY_MS: Max time in ms before a keepalive packet is sent
O2CB_KEEPALIVE_DELAY_MS=50000
```
# O2CB_RECONNECT_DELAY_MS: Min time in ms between connection attempts
O2CB_RECONNECT_DELAY_MS=20000

**Note:** `/etc/sysconfig/o2cb` is a configuration file for automatic startup of the O2CB driver. It is generated by running the following command:

```
/etc/init.d/o2cb configure
```

Use the following commands to modify the `o2cb` file:

- Heartbeat dead threshold = 901
- Network idle timeout: 100000
- Network keepalive delay: 50000
- Network reconnect delay: 20000
- Checking O2CB heartbeat: Active
AxiomONE Path Manager (APM) provides access over multiple data paths to LUNs defined on a Pillar Axiom storage system. APM, the device-mapper, Linux, and the Pillar Axiom software limit the following aspects of this access.

### Table 4 APM operating limits

<table>
<thead>
<tr>
<th>APM capabilities</th>
<th>Maximum value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Target Pillar Axiom systems</td>
<td>Eight for each SAN host</td>
</tr>
<tr>
<td>Connect to SAN Slammer storage controllers</td>
<td>Four for each Pillar Axiom system</td>
</tr>
<tr>
<td>Connect to LUNs</td>
<td>256</td>
</tr>
<tr>
<td>Handle data paths</td>
<td>32 to each LUN</td>
</tr>
<tr>
<td>Handle FC HBA ports</td>
<td>32 for each SAN host</td>
</tr>
</tbody>
</table>

The Linux device-mapper has a limitation of 1024 paths to all devices, including Pillar Axiom LUNs. If you use the maximum of 256 LUNs, you will have a maximum of four paths to each LUN.

**Important!** The Linux device-mapper does not gracefully handle more than 1024 visible paths and may fail in a variety of ways if that limit is exceeded.

**Important!** Not all combinations of the limits shown have been tested. Use care when operating a system that has been configured to run at or near these limits. The system may exhibit anomalies when all limits are exercised concurrently.
Supported OEL 4.8 Distributions

AxiomONE Path Manager (APM) is supported on Oracle Enterprise Linux 4.8 (OEL 4.8) platforms.

APM supports OEL 4.7 distributions for the following architectures:
  • x86-32 (32-bit x86 platforms)
  • x86-64 (64-bit AMD and Intel platforms)

To determine the hardware platform on which your distribution is running, run the following command:

```
# uname -i
```

Compare the output of this command with the information in the following table:

Table 5 Supported hardware platforms

<table>
<thead>
<tr>
<th>Hardware platform</th>
<th>Output from <code>uname -i</code></th>
</tr>
</thead>
<tbody>
<tr>
<td>x86</td>
<td>i386</td>
</tr>
<tr>
<td>AMD64/Intel EM64T</td>
<td>x86_64</td>
</tr>
</tbody>
</table>

To determine the Linux kernel installed on your system, run the following command:

```
# uname -r
```

Verify that the kernel identifier in the output of this command begins with the following value:

2.6.9-89
Supported Fibre Channel SAN Hardware Components

AxiomONE Path Manager (APM) supports a variety of Fibre Channel host bus adapters (HBAs) and storage area network (SAN) routers and switches.

Approved HBAs and switches that are compatible with the Pillar Axiom system are listed in:
- Supported Emulex Host Bus Adapters and Drivers.
- Supported QLogic Host Bus Adapters and Drivers.
- Supported Fibre Channel Switches.

Supported Emulex Host Bus Adapters and Drivers

AxiomONE Path Manager (APM) 3.2 supports the following Emulex host bus adapters (HBAs) and HBA drivers:

- LP10000
- LP10000DC
- LP10000ExDC-E
- LP11000
- LP11002
- LPe11000
- LPe11002
- LPe11004
- LPe12000
- LPe12002
- LPe12004

The above HBAs require Emulex driver version 8.0.16.46. In addition, the `elxlinuxapps-4.0a38-8.0.16.46-1-1` and HBAnyware package 4.0a38 are required. The driver is included in the OEL 4.8 distribution, but the HBAnyware package must be downloaded from the Emulex Open Source Driver Version 8.0.16.46 page (http://www.emulex.com/downloads/emulex/cnas-and-hbas/drivers/linux/801646-driver-and-hbanyware-kits.html).

Supported QLogic Host Bus Adapters and Drivers

The AxiomONE Path Manager (APM) 3.2 software supports the following QLogic Fibre Channel host bus adapters (HBAs) on x86-32 and x86-64 platforms:

- QLA2310F, QLA2310FL
- QLA2340, QLA2340L
- QLA2342, QLA2342L
- QLE2460
- QLE2462
- QLE2464
The above HBAs require QLogic driver version 8.02.23-3. In addition, the HBA API libraries for this driver are required. The driver and version qlapi-v5.00build6-rel of the SNIA API for Linux Drivers libraries must be downloaded from the QLogic Driver Downloads/Documentation page (http://driverdownloads.qlogic.com/QLogicDriverDownloads_UI) for your hardware platform.

**Supported Fibre Channel Switches**

For a list of supported Fibre Channel switches, choose one of:

- Call the Pillar World Wide Customer Support Center at the number listed in Contact Information.
- Refer to the Pillar Axiom Support and Interoperability Guide, which can be found on the Documents Web page (http://www.pillardata.com/techdocs).

**Note:** Refer to the switch vendor’s Web site for the most recent installation instructions, patches, and firmware.
Supported iSCSI Software and Hardware

AxiomONE Path Manager (APM) 3.2 for Oracle Enterprise Linux (OEL) 4.8 supports the following Internet Small Computer System Interface (iSCSI) software and hardware:

- The iSCSI software initiator included in the OEL 4.8 distribution.
- The iSCSI-to-Fibre Channel routing features of the Cisco MDS 9000 family of routers and switches.

**Note:** APM for OEL 4.8 does not support iSCSI host bus adapters (HBAs).

Supported iSCSI-to-Fibre Channel Routers

iSCSI-to-Fibre Channel (FC) routing features enable a host to use Internet Small Computer System Interface (iSCSI) to access LUNs on Pillar Axiom FC Slammers.

AxiomONE Path Manager (APM) supports the iSCSI-to-FC routing features of the Cisco MDS 9000 family of multilayer directors and fabric switches. The only supported iSCSI-to-FC routing solution is the solution provided by this family of switches.

The iSCSI-to-FC features were tested on Cisco MDS SAN-OS Release 3.0 (2a). For more information on these features, refer to the Cisco documentation (http://www.cisco.com/).

See Configure the iSCSI-to-Fibre Channel Router for the steps required to use the Cisco MDS switch as an iSCSI-to-FC router with APM and the Pillar Axiom system.

Supported iSCSI Switches

For a list of supported iSCSI switches, you can:

- Call Technical Support at the number listed in Pillar Contacts.
- Refer to the Pillar Axiom Support and Interoperability Guide, which can be found on the Pillar World Wide Customer Support Center Web site (http://support.pillardata.com/).

**Note:** Refer to the vendor’s Web site for the most recent installation instructions, patches, and firmware.
CHAPTER 2

Install AxiomONE Path Manager

Prepare to Install the AxiomONE Path Manager

To ensure a successful installation of AxiomONE Path Manager (APM), perform the following tasks in sequence:

1. Read AxiomONE Path Manager Release Notes.

2. Ensure that the Pillar Axiom storage system is running release 3.3.15 or higher of the Pillar Axiom software.

3. If you are using Fibre Channel (FC) connections, verify that your FC storage area network (SAN) components and host bus adapters (HBAs) are supported. See: Supported Fibre Channel SAN Hardware Components.

4. If you are using FC connections, confirm that your HBAs are installed according to our instructions. See one of:
   - Install Emulex Host Bus Adapters and Drivers.
   - Install QLogic Host Bus Adapters and Drivers.

5. If you are using Internet Small Computer System Interface (iSCSI) connections, verify that your network is configured for iSCSI multipathing, and that you have configured the iSCSI software initiator correctly.

   See About Network Configuration for iSCSI Multipathing, Configure the iSCSI Software Initiator, and Start the iSCSI Software Initiator Service.

6. If you are using iSCSI connections, confirm that any iSCSI-to-FC routers and IP switches you have installed are supported.

   See Supported iSCSI Routers and Switches.

7. Pre-Configure the SAN for Pillar Axiom Integration.

8. Verify Installation of the Device Mapper.
Pre-Configure the SAN for Pillar Axiom Integration

Before you install the AxiomONE Path Manager (APM) software, you need to prepare your storage area network (SAN) host connections with the Pillar Axiom storage system.

Prerequisites:
Verify that your system has:

- LUNs configured on your Pillar Axiom storage system.
- At least one SAN Slammer storage controller that has Fibre Channel (FC) or Internet Small Computer System Interface (iSCSI) ports.
- An FC or iSCSI protocol license.
- Supported host bus adapter (HBA) drivers and API libraries.
- Ethernet connections to the management ports on the Pilot management controller.
- A network configuration that allows an application on the SAN host to connect to TCP port 26004 on the Pilot.

**Tip:** To check network connectivity, issue a simple `pdscli` or `axiomcli` request from the host to the Pillar Axiom storage system. Both `pdscli` and `axiomcli` use the same port and protocols as those used by APM. Refer to the *Pillar Axiom CLI Reference Guide* or *Pillar AxiomONE CLI Guide* for details.

1. Verify that all FC and iSCSI components and software are installed on the SAN host according to the instructions in this guide.

2. Set up the physical connectivity and any required switch zoning for the SAN. Proper setup is needed so all required host HBA ports can access the Slammer ports on the Pillar Axiom server.

3. If you are using iSCSI connections, choose one or more of the following:
   - About Network Configuration for iSCSI Multipathing.
   - Configure the iSCSI Initiator.
   - Configure the iSCSI-to-Fibre Channel Router.

4. Launch the AxiomONE Storage Services Manager and navigate to the Storage > SAN > Hosts page.

5. Verify the SAN connections.
   Each host port should display individually as follows:
### Table 6 Characteristics of SAN connections to host ports

<table>
<thead>
<tr>
<th>Column label</th>
<th>Port type</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>FC</td>
</tr>
<tr>
<td>Host Name:</td>
<td>Hostname Unknown</td>
</tr>
<tr>
<td>Host Port:</td>
<td>WWN</td>
</tr>
</tbody>
</table>

See [Figure 2: Example host ports before APM installation](#) for an illustration.

6 If the host is using only iSCSI to connect to Slammers, choose one of:

- Install the `sg3_utils` packages.
- Ensure that at least one LUN on the Pillar Axiom storage system is visible to the host.

The `sg3_utils-libs-*` and `sg3_utils-*` packages are required for automatic discovery of the Pillar Axiom storage system over iSCSI when no iSCSI LUNs are visible to the host. An alternative is to make a LUN visible to the host by either creating a global LUN or mapping one to the host iSCSI software initiator IQN.

**Note:** If you mapped a LUN to the initiator IQN, it will automatically be remapped to the host name after APM is installed. If the LUN is temporary, delete it after you install the software.

### Verify Installation of the Device Mapper

The Linux 2.6 `device-mapper`, among other uses, maps a logical block device on the SAN host into a Pillar Axiom LUN. The AxiomONE Path Manager (APM) daemon monitors the `device-mapper` and uses it to provide multipathing.

APM requires `device-mapper` version 1.02.28-2.el4 or later.

1 Verify that `device-mapper` is installed.

Run the following command at a command prompt:

```bash
# rpm -qa | grep device-mapper | grep -v multipath
```

**Result:**

If `device-mapper` is installed, this command returns the version of `device-mapper` and your operating system.

2 If `device-mapper` version 1.02.28 or later is not installed, install this version.
Install device-mapper from your Linux installation CDs or operating system vendor Web site.

Install Emulex Host Bus Adapters and Drivers

To ensure compatibility between AxiomONE Path Manager (APM) and your Emulex host bus adapters (HBAs), be sure to follow the instructions in this section for installing the supported Emulex HBAs and drivers.

1. Install Emulex HBAs according to the instructions at the Emulex support download page (currently http://www.emulex.com/downloads).

2. Verify that you have the Emulex version 8.0.16.46 HBA driver installed.

   To determine your driver version, run the following command:

   ```
   modprobe lpfc
   ```

   If the driver version returned does not match the supported version, download the driver from the Open Source Driver Version 8.0.16.46 page (http://www.emulex.com/downloads/emulex/cnas-and-hbas/drivers/linux/801646-driver-and-hbanyware-kits.html), and follow the Emulex instructions for installing the driver.

3. Download the Emulex HBAnyware Applications Kit appropriate for your Linux operating system, and follow the Emulex instructions for installing the Applications Kit.

   The required HBA drivers are supplied as part of the Oracle Enterprise Linux 4.8 (OEL 4.8) operating system, but you must download the `elxlinuxapps-4.0a38-8.0.16.46-1-1` and HBAnyware package `4.0a38` from the Emulex Open Source Driver Version 8.0.16.46 page (http://www.emulex.com/downloads/emulex/cnas-and-hbas/drivers/linux/801646-driver-and-hbanyware-kits.html). The Applications Kit is required for the APM daemon to communicate with the Pillar Axiom system.

4. Use the HBAnyware utility to set the following HBA settings to the recommended values:

<table>
<thead>
<tr>
<th>HBA settings</th>
<th>Recommended value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Max Queue Depth (lpfc_lun_queue_depth)</td>
<td>64</td>
</tr>
</tbody>
</table>
5 If you have replaced the driver, or made any modifications to the driver configuration file, rebuild the kernel to ensure that any changes to the driver are picked up.

Use the following command:

```
  # /sbin/new-kernel-pkg --mknitrd --depmod --install `uname -r`
```

### Install QLogic Host Bus Adapters and Drivers

To ensure compatibility between AxiomONE Path Manager (APM) and your QLogic host bus adapters (HBAs), be sure to follow the instructions in this section for installing the supported QLogic HBAs and drivers.

1 Install QLogic HBAs according to the instructions at the [QLogic support download page](http://support.qlogic.com/support) (currently [http://support.qlogic.com/support](http://support.qlogic.com/support)).

2 Verify that you have the QLogic version 8.02.23-3 HBA driver installed.

To determine your driver version, run the following command:

```
  modprobe qla2xxx
```

If the driver version returned does not match the supported version, download the SANSurfer Linux Driver Installer from the QLogic [Driver Downloads/Documentation](http://driverdownloads.qlogic.com/QLogicDriverDownloads_UI) page for your hardware platform, and follow the QLogic instructions for installing the driver.

3 Download the QLogic HBA API libraries appropriate for your hardware platform, and follow the QLogic instructions for installing the libraries.

Download version qlapi-v5.00build6-rel of the SNIA API for Linux Drivers libraries from the QLogic [Driver Downloads/Documentation](http://driverdownloads.qlogic.com/QLogicDriverDownloads_UI) page for your hardware platform. The HBA API libraries are required for the APM daemon to communicate with the Pillar Axiom system.

4 Download and install the SANSurfer CLI (optional).
If you have not already installed the SANSurfer CLI as part of the SANSurfer Linux DriverInstaller package, download version 1.7.3 build 20 of the QLogic SANSurfer FC HBA CLI from the QLogic Driver Downloads/Documentation page (http://driverdownloads.qlogic.com/QLogicDriverDownloads_UI), and follow the QLogic installation instructions.

**Note:** If you use the SANSurfer CLI to change the settings in Steps 5 and 6, you will not need to rebuild the kernel for the changes to go into effect.

5 Set the following HBA settings in the `/etc/modprobe.conf.local` configuration file to the recommended values:

<table>
<thead>
<tr>
<th>HBA setting</th>
<th>Recommended value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Link Down Timeout</td>
<td>30</td>
</tr>
<tr>
<td>Execution Throttle</td>
<td>64</td>
</tr>
<tr>
<td>LUNs per Target</td>
<td>256</td>
</tr>
<tr>
<td>Port Down Retry Count</td>
<td>30</td>
</tr>
<tr>
<td>Max Queue Depth (ql2xmaxqdepth)</td>
<td>64</td>
</tr>
</tbody>
</table>

6 Disable QLogic’s multipathing to ensure recovery from path failures.

Ensure that the `/etc/modprobe.conf.local` file has the following settings:

```bash
options qla2xxx ql2xfailover=0 ConfigRequired=0 MaxRetriesPerPath=15 ql2xloginretrycount=30 ql2xlogintimeout=60 ql2xretrycount=90 qlport_down_retry=45
```

Be sure to rebuild the kernel after resetting any of these options. If you use the SANSurfer CLI to change these settings, it is not necessary to rebuild the kernel.

7 If you have replaced the driver, or if you did not use the SANSurfer CLI to make modifications to the driver configuration file, rebuild the kernel to ensure that any changes to the driver are picked up.

Use the following command:

```bash
# /sbin/new-kernel-pkg --mknitrd --depmod --install `uname -r`
```
About Network Configuration for iSCSI Multipathing

You can reduce the impact of failures in your Internet Small Computer System Interface (iSCSI) network by ensuring that iSCSI connections are made through several network interface cards (NICs) on the host.

We recommend using the normal IP configuration facilities to route connections to different Slammer storage controller ports through different host NICs. For example, if the host has two NICs available for iSCSI connections to a Slammer, you can set up routing to send all traffic to one port on each Slammer control unit (CU) through one NIC, and traffic to the other port on each Slammer CU through the other NIC.

The best way to ensure that your iSCSI paths use different physical connections depends on factors such as the number of available NICs in the host and the existing configuration of your IP network. We recommend using normal IP routing configuration techniques such as subnet configuration and explicit route configuration to distribute connections over multiple NICs. You can also use NIC bonding to provide redundancy on Ethernet connections between the host and the switch.

Subnet Configuration

Groups of host network interface cards (NICs) and Slammer ports can be configured into different subnets. Whenever the iSCSI initiator opens a connection to a Slammer port, that connection will automatically be routed through the host NIC in the same subnet as the Slammer port. For example, if a host has two NIC ports on the Internet Small Computer System Interface (iSCSI) network, one of the host NIC ports and one port on each Slammer control unit (CU) could be placed in one subnet, and another host NIC port connected to the other Slammer CU ports could be placed in a different subnet.

Refer to the Red Hat Enterprise Linux 4: System Administration Guide for instructions on setting up subnets.

Configure Explicit Routing

If two or more NICs on the host are configured into the same subnet, you should explicitly configure Internet Protocol (IP) routing to route connections to different destination ports through different host NICs.
1. Create or edit the routing configuration file for each NIC, and add entries for each destination IP address that you want to route through this NIC.

   The name of the routing configuration file is `/etc/sysconfig/network-scripts/route-NIC`, where `NIC` is the name used by the OS for the NIC. Add a line for each Slammer port for which access is to be routed through this NIC. The format of the line should be:

   **Slammer_port.IP_address via NIC.IP_address src NIC.IP_address**

   Example:
   If the NIC `eth0` has been configured with IP address 192.168.2.39, and you want to use this NIC to access Slammer ports 192.168.2.10 and 192.168.2.12, then you would create or edit the file `/etc/sysconfig/network-scripts/route-eth0` and add the following lines:

   ```
   192.168.2.10 via 192.168.2.39 src 192.168.2.39
   192.168.2.12 via 192.168.2.39 src 192.168.2.39
   ```

   You can also use the `ip route add` command to temporarily set up routes from the command line by using lines of the form described above as parameters.

   Example:
   The following command sets up a route for the first Slammer port described above:

   ```
   # ip route add 192.168.2.10 via 192.168.2.39 src 192.168.2.39
   ```

2. If the host has more than one NIC in a broadcast domain, you must modify the configuration to prevent a condition known as address resolution protocol (ARP) flux, which can prevent routing from operating correctly.

   To prevent **ARP flux**, edit the file `/etc/sysctl.conf`, and modify or add entries for the following parameters:

   ```
   net.ipv4.conf.all.arp_ignore=1
   net.ipv4.conf.all.arp_announce=2
   ```

   You can also temporarily prevent ARP flux by using lines of this form as parameters to `sysctl -w` commands.

   Example:
   The following commands temporarily prevent ARP flux:

   ```
   # sysctl -w net.ipv4.conf.all.arp_ignore=1
   # sysctl -w net.ipv4.conf.all.arp_announce=2
   ```

   Changes to the configuration files will take effect after you reboot the host.
NIC Bonding

Network interface card (NIC) bonding adds redundancy to Ethernet networks at the expense of not providing multiple Internet Small Computer System Interface (iSCSI) paths.

With *NIC bonding*, also known as *channel bonding*, two or more NICs and their physical connections to the switches are logically bonded together and presented to the Internet Protocol (IP) as a single virtual NIC. If one of the physical connections fails, the traffic is transferred to another NIC without the IP layer or the layers above it knowing about the transfer.

This approach protects against low-level Ethernet failures, such as a faulty NIC or cable, between the host and its local IP switch. Because the redundancy is at a very low level in the protocol stack, the higher layers such as Transmission Control Protocol/Internet Protocol (TCP/IP), iSCSI, and *device-mapper* are not aware that a transfer to a different NIC has taken place. To the IP protocol, the virtual bonded NIC appears as a single physical connection. To iSCSI, it appears as a single connection to each target port.

In short, the iSCSI, *device-mapper*, and APM layers are not aware of the physical path redundancy provided at the NIC bonding level and do not treat this redundancy as providing multiple paths to the Slammer storage controller. Redundancy created by NIC bonding will not be reported as multiple paths by *device-mapper* or in the AxiomONE Storage Services Manager.


Configure the iSCSI Software Initiator

You must configure the iSCSI software initiator before you can use Internet Small Computer System Interface (iSCSI) connections with the AxiomONE Path Manager (APM).

Prerequisite:

To support iSCSI connections, APM 3.2 for Oracle Enterprise Linux 4.8 (OEL 4.8) requires the 4.0.3.0-8 version of the iSCSI software initiator included in the OEL 4.8 distribution.
For complete installation instructions, refer to:

```
/usr/share/doc/iscsi-initiator-utils-4.0.3.0/README
```

**Important!** You must ensure that each iSCSI software initiator name set in the `/etc/intiatorname.iscsi` file is unique.

Create more than one DiscoveryAddress entry for each Pillar Axiom storage system to ensure that the iSCSI software initiator will be able to discover the Pillar Axiom iSCSI ports while faults are present in the systems or the network. Consider the topology of your network and select Slammer iSCSI ports that are on different Slammers or control units (CUs), and that are accessible through different NICs on the host and different network paths.

Adding entries for several different Slammer ports in this way ensures that at least one will be accessible during failures of various sorts. You can add up to one entry for every iSCSI port on the Pillar Axiom storage system. To protect yourself against CU failure, add a minimum of one entry for at least one port on every SAN Slammer CU with iSCSI.

1. Open the `/etc/iscsi.conf` file in a text editor.
2. Specify the IP address for the `DiscoveryAddress=IP address` setting.
   
   Specify an IP address (and optional IP port number) that the iSCSI software initiator will use to discover iSCSI ports on the target system. Create at least one discovery address for each Pillar Axiom storage system containing LUNs that the host will access. The IP address should be the address of one of the iSCSI ports on a Slammer storage controller. Specify the IP port number only for iSCSI ports configured to use IP port numbers other than the default port 3260.
3. Set `SendAsyncText` to `yes`.
   
   This setting is necessary for the iSCSI software initiator to receive vendor-specific asynchronous events from the target.
4. Set `Continuous` to `yes`.
   
   This setting globally specifies that all discovery sessions be kept open.
5. Configure the remaining `iscsi.conf` options according to the instructions within that file, and in the `README` file.

Pay particular attention to the safe timeout settings in the `USING MULTIPATH I/O SOFTWARE` section of the `README` file. We recommend using the following settings:

```
AbortTimeout=60
```
Start the iSCSI Software Initiator Service

After you have configured the iSCSI software initiator, set the iSCSI initiator to start at startup time and confirm that your Internet Small Computer System Interface (iSCSI) devices are visible.

1. Start the `iscsi` service.
   Run the following command:
   
   ```bash
   # service iscsi start
   ```

2. Configure the `iscsi` service to start at boot time.
   Run the following commands:
   
   ```bash
   # chkconfig --add iscsi
   # chkconfig iscsi on
   ```
   
   The first command checks that the scripts necessary to start and stop the service are available. The second command sets the service to start at the appropriate run levels.

3. Verify that the `iscsi` service is configured to start at boot time.
   Run the following command:
   
   ```bash
   # chkconfig --list iscsi
   ```

   Result:
   The following is a sample of the output of this command when the service is not configured to start at boot time:
   
   ```
   iscsi 0:off 1:off 2:off 3:off 4:off 5:off 6:off
   ```
   
   The following is a sample of the output of this command when the service is configured to start at boot time:
   
   ```
   iscsi 0:off 1:off 2:on 3:on 4:on 5:on 6:off
   ```
Configure the iSCSI-to-Fibre Channel Router

This release supports the iSCSI-to-Fibre Channel routing features of the Cisco MDS 9000 family of multi-layer directors and fabric switches. These features require configuration to work with the AxiomONE Path Manager (APM) and the Pillar Axiom system.

For more information on these features, refer to the Cisco documentation (http://www.cisco.com/univercd/cc/td/doc/product/sn5000/mds9000/3_0/fmcfg/index.htm).

1 Present the Pillar Axiom Slammer storage controller ports as Internet Small Computer System Interface (iSCSI) targets.

   Choose `Dynamic Mapping` or `Static Mapping`. However, we recommend that you use dynamic mapping because the main Cisco features for static mapping requirements are supplied by APM and the AxiomONE Storage Services Manager.

2 Present the iSCSI hosts as virtual Fibre Channel hosts.

   The hosts must be presented in transparent initiator mode (not in proxy-initiator mode). When you assign World Wide Names (WWNs) for the iSCSI initiators, use the static mapping mechanism.

After you configure the switch, APM on the iSCSI hosts interacts with the Pillar Axiom systems in exactly the same way as when both hosts and Slammers use the same SAN protocol.
Download and Install the AxiomONE Path Manager Software

The AxiomONE Path Manager (APM) installation for Oracle Enterprise Linux 4.8 (OEL 4.8) requires that you download both the APM package and the Multipath Tools package from the Pillar Support Web site. Then you need to install both packages on your system.

1. Download the AxiomONE Path Manager Software.
2. Install (or Update) the AxiomONE Path Manager Software.
3. Configure the Pillar Axiom System for LUN Access.

To remove the AxiomONE Path Manager software from your SAN host, see Remove AxiomONE Path Manager Software (Optional).

Download the AxiomONE Path Manager Software

The AxiomONE Path Manager (APM) 3.2 software consists of two packages: the APM daemon package, and a package containing an updated version of the multipath-tools component of device-mapper. You will need to download both packages.

The Multipath Tools component also contains Pillar bug fixes. When using APM, the Pillar version must be used in place of the one supplied with the Linux operating system.

2. In the left navigation pane, click the Software Downloads > AxiomONE Path Manager link.
3. In the content pane, expand the Linux > OEL 4 link.
4. Expand the APM 3.2 > OEL 4 link.
5. For each package (APM or Multipath Tools), click the name of the package for your hardware platform (x86, or AMD64/Intel EM64T) to download.
6. Under Software Download Details, click the green arrow to begin the download.
7. Choose the Save option to download the package to your SAN host.
Install (or Update) the AxiomONE Path Manager Software

After you download the AxiomONE Path Manager (APM) software and Multipath Tools packages, you can install them on your host system.

Before you install the APM software, verify that your system meets the prerequisites outlined in Supported Fibre Channel SAN Hardware Components and Pre-Configure the SAN for Pillar Axiom Integration.

Two steps in the installation process enable you to keep your original multipath configuration file (/etc/multipath.conf) so that you can continue to use your specific configurations for managing devices other than APM-managed Pillar Axiom LUNs:

• Because the configuration file will be deleted, Step 1 asks you to save a copy of that file before you begin the APM installation or update task.
• Step 5 asks you to merge any changes you made to the original configuration file into the new file.

Tip: We strongly recommend that you follow these two steps when you have previously added or modified entries in /etc/multipath.conf.

1 If you previously configured multipath-tools on your system, save a copy of the current /etc/multipath.conf file.

Saving a copy allows you to merge the changes into the new file that will be created.

2 Uninstall any previously installed versions of multipath-tools.

The name of the multipath-tools Red Hat Package Manager (RPM) package varies (depending on its source). The name usually begins with one of the following strings:

multipath-tools
device-mapper-multipath

Example:
Use one of the following commands, depending on the name of the multipath-tools RPM package:

# rpm -e multipath-tools
or

# rpm -e --nodeps device-mapper-multipath
Important! Other packages associated with device-mapper that begin with the string device-mapper may exist on the SAN host. Do not remove these packages. Remove only those packages that begin with the string multipath-tools or device-mapper-multipath.

3 Remove any previous versions of APM on your system using the following command:

   # rpm -e axiompm

4 Install the Multipath Tools package using the following command:

   # rpm -ivh multipath-tools-version.rpm

   Note: In the command above, version is the name of the release version you downloaded.

5 After the new /etc/multipath.conf is installed, merge in any previous configuration data for device-mapper from the copy of the configuration file you saved in Step 1.

Merging those changes allows you to retain previous configuration settings to manage devices other than APM.

   Note: The file format required by the updated version of device-mapper may be different from the file format you were using previously, so you may need to make adjustments as you merge the files. See About Multipathing and Device Mapper Automation for details.

6 Install the APM package using the following command:

   # rpm -ivh axiompm-version.rpm

   Note: In the command above, version is the name of the release version you downloaded.

   APM files and scripts are installed in the /opt/pillar directory.

7 Restart the host.

After you install the software, follow the instructions in Configure the Pillar Axiom System for LUN Access. You must complete that task for the software to function correctly.
Configure the Pillar Axiom System for LUN Access

The LUN configuration procedure provides the storage area network (SAN) host with access to Pillar Axiom LUNs. Refer to the Pillar Axiom Administrator’s Guide for instructions on how to create LUNs.

Prerequisites:
- Pre-Configure the SAN for Pillar Axiom Integration.
- Install (or Update) the AxiomONE Path Manager Software.

1. In the AxiomONE Storage Services Manager, navigate to the Storage > SAN > Hosts page.

2. Verify that the individual entries for the host ports have been replaced with a single entry under the host name.

Example:

Figure 2 Example host ports before APM installation

<table>
<thead>
<tr>
<th>Host Name</th>
<th>Host Port</th>
<th>Type</th>
<th>AxiomONE Path Manager</th>
<th>Number of LUNs</th>
<th>Host Port Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hostname Unknown</td>
<td>10:00:00:00:00:36:94:54:6e</td>
<td>FC</td>
<td>Not Registered</td>
<td>0</td>
<td>Connected</td>
</tr>
<tr>
<td>Hostname Unknown</td>
<td>10:00:00:00:00:36:94:54:6f</td>
<td>FC</td>
<td>Not Registered</td>
<td>0</td>
<td>Connected</td>
</tr>
<tr>
<td>Hostname Unknown</td>
<td>10:00:00:00:00:36:94:54:20</td>
<td>FC</td>
<td>Not Registered</td>
<td>8</td>
<td>Connected</td>
</tr>
<tr>
<td>Hostname Unknown</td>
<td>10:00:00:00:00:36:94:41:32:c3</td>
<td>FC</td>
<td>Not Registered</td>
<td>0</td>
<td>Connected</td>
</tr>
<tr>
<td>Hostname Unknown</td>
<td>10:00:00:00:00:36:94:41:32:c4</td>
<td>FC</td>
<td>Not Registered</td>
<td>0</td>
<td>Connected</td>
</tr>
<tr>
<td>lan.1937-03.com.01-00-01-00-01-33-25-99</td>
<td>192.168.2.83</td>
<td>ISCSI</td>
<td>Not Registered</td>
<td>0</td>
<td>Connected</td>
</tr>
<tr>
<td>lan.1937-03.com.01-00-01-00-01-33-25-99</td>
<td>192.168.2.84</td>
<td>ISCSI</td>
<td>Not Registered</td>
<td>0</td>
<td>Connected</td>
</tr>
</tbody>
</table>

Figure 3 Example host ports after APM installation

<table>
<thead>
<tr>
<th>Host Name</th>
<th>Host Port</th>
<th>Type</th>
<th>AxiomONE Path Manager</th>
<th>Number of LUNs</th>
<th>Host Port Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>Host</td>
<td>10:00:00:00:00:36:94:54:6a</td>
<td>FC</td>
<td>Communicating</td>
<td>0</td>
<td>Connected</td>
</tr>
<tr>
<td>Host</td>
<td>10:00:00:00:00:36:94:54:6b</td>
<td>FC</td>
<td>Communicating</td>
<td>0</td>
<td>Connected</td>
</tr>
<tr>
<td>192.168.2.63</td>
<td>192.168.2.64</td>
<td>ISCSI</td>
<td>Not Registered</td>
<td>0</td>
<td>Connected</td>
</tr>
<tr>
<td>192.168.2.54</td>
<td>192.168.2.54</td>
<td>ISCSI</td>
<td>Not Registered</td>
<td>0</td>
<td>Connected</td>
</tr>
<tr>
<td>Hostname Unknown</td>
<td>10:00:00:00:00:36:94:54:20</td>
<td>FC</td>
<td>Not Registered</td>
<td>6</td>
<td>Connected</td>
</tr>
<tr>
<td>Hostname Unknown</td>
<td>10:00:00:00:00:36:94:41:32:c3</td>
<td>FC</td>
<td>Not Registered</td>
<td>0</td>
<td>Connected</td>
</tr>
<tr>
<td>Hostname Unknown</td>
<td>10:00:00:00:00:00:36:94:41:32:c4</td>
<td>FC</td>
<td>Not Registered</td>
<td>0</td>
<td>Connected</td>
</tr>
</tbody>
</table>
Note: The Hosts page may display differently in your version of AxiomONE Storage Services Manager.

You will see one or more of the following AxiomONE Path Manager Status and Host Port Status messages on the Hosts page:

**APM Status**
- **Communicating**: The host control path is currently logged into the Pilot.
  
  **Note**: Communicating status is required for the APM control path to report path status, configure load balancing, and use the Pillar Axiom system to collect APM diagnostic logs.

- **Not Registered**: A control path from an APM host with this name has never logged into the Pilot.

- **Not Communicating**: The APM host control path has previously logged into the Pilot, but it is not currently logged in.

**Host Port Status**
- **Connected**: The host SAN connection is logged in to the SAN Slammer.

- **Not connected**: The host SAN connection is not logged in to the SAN Slammer.

See the AxiomONE Storage Services Manager Help for information about the remaining fields on the Hosts page.

3 As needed, create new LUNs on the Pillar Axiom server for the SAN hosts.

**Note**: In a clustered environment, LUNs shared in a cluster should be mapped to all host nodes in the cluster.

4 As needed, set up mappings of the LUNs to the new host entries.

5 Follow the recommendations in **SAN Dynamic Reconfiguration** to make any changes visible to the SAN host.

6 Run the following commands to list the multipath devices (optional):

```
# /sbin/multipath -v3
# /sbin/multipath -ll
```

The first command (`multipath -v3`) populates the path information, and the second command (`multipath -ll`, lower-case letters L) lists the state of the paths.

7 In the AxiomONE Storage Services Manager, navigate to the **Storage > SAN > Hosts** page.

8 Click the name of the new host and, on the Host Information page, verify the APM software version.
9 Click the **LUN Connections** tab and verify that the host and LUN connections are as expected.

The column titled **LUN Name on Host** should show the Linux disk names that APM allocates to each LUN.

**Important!** With a few exceptions (such as when you partition and format the LUN on the SAN host), you should use only these Linux disk names to access and configure the LUNs on the host. Linux creates device names for each individual path to a LUN, but almost all configuration and administration tasks should be done using the `/dev/mapper` name shown in the AxiomONE Storage Services Manager.

10 If you plan to partition and format the LUN on the SAN host, see **Partition and Format the LUN Disk (Optional)**.
Partition and Format the LUN Disk (Optional)

Follow these instructions if you plan to use the Linux `fdisk` or `parted` utilities to partition and format the disk on which a LUN resides.

The `fdisk` utility cannot be used with devices listed in the `/dev/mapper` directory. Instead, use `fdisk` on one of the underlying paths, and then run the scripts to restart the `multipath-tools` and APM daemons to notify `device-mapper` that a `/dev/mapper` device has a new partition.

1. Identify one of the highest priority paths to the LUN using the output of the `multipath -ll` command.

   **Example:**
   In the output below, you could identify either the `/dev/sdd` or the `/dev/sdh` path:

   ```
   2000b080002001395
   [size=10 GB][features=1_queue_if_no_path][hwhandler=0]
   
