# HP VAN SDN Controller 2.3 Administrator Guide


## Abstract

This guide is intended for network administrators and support personnel involved in:

- configuring and managing HP VAN SDN (Virtual Area Network Software-Defined Networking) Controller installations
- registering and activating HP VAN SDN Controller licenses

The information in this guide is subject to change without notice.



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### Acknowledgments



### Warranty

For the software end user license agreement and the hardware limited warranty information for HP Networking products, visit http://www.hp.com/networking/support .

### Open Source Software

For information on licenses for the open source software used by the HP VAN SDN Controller, see the *HP VAN SDN Controller Open Source and Third-Party Software License Agreements*.

For information on acquiring the open source code for the HP VAN SDN Controller, send an email to **HPN-Open-Source-Query@lists.hp.com**.

# Contents

# 1 Introduction

This document describes the configuration and management of the HP VAN Controller in standalone and team modes.

The HP VAN SDN Controller is a Java-based OpenFlow controller enabling SDN solutions such as network controllers for the data center, public cloud, private cloud, and campus edge networks. This includes providing an open platform for developing experimental and special-purpose network control protocols using a built-in OpenFlow controller.

The HP VAN SDN Controller includes an SDK providing the tools needed to develop applications to run on the Controller. The SDK includes sample source code, API specifications, and the *HP VAN SDN Controller Programming Guide*. See the programming guide for SDK information.

The following publications are provided with the HP VAN SDN Controller:

- *HP VAN SDN Controller Release Notes*
- *HP VAN SDN Controller Installation Guide*
- *HP VAN SDN Controller Administrator Guide*
- *HP VAN SDN Controller and Applications Support Matrix*
- *HP VAN SDN Controller Programming Guide*
- *HP VAN SDN Controller REST API Guide*
- *HP VAN SDN Controller Open Source and Third-Party Software License Agreements*
- *HP VAN SDN Controller and Applications Support Matrix*

The HP VAN SDN Controller is a platform for developing SDN applications and deploying SDN applications. The controller can be characterized as providing a Base Control Platform, a Distributed Platform for High-Availability and Scalability, and an Extensible Platform.

The base control platform is built on the Linux operating system. The principal software stack uses an OSGi framework (Equinox) and a container (Virgo) as the basis for modular software deployment. The base platform provides services such as authentication, data persistence, logging, and alerts. The base platform provides a device driver framework for out-of-band control and management of devices. The base platform also includes network services that provide the following:

- **Link Discovery** service to discover the physical links between devices.
- **Node Manager** service to discover the existence of end hosts. OpenFlow Packet_In messages are used to learn end-host MAC and IP addresses.
- **Topology Manager** service to create a network graph and compute the shortest path between two hosts.
- **Path Provisioning** service to provision L2 paths by programming end-to-end flow rules between discovered hosts.
- **Path Diagnostic** service to determine and verify the path taken by packets from a source host to a destination host.

The SDN Controller is a distributed platform enabling high-availability and scalability. Controllers can be configured in a team to enable load-balancing and control domain partitioning. Controllers in the team synchronize state information for smooth and rapid failover.

The SDN Controller is an extensible platform supporting native applications (sometimes referred to as modules) and external applications. Native applications are authored in Java or a byte-code compatible language and are deployed on the controller as collections of OSGi bundles. Native applications use the Java services exported and advertised by the controller platform and by other applications. Native applications can dynamically extend the controller REST API surface, extend the controller's GUI, and integrate with the controller authentication and authorization framework.

Native application are well suited when the application needs frequent and low latency interactions with network devices.

External applications can be developed in any language and are deployed on a platform outside the controller platform or on the same platform as the controller. External applications interact with the controller using the REST API services exported and advertised by the controller platform, and by native applications deployed on the controller. Because external applications are deployed outside the controller platform they cannot extend the REST API or GUI surface of the controller. External applications are suitable for applications that have relatively infrequent and high latency control interactions with network devices, and when deploying on a different platform is required.

## 1.1 Supported switches and OpenFlow compatibility

For information about supported network switches, OpenFlow versions, and switch configuration requirements, see the *HP VAN SDN Controller and Applications Support Matrix*.

△ **CAUTION:** OpenFlow switches in a controller domain should not be connected in a loop topology with switches outside the domain. Allowing such connections can create broadcast loops inside the OpenFlow network. For more on packet-forwarding decisions, see "Hybrid mode for controlling packet-forwarding" (page 73).

**NOTE:** Including a switch that does not support OpenFlow in a controller domain creates two separate clusters.

### 1.1.1 OpenFlow requirements

The controller must be connected to a network that includes one or more switches configured to run OpenFlow. HP recommends that you plan and implement the switch OpenFlow configurations before connecting the controller to the network.

**NOTE:** Running the OpenFlow control mode on a specified switch VLAN disrupts the traffic on that VLAN until the controller configures the required flow rules in the switch using the OpenFlow controller API. For information on configuring OpenFlow, see the latest manual for the version of OpenFlow running on your switches.

OpenFlow switches in the network must be configured to allow control by the SDN Controller. In a controller domain, including a switch that does not support OpenFlow or allow control by the SDN Controller creates separate clusters of OpenFlow networks.

### 1.1.2 IPv6 traffic

IPv6 traffic running in the data plane of an OpenFlow network is supported when the controller is operating with hybrid mode set to "true" (the default). In this state the controller is not aware of the IPv6 traffic. However, with hybrid mode set to "false" (all packets sent to the controller), the controller drops IPv6 packets, and they do not reach their destinations. For more information, see the release notes.

# 2 Understanding the embedded applications

## 2.1 Link manager

The Link Manager builds information about links between network elements in the controller domain. This application maintains a table of source and destination devices and ports, and transmits discovery packets to ports on attached datapaths.

Link Manager

- Learns and maintains all inter-switch links in the control domain.
- Provides data used by the controller topology module to construct end-to-end paths.
- Deciphering port state changes.
- Generates link events to notify interested listeners.
- Identifies multi-hop links between disconnected segments of the control domain.
- Provides information used by applications to reconfigure flows when a link goes down.

**NOTE:** The controller injects BDDP packets for discovery. No LLDP packets are sent.

To avoid sending discovery packets on certain ports such as an edge port, LinkManager maintains a special list of ports identified as "Suppressed LLDP Ports". Adding ports to the suppressed LLDP list can be done using the REST API.

Link Service sends BDDP packets with LLDP payloads containing a TLV with an associated link controller ID in one of the optional LLDP TLVs. This enables Link Service to differentiate the BDDP messages it has generated.

As it is possible for non-OpenFlow devices to be present between OpenFlow switches, Link Service also sends out BDDP messages to discover "multi-hop links", which refer to a link between two OpenFlow switches on a path through one or more non-OpenFlow devices.

## 2.2 Node manager

- Learns and maintains end-host locations in the network.
- Uses information received from network devices to maintain the ARP table and end host data.
- Uses the Topology Service to determine if a port receiving a packet is an edge port or not.
- Learns and maintains end nodes in the controller domain, and associates end nodes with edge ports.
- Builds an ARP cache with MAC-IP translations of end hosts.
- Maintains ARPs on a per-VID basis.
- Provides the edge port details for end hosts.

Example ARP table data:

| IP Address | MAC | VID |
|---|---|---|
| 192.0.2.1 | 00:00:5e:00:53:01 | 100 |
| 192.0.2.2 | 00:00:5e:00:53:20 | 110 |
| 192.0.2.3 | 00:00:5e:00:53:02 | 120 |

## 2.3 Path daemon

**Path daemon** is a "proof of concept" network service application built on top of the SDN controller.

The Path Daemon application is responsible for pushing end-to-end flows for all ARP and IPv4 flow misses that arrive at the controller. By default, Path Daemon is responsible for Layer-2 forwarding only. This component depends on other network service components like **Node manager** and **Topology manager**.

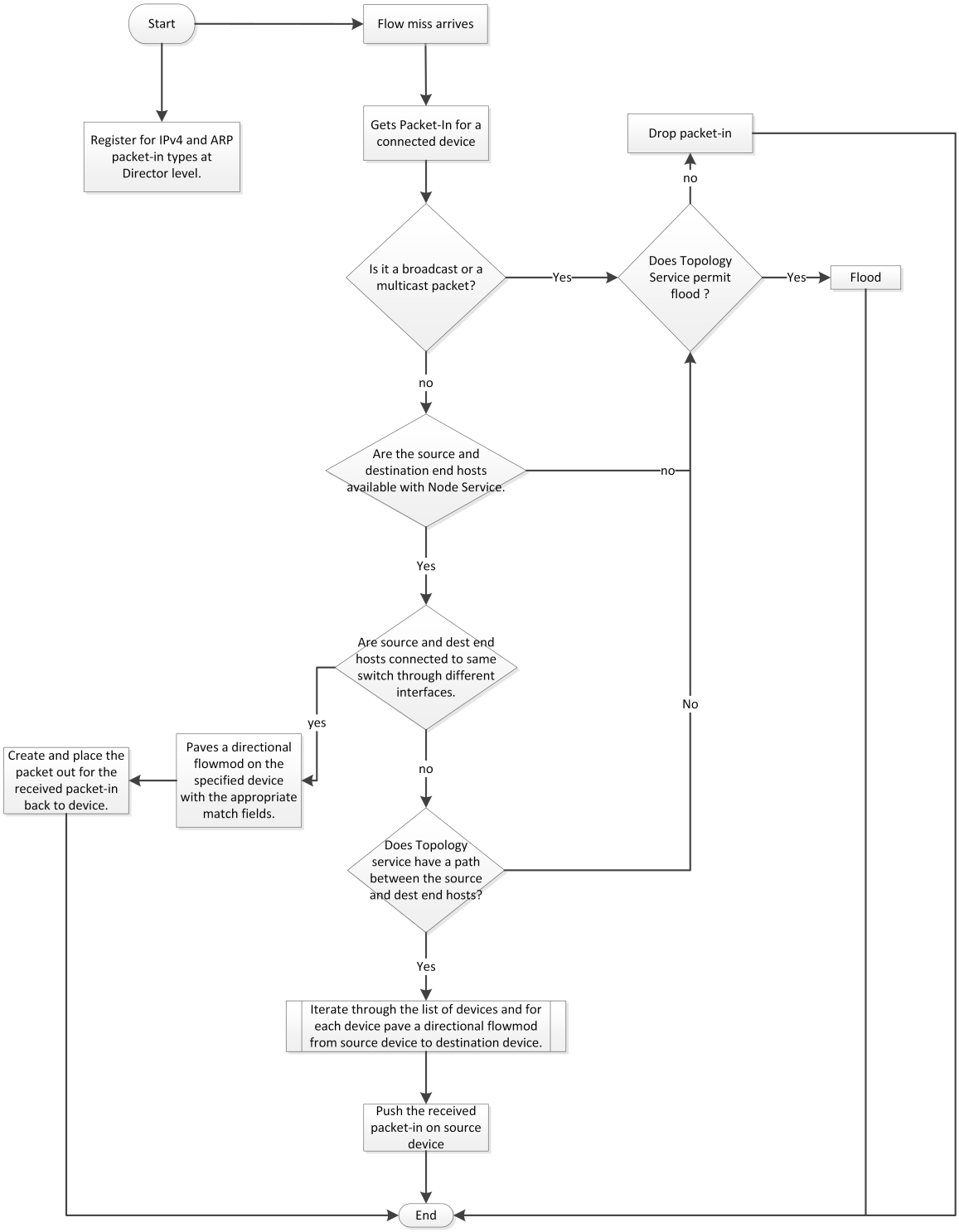
Path Daemon does the following:

- Registers with the controller as a *Director*. Directors are allowed to send a packet out.
- Registers for ARP packets and IPv4 packets.
- Uses the **Node Manager** to get the end hosts corresponding to the source and destination MAC addresses and the switches to which these hosts are connected. It makes use of the **Topology Manager** service to get the end-to-end path between the source and destination switches. It makes use of the controller to push flows to the switches. The flowchart in Figure 1 provides more details of its operation.
- Path Daemon uses the following match fields when pushing a flow module. These match fields have been chosen so that the flow modules are pushed on hardware tables in both Provision and Comware switches.
    - Ether Type
    - Source Macaddress
    - Destination Macaddress
    - Input Port
    - Output port
- Path Daemon also registers for *Port Status Down* messages. When such messages are received, Path Daemon removes all flows configured for the impacted port, thereby causing the packet-ins to again come to the controller.

Operation notes:

- Does not handle multicast and broadcast traffic
- Does not configure the reverse path along with the forward path
- Drops packets from sources that the controller has not learned
- Floods packets when their destinations are not known
- Does not support multi-pathing or fast-failover
- Performance is topology-dependent, recommended for 100-200 node environments

**Figure 1 Path daemon flowchart**




## 2.4 Path diagnostics

The path diagnostics application determines and verifies the path taken by a specific packet from a source host to destination host.

- Evaluates flows configured across the switches in the control domain for diagnosis.
- Creates 'Observation posts' on every switch in the path that the packet would take.
- Tallys packet_in messagess from the observation posts to detect where a path is broken.
- Lists neighbors for any given device.

## 2.5 Topology manager

The topology manager computes the broadcast tree to avoid loops and broadcast storms. On a given switch it also does the following:

- Provides a list of discovered ports on a given switch.
- Indicates whether a switch port is an edge port (connection point) or part of a link.
- Indicates whether a port is in a blocked or open state by determining whether ingress broadcast traffic is allowed through the port.
- Verifies whether a path exists between two nodes.
- Enumerates the clusters of OpenFlow-capable switches.
- For a given switch, provides details of the cluster to which it belongs.
- The Topology Manager provides notification to subscribed applications regarding changes in the broadcast tree and cluster. This enables development of intelligent and proactive applications that can subscribe to topology change notifications.

## 2.6 Topology viewer

The topology viewer creates and updates a network graph for visualizing the network the controller discovers. The Reload button will force a reload of all the nodes and links from the server. For enhanced performance, the topology view caches nodes and links. In some situations this cache may get out of sync with the controller.  Performing a “Reload” will clear out the topology viewer cache and regenerate the topology view.

The topology viewer uses the services of the topology manager and link manager.