   \_ round-robin 0 [prio=61568][active]
   \_ 0:0:1:3  sdd 8:48  [active][ready]
   \_ 1:0:1:3  sdh 8:112 [active][ready]
   \_ round-robin 0 [prio=1986][enabled]
   \_ 12:0:0:3 sdl 8:176 [active][ready]
   \_ 13:0:0:3 sdq 65:0  [active][ready]
   \_ round-robin 0 [prio=64][enabled]
   \_ 0:0:0:3  sdb 8:16  [active][ready]
   \_ 1:0:0:3  sdf 8:80  [active][ready]
   \_ round-robin 0 [prio=2][enabled]
   \_ 10:0:0:3 sdk 8:160 [active][ready]
   \_ 11:0:0:3 sdp 8:240 [active][ready]
   ```

2. Use `fdisk` to partition one of the highest priority paths identified in Step 1.

3. Run the following command to restart the `device-mapper`:

   ```
   # /etc/init.d/multipathd restart
   ```

4. Run the following command to restart the APM daemon:

   ```
   # /etc/init.d/axiompmd restart
   ```

5. Verify that the new partitions are listed as follows:

   ```
   # /dev/mapper/LUNp\n
   LUN is the LUN identifier, and x is the partition number used in Step 2.

   **Note:** The letter `p` that appears between the LUN identifier and the partition number is required in this command.
Example:
In the example above, if only partition 1 were created with `fdisk`, it would appear as follows:

```
localhost$ ls -l /dev/mapper/2000b080002001395*
brw-rw----  1 root disk 253,  2 Jul  7 12:02
2000b080002001395
brw-rw----  1 root disk 253,  3 Jul  7 15:12
2000b080002001395p1
```

6 Format the new partition.

Example:
To format the partition created in the example above, you might run the following command:

```
# mke2fs -j /dev/mapper/2000b080002001395p1
```

7 Mount the filesystem.

For detailed information, refer to your Linux documentation.
About Load Balancing Configuration

AxiomONE Path Manager (APM) 3.2 for Oracle Enterprise Linux 4.8 (OEL 4.8) is pre-configured for round-robin load balancing.

APM 3.2 for OEL 4.8 supports only round-robin load balancing. It is pre-configured in the multipath.conf file, where path_grouping_policy is set to group_by_prio. Pillar Data Systems does not support the use of any other value for path_grouping_policy.

In round-robin load balancing, commands are sent in turn over the best available paths. Round-robin load balancing ensures that LUN commands are evenly distributed over any path that is available to access the LUNs.

Load balancing allows the paths to share load in different ways:

- Balances access to a LUN across all optimized Slammer storage controller ports available for that LUN. For more information on path selection, see About Path Selection.
- Balances access from a host across the host HBA channels.

Important! The load balancing options in the AxiomONE Storage Services Manager must always be set to round-robin for all hosts running APM 3.2 for OEL 4.8. See Known Pillar Axiom Issues for additional load balancing considerations.
About Path Selection

AxiomONE Path Manager (APM) supports access to LUNs using Internet Small Computer System Interface (iSCSI) and Fibre Channel (FC) protocol at the same time, as well as individually.

Paths to a LUN may have different performance characteristics. Paths to the Slammer control unit where the LUN resides are considered optimized paths; other paths to the LUN are considered non-optimized paths. When both FC and iSCSI access to a LUN are available, FC access generally performs better.

APM divides the paths to each LUN into four groups with different performance characteristics, in this order of precedence:

- First, FC optimized
- Next, iSCSI optimized
- Next, FC non-optimized
- Finally, iSCSI non-optimized

At any given time, the device-mapper framework only uses paths from the most preferred group that has paths available.

**Note:** When an active path fails, and I/O traffic is transferred to a different path, I/O performance will be reduced for a short time while the operating system recognizes the failure and makes the path transfer. If the failing path was optimized and the new path is non-optimized, I/O performance may remain lower than before since it is now using a lower-performance path. Within a few minutes of traffic being transferred to a non-optimized path, the Pillar Axiom storage system will, if possible, reconfigure the LUNs to use an optimized path. I/O performance will improve.
Remove AxiomONE Path Manager Software (Optional)

When you uninstall AxiomONE Path Manager (APM), support for multiple paths to Pillar Axiom LUNs is removed.

Before you uninstall APM, if you do not want to access Pillar Axiom LUNs, we recommend that you disconnect the storage area network (SAN) host from the Pillar Axiom storage system.

Sometimes, the uninstall process may take longer than expected, and the process may appear to be hanging. Allow the process to run for at least an hour before attempting to restart the process.

1 Run the following commands to stop and remove the APM daemon:

   # /etc/init.d/axiompmd stop
   # rpm -e axiompm

2 Run the following command to remove the version of `multipath-tools` supplied by Pillar Data Systems:

   # rpm -e multipath-tools

3 Reinstall the `multipath-tools` that came with your Linux software (optional).

After the APM software (both `axiompm` and `multipath-tools`) has been removed, the host appears not to be communicating in the AxiomONE Storage Services Manager, and the multipath behavior stops working.

**Important!** If you want to continue LUN access without multipathing, we recommend that you reconfigure the SAN so that only a single path exists from the host to each Pillar Axiom Slammer storage controller. You may need to reconfigure LUN mapping on the Pillar Axiom storage system to map the LUNs to the host port or iSCSI Qualified Name (IQN), and you may need to reconfigure the host to access the LUNs through new device names.
AxiomONE Path Manager Release Notes

New in this Release

AxiomONE Path Manager 3.2 supports Oracle Enterprise Linux 4.8.
Known APM Issues

There are no known AxiomONE Path Manager (APM) issues for this release.
Known Pillar Axiom Issues

The following issues might be associated with the version of the Pillar Axiom software you are using.

Table 9 Known Pillar Axiom issues

<table>
<thead>
<tr>
<th>Issue</th>
<th>Workaround or planned fix</th>
</tr>
</thead>
<tbody>
<tr>
<td>If an AxiomONE Path Manager (APM) host uses iSCSI to connect to a Pillar Axiom storage system, and it uses an iSCSI initiator name that is the same as its host name, then the entry for that host in the AxiomONE Storage Services Manager will be continually deleted and recreated, causing the host entry to disappear and reappear intermittently.</td>
<td>Ensure that the iSCSI initiator names configured on hosts that use iSCSI to connect to a Pillar Axiom system are different from all host names used by APM hosts connected to that Pillar Axiom system. The iSCSI standards require that iSCSI names follow particular formats, as specified in RFC 3720 (<a href="http://tools.ietf.org/html/rfc3720#section-3.2.6">http://tools.ietf.org/html/rfc3720#section-3.2.6</a>). If hosts are configured to use iSCSI initiator names that conform to these requirements, it is extremely unlikely that they will be the same as any host name. This issue will be fixed in a future release of the Pillar Axiom software.</td>
</tr>
<tr>
<td>If all paths to a LUN's configured Slammer control unit (CU) fail, APM will re-route all traffic through the non-optimized paths to the LUN's alternate CU. In response, the Pillar Axiom system will initially log events indicating non-optimized access, then when this traffic continues it will temporarily move the LUN to the alternate CU. This process leaves the host using optimized paths to the LUN, but the LUN is resident on a CU other than its configured home. Normally, the system will attempt to move the LUN back to its configured CU from time to time, and if the paths to the other CU have recovered the traffic will transfer back and the system returns to its normal configured state.</td>
<td>This issue is fixed in release 3.4 and 4.0 of the Pillar Axiom software.</td>
</tr>
</tbody>
</table>
However, if the Pilot software is restarted while a LUN is in this temporary state, as might happen during a software update that includes the option to update the Pilot software, two problems occur:

1. The graphical user interface (GUI) and command line interface (CLI) wrongly report that the LUN's current CU is its configured CU.

2. Non-optimized access events are no longer logged for the LUN, and the system does not attempt to move the LUN back to its configured CU.

If subsequent path failures and recoveries cause traffic to be sent to the CU on which the LUN is not resident, the system will not move the LUN to the CU receiving the traffic. This means that all traffic to the LUN would have non-optimized access, which decreases performance, and this non-optimized access would not be logged.

When a LUN is created on a Pillar Axiom system, its load balancing attribute is set to round-robin by default. If the LUN is then mapped to a host running APM, the load balancing attribute setting can change to static when APM on the host first communicates with the Pillar Axiom system after detecting the LUN. Instead, this attribute should be set to round-robin when the LUN is first created, and should change only if an administrator changes it using the Pillar Axiom graphical user interface (GUI) or command line interface (CLI).

This issue is fixed in Pillar Axiom software release 4.0. If the Pillar Axiom system is running a release earlier than 4.0, check that the load balancing attribute for the LUN is still set to the desired value after APM on the host has detected the LUN and its LUN name on Host has been reported in the Pillar Axiom GUI. If the setting has changed, change it back to the desired value, which can then be correctly saved.

<table>
<thead>
<tr>
<th>Issue</th>
<th>Workaround or planned fix</th>
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<tbody>
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<td>However, if the Pilot software is restarted while a LUN is in this temporary state, as might happen during a software update that includes the option to update the Pilot software, two problems occur: 1. The graphical user interface (GUI) and command line interface (CLI) wrongly report that the LUN’s current CU is its configured CU. 2. Non-optimized access events are no longer logged for the LUN, and the system does not attempt to move the LUN back to its configured CU. If subsequent path failures and recoveries cause traffic to be sent to the CU on which the LUN is not resident, the system will not move the LUN to the CU receiving the traffic. This means that all traffic to the LUN would have non-optimized access, which decreases performance, and this non-optimized access would not be logged. When a LUN is created on a Pillar Axiom system, its load balancing attribute is set to round-robin by default. If the LUN is then mapped to a host running APM, the load balancing attribute setting can change to static when APM on the host first communicates with the Pillar Axiom system after detecting the LUN. Instead, this attribute should be set to round-robin when the LUN is first created, and should change only if an administrator changes it using the Pillar Axiom graphical user interface (GUI) or command line interface (CLI).</td>
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<td>Issue</td>
<td>Workaround or planned fix</td>
</tr>
<tr>
<td>----------------------------------------------------------------------</td>
<td>--------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>If an iSCSI initiator is added to a SAN host that has authentication enabled, authentication will not be enabled for that initiator. Also, if an iSCSI initiator with authentication enabled on a previous SAN host is moved to another host with or without authentication enabled, the initiator will retain its original configuration.</td>
<td>This issue is fixed in Pillar Axiom software release 4.0. If the Pillar Axiom system is running a release earlier than 4.0, disable then re-enable authentication for the host after iSCSI initiators are added to or moved between SAN hosts.</td>
</tr>
</tbody>
</table>
Known Operating System Issues

The following operating system issues may have an impact on running APM on Linux platforms.

Access to LUNs

In most cases, you should only access LUNs through device-mapper or individual partition paths.

The Linux device-mapper creates paths of the form /dev/mapper/2000b08003d001321 to represent multipath Pillar Axiom LUNs. Individual partitions on a LUN have names of the form /dev/mapper/2000b08003d001321p3. With the exception of the situation described in Partition and Format the LUN Disk (Optional), you should access multipath LUNs and their partitions exclusively through these paths.

If a multipath partition is configured into /etc/fstab, omit the sixth field of its entry (fs_passno), or set it to 0 to prevent fsck from running automatically on the partition during a system boot. This is because device-mapper is not yet configured at the time fsck runs during boot, so the multipath devices are not accessible.

Important! Failure to disable fs_passno will cause host boot failure.

SAN Dynamic Reconfiguration

Linux does not automatically detect storage LUNs after a dynamic reconfiguration. Dynamic reconfiguration is the addition, deletion, growing, resizing, or cloning of one or more LUNs attached to a host.

Follow the instructions for dynamic reconfiguration in the Online Storage Reconfiguration Guide (http://www.redhat.com/docs/en-US/Red_Hat_Enterprise_Linux/5.2/html/Online_Storage_Reconfiguration_Guide/index.html). If you continue to have problems with dynamic reconfiguration, the following steps will help you handle exceptions.

Linux requires a series of steps, including a potential host reboot, when a LUN is dynamically reconfigured. After Linux detects the new LUNs, you must restart AxiomONE Path Manager (APM) to update the Pillar Axiom system with the new LUN status.
LUNs Added Dynamically

In most systems, a newly added LUN is immediately visible on the host without a rescan. However, due to inconsistent device driver behavior on some hosts, if the added LUN is not visible, a rescan usually makes it visible. A rescan normally involves an I/O reset.

If, after creating a new LUN on the Pillar Axiom system and assigning it to the host, running the rescan script does not bring up the LUNs, this may have happened because Linux incorrectly believes that the LUN number is already in use. To correct this situation, modify the host LUN number in the AxiomONE Storage Services Manager. Give it a new, unique value that falls within the range of permitted values. If necessary, rescan to add the LUN.

Both Emulex and QLogic provide rescan scripts that may help in dynamically configuring LUNs:

- The Emulex HBA driver for Linux enables you to dynamically add or delete LUNs and targets without unloading or reloading the lpfc module and without resetting the adapter. Use the Emulex lun_scan script in /usr/sbin. Refer to the Emulex Driver for Linux User Manual (http://www-dl.emulex.com/support/linux/82022/manual.pdf) for details.
- For QLogic HBAs, use the Dynamic Target and LUN Discovery script ql-dynamic-tgt-LUN-disc.sh, available from the QLogic Downloads page (http://driverdownloads.QLogic.com).

LUNs Deleted Dynamically

Deleting a LUN prevents the LUN from being visible from the host. This includes deleting LUN mapping and LUN masking. In general, LUN deletion disrupts normal function of the Linux multipath framework and must be planned.