# 3 Navigating the controller user interface

## 3.1 Starting the SDN controller console UI

1. Use a supported browser, such as Google Chrome, to access the controller's GUI at the controller IP address:

   ### GUI

   `https://controller_ip_addr:8443/sdn/ui`

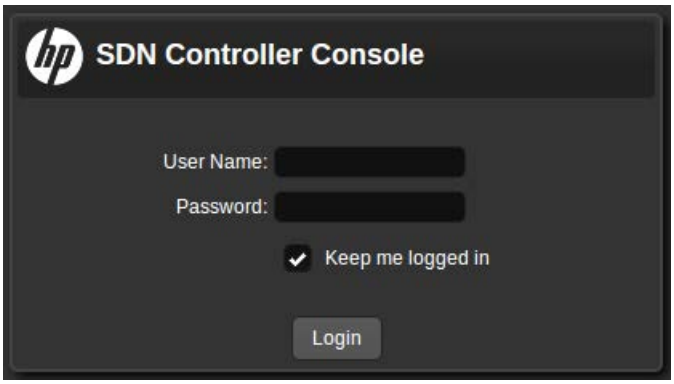
   ### Example

   `https://192.0.2.1:8443/sdn/ui`

2. Enter user name and password credentials, then select **Login**.

   ### Example

   Default user name: `sdn`
   Default password:`skyline`

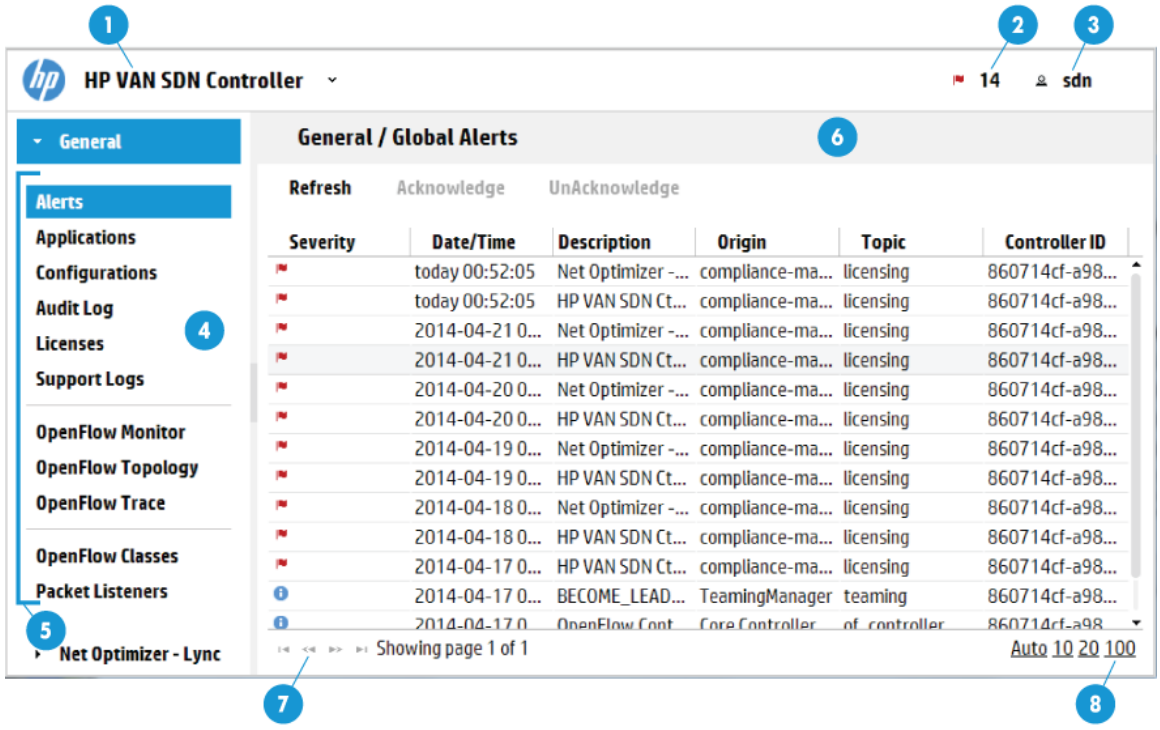
   
   

3. The main controller screen appears with the **Alerts** screen displayed. For more information about the controller console UI, see "About the user interface" (page 14).

## 3.2 About the user interface

**NOTE:** The names for common areas, icons, and controls on the UI screen appear after the image.

## Figure 2 Screen topography




1. Banner: Identifies the user interface. Contains the alert notification counter and links to the navigation menu, alert information, and the SDN **User** window.
2. Alert notification counter: Displays the current number of active alerts. Clicking this icon displays the Alerts as of Today window box.
3. SDN User window: Enables you to log out of the controller, link to external websites, change the theme for the controller, and identify the version of controller software currently in use.
4. navigation menu: The primary menu for navigating to controller and application resources. Contains the controller navigation tree, labelled **General**, and can contain additional navigation trees for installed applications that integrate with the controller UI. Can be displayed as a pane (as shown) or as a window that overlays the controller screen (see "Expanding or collapsing the navigation menu" (page 17)).
5. navigation tree: Used to select the controller or application screen to display in the details pane. **General** is the controller navigation tree. Navigation trees for installed applications are displayed below or to the right of the **General** navigation tree. In this figure, there are two navigation trees: **General** and **Net Optimizer - Lync**.
6. Details pane: Displays the detailed interface for the controller or application resource selected in the navigation menu. When the controller starts, it displays the Alerts screen.
7. Pagination control: Can appear on screens that have lists of items. Use these controls to view the listings page by page.
8. Listing control: Can appear on screens that have lists of items. Use these controls to select the number of items to display in a single view. The **Auto** option displays all items in a single screen. For listings exceeding the length of the screen, you can use the scroll bar on the right side of the screen.

### 3.2.1 Banner

| Screen component | Description |
|---|---|
| **SDN Controller** ⌄ | Expands or collapses the "navigation menu" (page 16) as an overlay window. |
| 🚩 | Expands or collapses the controller "Alerts as of today" (page 21) window. |

| Screen component | Description |
|---|---|
| | The number next to the icon is the "alert notification counter" (page 20), which provides a count of the current active alerts. |
| sdn | Expands or collapses the "SDN User" (page 17) window. |

### 3.2.2 Changing column widths

To change the column widths, drag the column head borders. For example:

- To narrow the **Severity** column width, click the border to the left of **Date/Time** and drag it to the left.
- To change the width of the navigation menu pane, click and drag the divider between the menu pane and the details pane.

### 3.2.3 Changing the background and text colors

The background and text colors are part of the theme of the controller UI. To change the theme:

1. Expand the SDN **User** window.
2. In **Set Theme:**, select one of the following options:
   - **Day**
   - **Night**

## 3.3 Navigation menu

### 3.3.1 About the navigation menu

The navigation menu is the primary menu for navigating to controller resources. The resources included with the controller are described in this document. Applications installed on controller might add resources to this menu.

**Displays as a pane or an overlay window**

You can display the navigation menu in the following ways:

- As a pane on the left side of the controller browser window.
- As a window that overlays part of the main screen of the controller browser window.

**Contains one or more navigation trees**

The navigation menu contains the **General** controller navigation tree and can contain additional navigation trees for installed applications that integrate with the controller UI.

### 3.3.2 Navigation menu screen details

| Screen component | Description |
|---|---|
| **General** | Displays the navigation tree for the resources that are provided with the controller. By default, the **General** controller navigation tree is expanded and the **Alerts** screen is selected and displayed.<br>To display the screen for another resource, select the resource in the navigation tree. |
| | Expands or collapses the controller navigation menu. If the navigation menu is collapsed, this icon is located in the left margin of the console screen. |
| | Expands the selected navigation tree. This control is available in the navigation menu for the **General** controller navigation tree and for each application that is installed and available through the controller navigation menu. |

| Screen component | Description |
|---|---|
| | When the navigation menu is displayed as a widow pane on the console, exactly one navigation tree can be expanded. To collapse a navigation tree for the controller or an application, click the expand icon for a different navigation tree. |
| ▲ | Collapses the navigation window when it is displayed as an overlay window on the console screen. |

### 3.3.3 Expanding or collapsing the navigation menu

The navigation menu is displayed as a navigation pane by default. You can display the navigation menu as a pane on the controller screen or as a window that overlays the controller screen.

**Expanding or collapsing the navigation menu as a window pane**

To expand or collapse the navigation menu as a window pane, click the following icon:

- When the navigation menu is expanded as a window pane, the icon is located on the right side of the menu.
- When the navigation menu is collapsed, the icon is located in the left margin of the controller screen.

**Expanding or collapsing the navigation menu as an overlay window**

To display the navigation menu as an overlay window, from the top banner of the controller screen, click **SDN Controller**.

To collapse the navigation window, do one of the following:

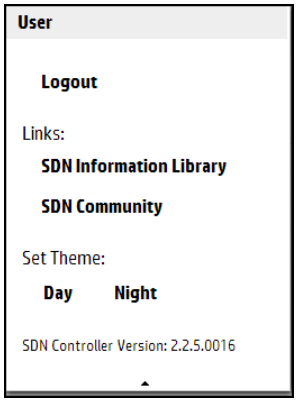
- In the window, click ▲
- From the top banner, click **SDN Controller**.

## 3.4 SDN User window

The SDN **User** window displays as an overlay on the controller screen.

## 3.4.1 User window screen details

**Figure 3 SDN user window**




| Screen component | Description |
|---|---|
| **Logout** | Logs the user out of the controller. |
| **Links:** | Links to websites outside of the controller:<br>**Name** / **Description**<br>**SDN Information Library**: Links to the information library on the HP Software-Defined Networking website. The HP SDN information library provides links to the technical documentation for the HP VAN SDN Controller and the HP SDN applications. The HP Software-Defined Networking website provides fact sheets, case studies, white papers, product summaries, technical and business documentation, and other information to help you identify SDN solutions for your business needs.<br>**SDN Community**: Links to the HP SDN community discussion forum website within the HP Enterprise Business Community. This site offers resources such as:<br>• SDN discussion boards<br>• SDN development information<br>• An SDN knowledge base |
| **Set Theme:** | Changes the theme for the controller UI:<br>**Name** / **Description**<br>**Day**: When selected, plain text is black and the background is white.<br>**Night**: When selected, plain text is white and the background is black. |
| **SDN Controller Version:** | Displays the version of the controller software that is running on this system. |
| ▲ | Collapses the window. |

## 3.4.2 Expanding the SDN user window

To expand the SDN **User** window, from the top banner, click sdn .

### 3.4.3 Collapsing the SDN user window

To collapse the SDN **User** window, do one of the following:

- In the SDN **User** window, click ▲.
- From the top banner, click sdn .

### 3.4.4 Logging out of the controller

To log out of the controller UI:

- From the SDN **User** window, select **Logout**.

## 3.5 Alerts screen

### 3.5.1 About alerts

Alerts give notification of events that affect controller operation, and in some cases indicate that some action is needed to correct a condition.

**Alerts and controller teams**

When controllers are operating in a team, alerts generated by any team member are visible in the **Alerts** screen for all active team members.

**Active, unacknowledged alerts**

By default, alerts are in an unacknowledged, active state. An alert must be in an active state to appear in the following places:

- The alert notification counter
- The **Alerts as of today** window

### 3.5.2 About alert policies

The values for the AlertManager component keys determine the alert age-out policy. The following table describes the keys for the AlertManager component (`com.hp.sdn.adm.alert.impl.AlertManager`).

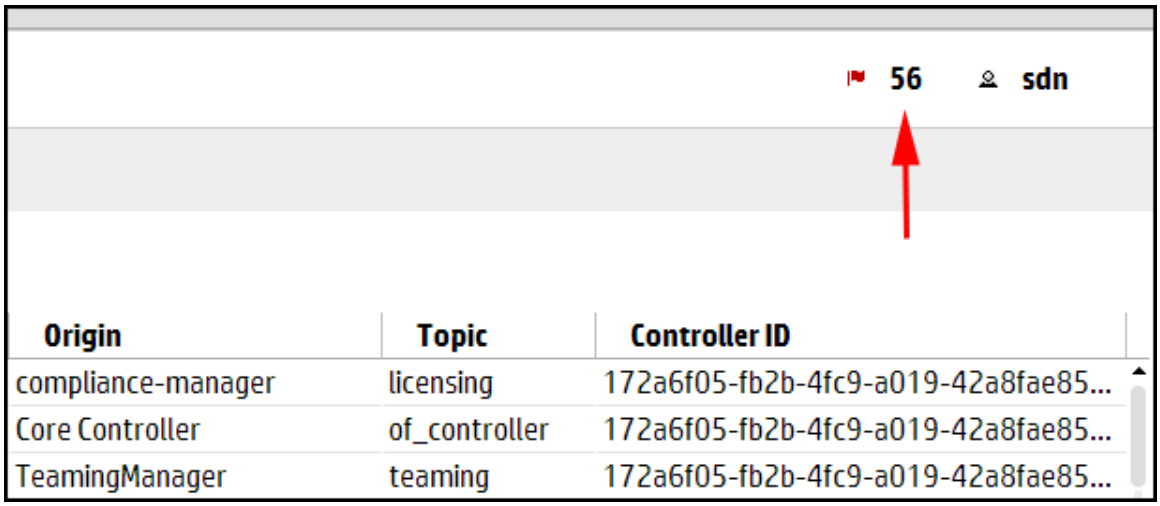
| Key | Description |
|---|---|
| **trim.alert.age** | Specifies the number of days an alert remains in persistent storage and remains displayed on the Alerts screen.<br>Data type A number from 1 through 31<br>Default value 14 |
| **trim.enabled** | When true, specifies that the controller deletes alerts that have exceeded the `trim.alert.age` limit.<br>Default value `true` |
| **trim.frequency** | Specifies how often, in hours, the controller is to delete alerts that have exceeded the `trim.alert.age` limit.<br>Data type A number from 8 through 168<br>Default value 24<br>Example Enter `8` to specify that the controller delete aged-out alerts every eight hours. |

## 3.5.3 Alert notification counter

The alert notification counter is displayed in top banner and appears on all controller screens. This counter indicates the number of active alerts:

- The controller increments this counter when each new alert occurs.
- The controller decrements this controller when you acknowledge an alert or when the controller deletes an alert according to the "alert age-out policy" (page 21) .

**Figure 4 Alert notification counter**




## 3.5.4 Alerts screen details

| Screen component | Description |
|---|---|
| **Refresh** | Updates the alerts displayed on the screen. The controller does not update the display as new alerts are generated. Use this action to refresh the display. |
| **Acknowledge** | Changes the selected alert to an acknowledged state. The controller displays the alert in gray text. Use this action to indicate that you have read the alert. |
| **UnAcknowledge** | Changes the selected alert to an active, unacknowledged state. |
| Alert text color | Indicates the state of the alert:<br>• The controller displays active, unacknowledged alerts the alert in the text color corresponding to the controller theme. For example, when the controller theme is daylight, the active alerts appear in black text.<br>• The controller displays the selected alert in blue text. Click an alert to select it.<br>• The controller displays acknowledged alerts in gray text. |
| **Severity** | Indicates the severity of the alert.<br>**Icon** / **Description**<br>Informational<br>Warning<br>Critical |
| **Date/Time** | Indicates the date and time the alert was generated. |
| **Description** | Describes the alert in human readable text. |

| Screen component | Description |
|---|---|
| **Origin** | Indicates which component or application generated the alert. |
| **Topic** | Indicates of the category for this alert. Multiple origins can contribute alerts to the same topic. |
| **Controller ID** | Identifies the controller that generated the alert. The controller is represented as a hexadecimal number. When you use controller teaming, this ID enables you to identify which controller in the team generated the alert. |

### 3.5.5 Viewing the ten most sever recent active alerts

To display a summary of up to 10 alerts ranked by severity (highest to lowest) and then by date and time (newest to oldest):

- In the top banner, click .

  The **Alerts as of today** window is displayed.

To close the window, do one of the following:

- To close the window and display the **Alerts** screen, click **All**.
- At the bottom of the window, click the collapse icon ( ).
- In the top banner, click either the alert counter number or .

### 3.5.6 Acknowledging an alert

To acknowledge an alert from the **Alerts as of today** window:

1. Click the alert to select it.
2. Click **Acknowledge**.

   The controller removes the alert from the **Alerts as of today** window, displays the alert in gray text on the **Alerts** screen, and decrements the alert notification counter by one.

To acknowledge an alert from the **Alerts** screen:

1. Click the alert to select it.
2. Click **Acknowledge**.

   The controller displays the alert in gray text on the **Alerts** screen, and decrements the alert notification counter by one.

### 3.5.7 Deleting an alert

You can acknowledge an individual alert, but you can not clear or delete the alert.

The controller deletes alerts according to the configured alert age-out policy. To configure the age-out policy, see “Configuring the alert policies” (page 21)

### 3.5.8 Configuring the alert policies

1. From the **Configurations** screen, under **Component**, select the `com.hp.sdn.adm.alert.impl.AlertManager` component.
2. Click **Modify**.

   The **Modify Configuration** dialog box appears.
3. Change the values for the keys. For more information about the keys and values that affect the alert policy, see “About alert policies” (page 19).
4. Click **Apply** .

# 3.6 Applications screen

## 3.6.1 About the application manager

The Application Manager supports default and add-on network services, and enables installing, upgrading, enabling (starting), disabling (stopping), and uninstalling SDN applications.

**Application manager and controller teams**

When controllers are operating in a team, actions performed on one controller are propagated to the other controllers in the team. Actions you select in the **Applications** window for one controller, such as **Install**, **Enable**, and **Disable**, are propagated to the other controllers.