If a LUN is deleted, it may appear as either a 20000000000000 entry or as the original LUID with Path down messages. These entries may persist until the host is rebooted.

To avoid disruption, you may blacklist the LUN. Refer to your Linux documentation and About Multipathing and Device Mapper Automation.

The host usually picks up the deleted LUN, and it is deleted from the /dev/mapper table. However, this may not occur on all platforms consistently. If you want to view the device-mapper LUN mapping table, start the multipathd shell by running the following command:

```
# /sbin/multipathd -k
```

To delete a LUN, we recommend shutting down the host, deleting the LUN or LUN mapping from the Pillar Axiom storage system, and then restarting the host. If this procedure is not possible, you may want to run the following procedure.
**Important!** The following procedure will interrupt I/O and may require an immediate reboot of your host. In some cases, this may require a power cycle of the host to recover.

1. Copy the following and run it as a script:

```bash
#!/bin/bash
# Must be run as root
/etc/init.d/axiompmd stop
/sbin/multipath -F
/etc/init.d/multipathd stop
# RESCAN SCRIPT FROM QLOGIC / EMULEX
# Please modify the following line based on your rescan
script location
/usr/bin/ql-dynamic-tgt-lun-disc.sh -s -r
/etc/init.d/multipathd start
/etc/init.d/axiompmd start
/sbin/multipath –v3 -ll
```

**Tip:** The rescan script might require your interaction.

2. Be prepared to reboot the host as soon as possible after deleting LUNs in case something goes wrong.

If a LUN that is visible to a Linux 2.6 host is deleted from the Pillar Axiom system, and the `/sbin/multipath -F` or `/sbin/multipath -f` command is run before rebooting the host, the device-mapper configuration map may become unusable and all access to LUNs may be lost due to a bug in the Linux device-mapper code. If this occurs, the only way to recover is to reboot the host.

After LUN deletion, you may see a message similar to the following while the Pillar Axiom system is restarting the daemon:

```
error calling out /sbin/scsi_id -g -u -s /block/sd*
```

This message indicates that entries for the deleted LUNs still exist in the device-mapper device table. Rebooting the host will flush these deleted path entries from the device table.

### LUNs Resized Dynamically

When you resize a LUN, a host reboot is necessary due to the constraints in the Linux device-mapper. You must stop the iSCSI services before you reboot the host.

However, if you follow the procedures documented in the Online Storage Reconfiguration Guide (http://www.redhat.com/docs/en-US/Red_Hat_Enterprise_Linux/html/Online_Storage_Reconfiguration_Guide/index.html) to force your device drivers to recognize the resized LUN, the device-mapper may recognize the resized LUN without a host reboot. The ability to use the resized LUN is a function of the host filesystem.
LUN Clones or LUN Snapshots Added or Deleted Dynamically

The procedures for adding or deleting LUNs described above also apply for LUN clones and LUN snapshots.

Restore Paths After Path Failure

Due to a Linux limitation, SCSI device paths may be marked offline after path failure.

Pillar Data Systems ships a unified `online_lun_utility` to automatically restore offline SCSI device paths, but this utility may occasionally require manual intervention on the part of the system administrator.

If you notice that you need manual intervention very often, tune the `online_lun_utility` script by commenting out the following lines in the `/opt/pillar/bin/online_lun_utility` file:

```bash
# Start
#NUMBEROFINSTANCES=2
#UTILITYRUNTST=`/bin/ps -aef | /bin/grep /opt/ pillar/bin/online_lun_utility | /bin/grep -v grep | /usr/bin/wc -l`
#if [ $UTILITYRUNTST -le $NUMBEROFINSTANCES ] ; then
cd /sys/class/scsi_device
HOST=( `ls -d /sys/bus/pci/drivers/*/host* | sed -e "s/.*host//"` )
change_lun_state
#fi
```

In addition, if you are using QLogic HBAs, QLogic recommends that you use the following procedure to set driver parameters for failover:

1. Open the `/etc/modprobe.conf` file in a text editor, and set the options as follows:

   ```bash
   options qla2xxx ql2xfailover=0 MaxRetriesPerPath=3
   ql2xloginretrycount=30 ql2xlogintimeout=30
   ql2xretrycount=90 qlport_down_retry=45
   ```

2. Run the following command to rebuild the kernel:

   ```bash
   # /sbin/new-kernel-pkg --mknitrd --depmod --install
   `uname -r`
   ```

3. Reboot the host.
Multipath Failed Path Errors

The multipath command may return errors that indicate only that there are failed paths.

If paths are in a failed state, the `multipath` command returns the following error messages:

```
multipath -ll 2000b08005c001259
9:0:0:3: sg_io failed status 0x8 0x1 0x0 0x0
9:0:0:3: Unable to get INQUIRY vpd 1 page 0x0.
error calling out /sbin/scsi_id -g -u -s /block/sdaf
8:0:0:3: sg_io failed status 0x8 0x1 0x0 0x0
```

These error messages indicate only that there are failed paths in the multipath device map. The multipath device map shows paths that are failed and active, and `sg_io failed` refers to the fact that SCSI generic (`sg`) devices do not exist for iSCSI device paths that are failed. These errors indicate that the system is responding correctly.

You must fix the failed paths or, if these errors occur during failover testing, recognize that this is normal and expected Linux multipath behavior.

**Note:** The `multipath` command can be invoked automatically by the system at various times, so it is possible for messages like these to be seen whenever paths are in an unusual state, such as during dynamic reconfiguration.

Multipath Commands Hang After Path Failure

Because of a defect in the OEL 4 kernel, commands initiated with the `multipath`, `multipath -ll`, or `multipath -v3` commands may fail after a path failure occurs.

If any processes hang because of this defect, you can kill the hung processes or start a new terminal session.
Additional Notes

Mount iSCSI Filesystems

We recommend that iSCSI filesystems be auto-mounted with the \texttt{\_netdev} option. If the iSCSI filesystem is manually mounted, it must be unmounted manually before a reboot to avoid hangs.

Filesystems installed on iSCSI devices cannot be automatically mounted at system reboot because the IP network is not yet configured at mount time. However, the driver provides a method to auto-mount these filesystems as soon as the iSCSI devices become available, after the IP network is configured.

To auto-mount a filesystem installed on an iSCSI device:

1. List the iSCSI partitions to be automatically mounted in /etc/fstab.

2. For each filesystem on each iSCSI device, enter the logical volume on which the filesystem resides.

   The mount points must exist for the filesystems to be mounted. For example, the following /etc/fstab entry will mount the iSCSI devices with partition \texttt{p1} specified by the LUID \texttt{20000121390p1}:

   \begin{verbatim}
   #device mount FS mount backup fsck
   #to mount point type options frequency pass
   LABEL=/ / ext3 defaults 1 1
   LABEL=/boot /boot ext3 defaults 1 2
   /dev/mapper/20000121390p1 ext2 _netdev 0 0
   \end{verbatim}

3. Restart the system.

   Result:
   
   The \texttt{netfs} initialization script mounts all filesystems with the \texttt{\_netdev} mount option. Run this initialization script after the networking and iSCSI scripts to ensure that the system is ready to mount these devices.

Due to variable network delays, targets may not always become available in the same order from one boot to the next. Thus, the order in which iSCSI devices are mounted may vary and may not match the order the devices are listed in /etc/fstab. You should not assume mounts of iSCSI devices will occur in any particular order.
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