**Embedded applications**

The following applications are embedded in the controller and are installed when you install the controller:

- **Link Manager**
- **Node Manager**
- **Path Daemon**
- **Path Diagnostics**
- **Topology Manager**
- **Topology Viewer**

For more information about the embedded applications, see "Understanding the embedded applications" (page 10).

**Prerequisites for installing an application**

Any application to be installed on the controller must meet the following requirements:

- It must be in a zip format.
- The zip file must be on the same system as the controller.
- It must contain an application descriptor file containing key value pairs of the attributes associated with the application, including all mandatory attributes.

Applications you purchase from HP or the HP SDN App Store meet these requirements.

For information about developing applications that meet these requirements, see the *HP VAN SDN Controller Programming Guide*.

## 3.6.2 Applications screen details

| Screen component | Description |
|---|---|
| **Refresh** | Reloads the view. |
| **New** | Installs an application on the controller. |
| **Upgrade** | Installs an upgrade to an application that has already been installed on the controller. |
| **Uninstall** | Removes an application from the controller. |
| **Enable** | Starts or allows an application to continue operations on the controller. |
| **Disable** | Stops or prevents an application from operating on the controller. |
| **Name** | The name of the application |

| Screen component | Description |
|---|---|
| **Version** | The version number of the application |
| **State** | The most common states are listed in the following table.<br><br>**State** / **Description**<br>ACTIVE — The application has been started and is servicing requests.<br>STAGED — A new application has been downloaded to the controller and is ready to be installed.<br>DISABLED — The application has been stopped. Applications in this state are not restarted when the controller restarts. |

### 3.6.3 Obtaining applications from the HP SDN AppStore

When the AppStore becomes available you will be able to purchase and download applications for your controller. Until the AppStore becomes available, the following buttons do not access AppStore features:

- **Log in to view applications…**
- **Launch AppStore**

### 3.6.4 Adding or upgrading an application

Any application in the proper format can be added to the controller (see "About the application manager" (page 22)).

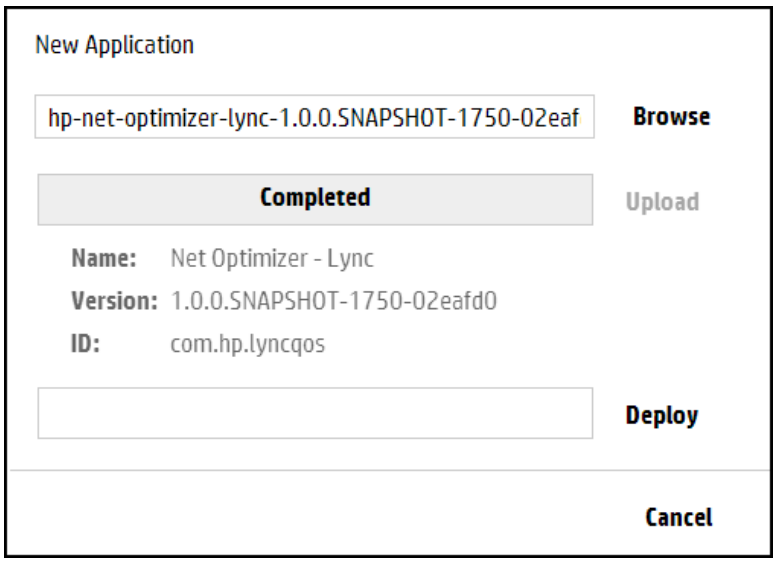
After you complete this procedure:

- The application is started and in an ACTIVE state.
- If the controller is in a controller team, the controller propagates the application to all the controllers in the team automatically.

Use this procedure to install either a new application or a new version of an existing application on the controller using the UI.

1. Do one of the following:
   - To install a new application, click **New**.
   - To upgrade to a new version of an existing application, select the application from the **Name** list and click **Upgrade**.
2. Click **Browse** to navigate to the location of the application zip file and select the file.
3. Click **Upload** to upload the file.

   Wait for **Completed** to appear. For example:



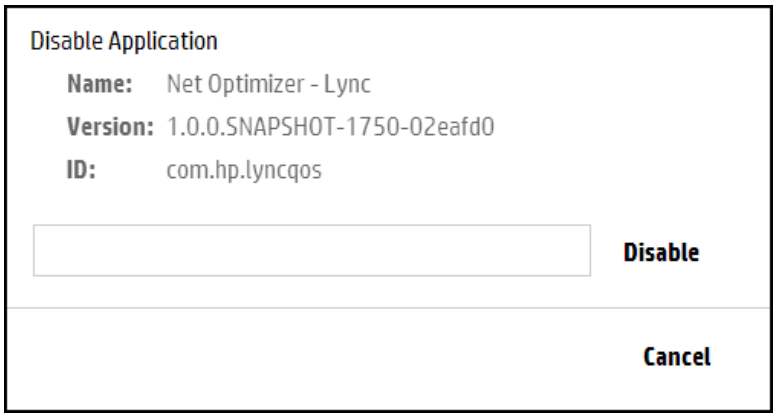

4. Click **Deploy**.
   The new application then appears by name on the **Applications** screen as ACTIVE.

## 3.6.5 Disabling (stopping) or enabling (starting) an application

This procedure temporarily stops an active application from servicing requests, but retains the application on the system. The application remains present on the system and can be restarted when needed. (The application does not automatically restart when the controller restarts.)

### Procedure 1 Disabling an application using the UI

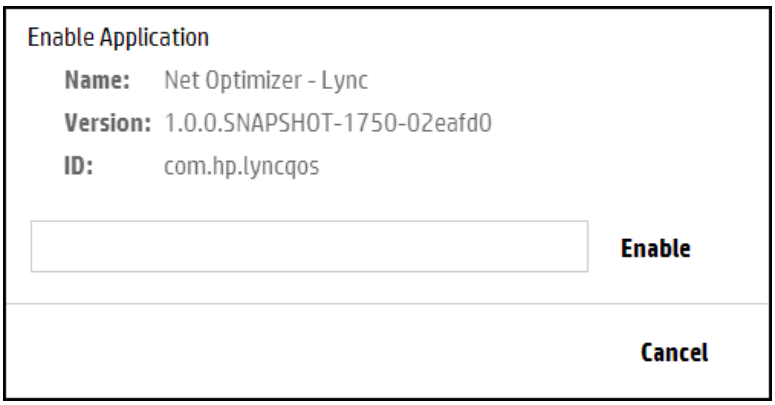
1. In the **Applications** screen, select the application you want to stop.
2. Click **Disable** to display the **Disable Application** dialog box.




3. In the **Disable Application** dialog box, click **Disable**.
   The **Disable Application** dialog box closes and the application state is changed to `DISABLED`.

### Procedure 2 Enabling an application using the UI

1. In the **Applications** screen, select the application you want to enable.
2. Click **Enable** to display the **Enable Application** dialog box.



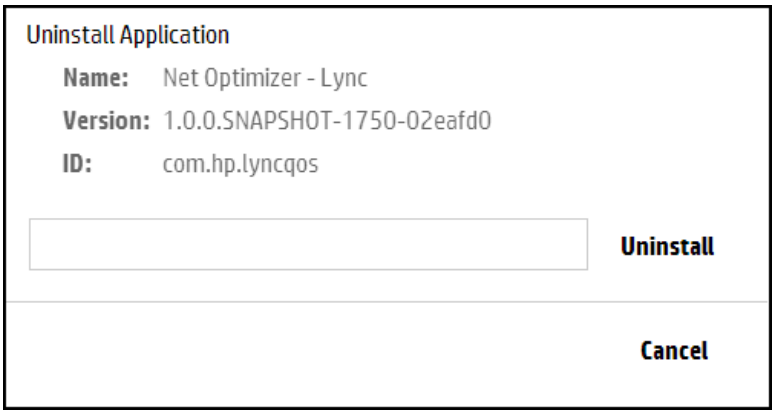

3. Click **Enable** button to activate the application. The application starts or resumes operation and the application state is changed to `ACTIVE`.

### 3.6.6 Uninstalling an application

This procedure completely removes an application from the controller. To later restore the removed application, see Adding or upgrading an application.

Use the following procedure to uninstall an application using the UI.

1. In the **Applications** screen, select the application you want to uninstall.
2. Click **Uninstall**.




3. Click the **Uninstall** button to remove (delete) the application.

## 3.7 Configurations screen

The **Configurations** screen enables access to the configurable components in the controller.

### 3.7.1 About the configurable components

The configuration components are used to manage the controller and application features. The base set of controller components support the applications that are embedded in the controller. Adding or removing an SDN application might add or remove additional configuration component. However, direct addition or removal of configuration components is not supported.

Each configuration component contains one or more component keys, each of which identify a configurable property of the component.

△ **CAUTION:** Inappropriate changes to key values can result in severely degraded system performance. For this reason, HP strongly recommends that managing the default key values be done only by experienced network administrators and programmers who have a strong understanding of SDN controller systems.

**Configurations and controller teams**

When controllers are operating in a team, configuration changes on one active controller propagate to the other active controllers in the team.

#### 3.7.1.1 About component keys

Each configuration component contains one or more component keys, each of which identify a configurable property of the component.

△ **CAUTION:** Inappropriate changes to key values can result in severely degraded system performance. For this reason, HP strongly recommends that managing the default key values be done only by experienced network administrators and programmers who have a strong understanding of SDN controller systems.

Information about each component key includes the current value, the default value, and a brief description. Where applicable, the range of suggested values is also included. Component key information

Information about the component keys are available from:

- The **Configuration** screen of the controller UI.
- The controller `Configs` REST API.

### 3.7.2 Summary of configurable controller components

#### 3.7.2.1 AdminREST Component

**Component name**

`com.hp.sdn.misc.AdminRESTComponent`

**Description**

The AdminRestComponent provides parameters for internal communication between SDN components and the Admin REST API of the controller.

**Component keys**

Information about the configurable component keys, including descriptions, current values, suggested ranges, and default values are available from:

- The **Configuration** screen of the controller UI.
- The controller `Configs` REST API.

#### 3.7.2.2 Alert manager

**Component name**

`com.hp.sdn.adm.alert.impl.AlertManager`

**Description**

The AlertManager controls the quantity of alert data present on the system by periodically checking for alert data to be deleted based on the configured age-out policy.

**Component keys**

Information about the configurable component keys, including descriptions, current values, suggested ranges, and default values are available from:

- The **Configuration** screen of the controller UI.
- The controller `Configs` REST API.

### 3.7.2.3 Alert post manager

**Component name**

`com.hp.sdn.api.impl.AlertPostManager`

**Description**

The AlertPostManager uses the HTTP(s) protocol to send alert data as a a JSON string to registered alert topic listeners.

**Component keys**

Information about the configurable component keys, including descriptions, current values, suggested ranges, and default values are available from:

- The **Configuration** screen of the controller UI.
- The controller `Configs` REST API.

### 3.7.2.4 Audit log manager

**Component name**

`com.hp.sdn.adm.auditlog.impl.AuditLogManager`

**Description**

The AuditLogManager controls the quantity of audit log data present on the system by periodically checking for audit log data to be deleted based on the configured age-out policy. For more information about audit log policies, see "Configuring audit log policies" (page 33).

**Component keys**

Information about the configurable component keys, including descriptions, current values, suggested ranges, and default values are available from:

- The **Configuration** screen of the controller UI.
- The controller `Configs` REST API.

### 3.7.2.5 Authentication manager

**Component name**

`com.hp.sdn.adm.auth.impl.AuthenticationManager`

**Description**

The AuthenticationManager provides for the authentication of external users to the SDN Controller.

**Component keys**

Information about the configurable component keys, including descriptions, current values, suggested ranges, and default values are available from:

- The **Configuration** screen of the controller UI.
- The controller `Configs` REST API.

### 3.7.2.6 Controller manager

**Component name**

`com.hp.sdn.ctl.of.impl.ControllerManager`

**Description**

The ControllerManager provides parameters used in the implementation of the OpenFlow protocol.

**Component keys**

Information about the configurable component keys, including descriptions, current values, suggested ranges, and default values are available from:

- The **Configuration** screen of the controller UI.
- The controller `Configs` REST API.

### 3.7.2.7 Link manager

**Component name**

`com.hp.sdn.ctl.linkdisco.impl.LinkManager`

**Description**

The LinkManager provides parameters used for discovering links between network elements.

**Component keys**

Information about the configurable component keys, including descriptions, current values, suggested ranges, and default values are available from:

- The **Configuration** screen of the controller UI.
- The controller `Configs` REST API.

### 3.7.2.8 Log manager

**Component name**

`com.hp.sdn.adm.log.impl.LogManager`

**Description**

The LogManager controls the number of log message rows displayed in the Support Logs display.

**Component keys**

Information about the configurable component keys, including descriptions, current values, suggested ranges, and default values are available from:

- The **Configuration** screen of the controller UI.
- The controller `Configs` REST API.

### 3.7.2.9 Metric manager component

**Component name**

`com.hp.sdn.adm.metric.impl.MetricManagerComponent`

**Description**

The MetricManagerComponent determines how measurement data is maintained by the controller.

The controller includes a metering framework that internal components and installed applications can use to collect various types of data. (Data can be persisted on the controller from sources external to the controller.) Any metric created with the framework may optionally be persisted over time or directed to the controller JMX facility for viewing. Data persisted over time can be viewed using the controller REST API, while data sent to JMX can be viewed using JConsole or another JMX client. The MetricManagerComponent permits configuring default values for certain aspects of the metering framework operation, such as how long the controller should retain persisted data, at what time of day persisted data that is too old should be trimmed, and how often persisted metric values should be saved to disk. (This value can be overridden for any metric when the metric is created).

**Component keys**

Information about the configurable component keys, including descriptions, current values, suggested ranges, and default values are available from:

- The **Configuration** screen of the controller UI.
- The controller `Configs` REST API.

#### 3.7.2.10 Node manager

**Component name**

`com.hp.sdn.ctl.nodemgr.impl.NodeManager`

**Description**

The NodeManager provides parameters for discovering and maintaining end host locations in the network.

**Component keys**

Information about the configurable component keys, including descriptions, current values, suggested ranges, and default values are available from:

- The **Configuration** screen of the controller UI.
- The controller `Configs` REST API.

#### 3.7.2.11 Path diagnostic manager

**Component name**

`com.hp.sdn.ctl.diag.impl.PathDiagnosticManager`

**Description**

The PathDiagnosticManager defines the lifetime of the diagnostics flows used for tracing a path.

**Component keys**

Information about the configurable component keys, including descriptions, current values, suggested ranges, and default values are available from:

- The **Configuration** screen of the controller UI.
- The controller `Configs` REST API.

#### 3.7.2.12 Path daemon

**Component name**

`com.hp.sdn.ctl.path.impl.PathDaemon`

**Description**

The PathDaemon provides parameters used by the path daemon to perform Layer-2 forwarding. See also "Understanding the embedded applications" (page 10).

**Component keys**

Information about the configurable component keys, including descriptions, current values, suggested ranges, and default values are available from:

- The **Configuration** screen of the controller UI.
- The controller `Configs` REST API.

#### 3.7.2.13 RestPerf provider

**Component name**

`com.hp.sdn.rs.RestPerfProvider`

**Description**

The RestPerfProvider reports performance data for the REST API.

**Component keys**

Information about the configurable component keys, including descriptions, current values, suggested ranges, and default values are available from:

- The **Configuration** screen of the controller UI.
- The controller `Configs` REST API.

#### 3.7.2.14 Role assert manager

**Component name**

`com.hp.sdn.adm.role.impl.RoleAssertManager`

**Description**

The RoleAssertManager provides parameters the controller uses for determining role message transmit retries and response periods.

**Component keys**

Information about the configurable component keys, including descriptions, current values, suggested ranges, and default values are available from:

- The **Configuration** screen of the controller UI.
- The controller `Configs` REST API.

#### 3.7.2.15 Service REST component

**Component name**

`com.hp.sdn.misc.ServiceRestComponent`

**Description**

The ServiceRestComponent provides parameters for internal communication between SDN components and the SDN controller Northbound REST API.

**Component keys**

Information about the configurable component keys, including descriptions, current values, suggested ranges, and default values are available from:

- The **Configuration** screen of the controller UI.
- The controller `Configs` REST API.

#### 3.7.2.16 System watchdog manager

**Component name**

`com.hp.sdn.adm.system.impl.SystemWatchdogManager`

**Description**

The SystemWatchdogManager provides heartbeat status checking between SDN controllers that are running as part of a team.

#### 3.7.2.17 Trace manager

**Component name**

`com.hp.sdn.ctl.of.impl.TraceManager`

**Description**

The TraceManager specifies how long a trace is to run after it starts.

**Component keys**

Information about the configurable component keys, including descriptions, current values, suggested ranges, and default values are available from:

- The **Configuration** screen of the controller UI.
- The controller `Configs` REST API.

#### 3.7.2.18 End-Host discovery via ARP protocol

**Component name**

`com.hp.sdn.disco.of.node.impl.OfArpDiscoveryComponent`

**Description**

OpenFlow end-host discovery via the ARP protocol.

#### 3.7.2.19 End-Host discovery via DHCP protocol

**Component name**

`com.hp.sdn.disco.of.node.impl.OfDhcpDiscoveryComponent`

**Description**

OpenFlow end-host discovery via the DHCP protocol

#### 3.7.2.20 End-Host discovery via IP Protocol

**Component name**

`com.hp.sdn.disco.of.node.impl.OfIpDiscoveryComponent`

**Description**

OpenFlow end-host discovery via the IP protocol.

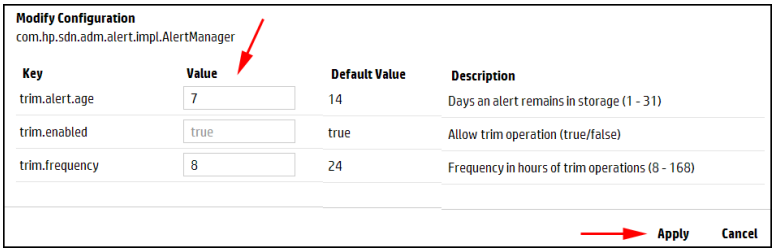
### 3.7.3 Configurations screen details

| Screen component | Description |
|---|---|
| **Modify** | Opens the **Modify Configuration** dialog box for the selected component. |
| **Component** | The name of the component. |
| expand icon | Click to display the key and value information for the component.<br>The display for each key includes the current value, the default value, and a brief description. Where applicable, the range of suggested values is also included. |
| collapse icon | Click to hide the key and value information for the component. |

### 3.7.4 Modifying a component configuration

1. Select the component you want to modify.
2. Click **Modify**.

   The **Modify Configuration** dialog box is displayed. For example:



3. Enter new values for each of the keys you want to modify.
4. Do one of the following:
   - To save your changes and close the dialog box, click **Apply**.
   - To close the dialog box without saving changes, click **Cancel**.

# 3.8 Audit log screen

## 3.8.1 About the audit Log

The audit log is available through both the controller GUI and the REST API, and records events related to activities, operations, and configuration changes initiated by an authorized user. This includes activities such as:

- Installing an application (or starting, stopping, uninstalling an application)
- Modification to a components configuration
- Installing a license
- Forming a controller team

**Audit log and controller teams**

When controllers are operating in a team, the audit log shows events for all controllers in the team.

### 3.8.1.1 About audit log policies

The values for the AuditLogManager component keys determine the alert age-out policies. The following table describes the keys for the AuditLogManager component (`com.hp.sdn.adm.auditlog.impl.AuditLogManager`).

| Key | Default Value | Description |
|---|---|---|
| `trim.auditlog.age` | 365 | Specifies the number of days to retain a log entry. Use this key to implement your record retention policy.<br>Data type: A number from 31 through 1825. |
| `trim.enabled` | `true` | `true`: Specifies that the controller deletes log entries that have exceeded the `trim.auditlog.age` limit.<br>`false`: Specifies that the controller does not delete log entries that have exceeded the `trim.auditlog.age` limit. |
| `trim.frequency` | 24 | Specifies how often, in hours, the controller is to delete log entries that have exceeded the `trim.alert.age` limit.<br>Data type: A number from 8 through 168<br>Example: Enter **`24`** to specify that the controller delete aged-out log entries every 24 hours (once per day). |

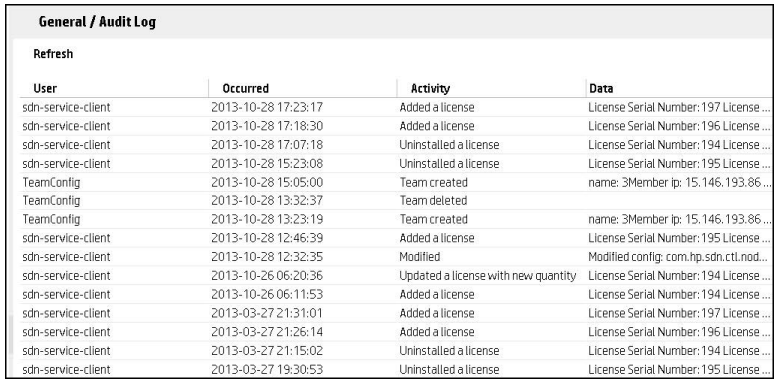
## 3.8.2 Audit Log screen details

| Screen component | Description |
|---|---|
| **Refresh** | Updates the log entries displayed on the screen. The controller does not update the display as new entries are generated. Use this action to refresh the display. |
| **User** | The user that performed the operation that triggered the log entry |
| **Occurred** | A time stamp (in UTC format) indicating when the controller created the log entry. |
| **Activity** | The type of activity that triggered the creation of the log entry. |
| **Origin** | The application or controller component that generated the log entry. |

| Screen component | Description |
|---|---|
| **Data** | Detailed information about the log entry. |
| **Controller ID** | A hexadecimal number that identifies controller that generated the log entry. When you use controller teaming, this ID enables you to identify which controller in the team generated the alert. |

For example, the audit log displays software license and teaming activity:

**Figure 5 Audit Log screen example with licensing and teaming activity**




### 3.8.3 Deleting a log entry

You cannot delete or modify a log entry. The controller deletes entries according to the configured audit log policies. To configure the audit log policies, see "Configuring audit log policies" (page 33)

### 3.8.4 Configuring audit log policies

1. From the **Configurations** screen, under **Component**, select the `com.hp.sdn.adm.auditlog.impl.AuditLogManager` component.
2. Click **Modify**.

   The **Modify Configuration** dialog box appears.
3. Change the values for the keys. For information about the keys and values for this component, see "About audit log policies" (page 32).
4. Click **Apply** .

### 3.8.5 Exporting and archiving audit log data

To retain log records for longer than the `trim.auditlog.age` limit, you must export the audit log from the controller to a file before the `trim.auditlog.age` limit is reached. Exporting audit log data does not remove it from persistent storage.

To export the audit log, you must use the REST APIs.

## 3.9 Licenses screen

The **Licenses** screen displays the controller Install ID, activates new licenses, and deactivates installed licenses (for transfer to another installation).

### 3.9.1 About licenses

Licenses are required for the controller and for any installed applications. For information about licenses, see "License Registration and Activation" (page 52).

### 3.9.2 Licenses screen details

| Screen component | Description |
|---|---|
| **Refresh** | Updates the screen with the latest license information. |
| **Add** | Adds and activates the specified license key on this controller. |
| **Deactivate** | Deactivates the selected license. |
| **Install ID** | Contains the installation identifier for this controller. |
| **Serial#** | |
| **Product** | |
| **Licensed For** | |
| **Qty** | |
| **Type** | |
| **Status** | |
| **Expire By** | |
| **Uninstall Key** | |

### 3.9.3 Installing, activating, uninstalling, or transferring licenses

For information about installing, activating, uninstalling, and transferring licenses, see "License Registration and Activation" (page 52).

## 3.10 Support logs screen

### 3.10.1 About support logs

The support logs maintain an internal record of events of interest from the operations of an active SDN controller. This information is the type of data a support engineer would request when troubleshooting an SDN installation.

**Support logs and controller teams**

In a controller team environment:

- Each controller maintains its own support logs.
- Changing the `log.queue.size` on any controller propagates to all active controllers in the team.
- The **Export** action gathers the set of support log file data from all active controllers in the team, and stores the data as a single compressed archive.

**Multiple support logs**

The controller allows up to five support logs; one active and four in storage:

- When the current log reaches 10MB, the controller copies the log to storage and starts a new log.
- When the space allocated for all support logs is full, the controller purges the oldest log file to make room for continued logging operation.
- Support logs are stored in the controller `/var/log/sdn/virgo/logs` directory.
- Support logs can be exported to a file (see "Exporting the support logs " (page 36))

## 3.10.2 Support logs screen details

<table>
<tr><th>Screen component</th><th>Description</th></tr>
<tr><td>Refresh</td><td>Displays a listing of the most recent log messages, as determined by the currently configured queue size. For example, with a queue size of 100, Refresh lists the 100 most recent log messages.</td></tr>
<tr><td>Export</td><td>Gathers the set of support log file data from the standalone controller or all active controllers in the team, and stores the data as a single compressed archive.</td></tr>
<tr><td>Level</td><td>The severity level for the entry. Levels are:<br><table><tr><th>Value</th><th>Description</th></tr><tr><td>ERROR</td><td>Recorded in support logs</td></tr><tr><td>WARN</td><td></td></tr><tr><td>INFO</td><td></td></tr><tr><td>DEBUG</td><td></td></tr><tr><td>TRACE</td><td></td></tr></table>In the default configuration, the ERROR, WARN, and INFO levels are recorded in the Support Logs. DEBUG and TRACE are verbose logging that are used in troubleshooting situations that may involve support engineering.<br>The logging level for a component that is writing to the support log can be dynamically changed using the Virgo Administrator console. For example, DEBUG level logging can be enabled for just the NodeManager configuration component.</td></tr>
<tr><td>Logger</td><td></td></tr>
<tr><td>Thread</td><td></td></tr>
<tr><td>Message</td><td></td></tr>
<tr><td>Data</td><td>Detailed information about the log entry.</td></tr>
<tr><td>Controller ID</td><td>A hexadecimal number that identifies controller that generated the log entry. When you use controller teaming, this ID enables you to identify which controller in the team generated the alert.</td></tr>
</table>

## 3.10.3 Configuring the support log queue size

The default queue size is 100 lines. To configure a different queue size, change the value for the `max.display.rows` key of the LogManager component.

1. From the **Configurations** screen, under **Component**, select the `com.hp.sdn.adm.log.impl.LogManager` component.
2. Click **Modify**.

   The **Modify Configuration** dialog box appears.
3. Change the value for the `max.display.rows` key.
4. Click **Apply**.

## 3.10.4 Configure signed application zip file verification

By default, the SDN Controller *does* verify that an application zip file has been signed from a trusted source as defined in your /opt/sdn/admin/sdnjar_trust.jks truststore. To enable or disable checking that all application zip files downloaded through the application manager are signed and are from a trusted source, you must change the value for the “verifyZips” key.

1. From the **Configurations** screen, under **Component**, select the `com.hp.sdn.adm.mgr.impl.AppManager` component.
2. Click **Modify**.

   The **Modify Configuration** dialog box appears.
3. Change the "verifyZips" key value to "False" to enable checking.
4. Click **Apply**.

**NOTE:** To download an application with this check enabled, the public certificate used to recognize the signed zip file must be installed in the sdnjar_trust.jks truststore. See "Adding certificates to the jar-signing truststore " (page 68).

### 3.10.5 Exporting the support logs

The **Export** operation:

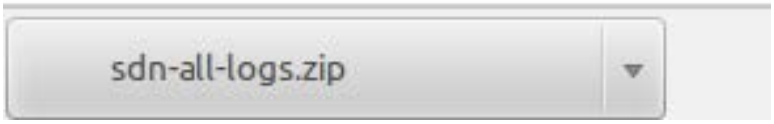
1. Gathers the set of support log file data from the controller, or in a team environment, all active controllers in the team, and stores the data as a single compressed archive file:

   `sdn-all-logs.zip`
2. Downloads the archive file from the controller to the default download directory specified by your browser. For example, in Ubuntu installations, this is usually the `Downloads` directory.

1. Click **Export**.

   The following menu appears in the lower-left corner of the controller console:

**Figure 6 Completion of the export operation**




2. When the download completes, you can either resume interaction with the controller or examine the log by selecting an item from the menu, such as:
   - Open a window showing the new log zip file.
   - Set the default operation to always open the directory containing the log zip file.
   - Show the log zip file in the default directory for receiving downloads.

**NOTE:** The actions resulting from these choices depend on the browser and operating system, not on the controller.

## 3.11 OpenFlow monitor screen

When the controller is active in an OpenFlow domain, the OpenFlow Monitor enables tracking of switch traffic summaries, packet traffic per port, and applied flow rules for switches detected in the controller domain. The main display lists the Data Path IDs for the active switches and the options for viewing traffic information.

### 3.11.1 About the OpenFlow monitor

When the controller is active in an OpenFlow domain, the OpenFlow Monitor enables tracking of switch traffic summaries, packet traffic per port, and applied flow rules for switches detected in the controller domain. The main display lists the Data Path IDs for the active switches and the options for viewing traffic information.

## 3.11.2 OpenFlow monitor screen details

### 3.11.2.1 Main display

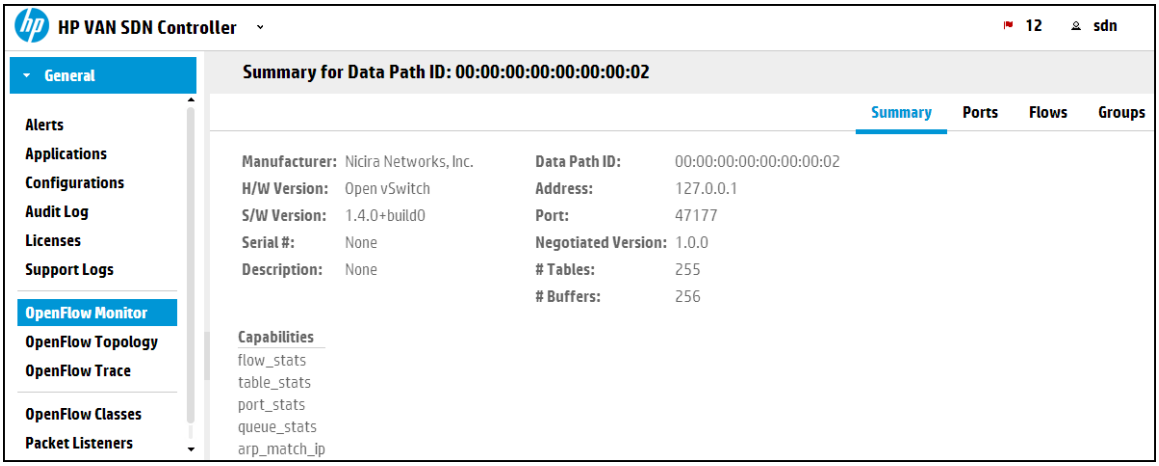
| Screen component | Description |
|---|---|
| **Refresh** | Updates the information displayed on the screen. |
| **Summary** | Displays the "Summary for data path view" (page 37) for the selected data path. |
| **Ports** | Displays the "Ports for data path display" (page 37) for the selected data path. |
| **Flows** | Displays the "Flows for data path display" (page 38) for the selected data path. |
| **Groups** | Displays the Groups view for the selected data path. |
| **Data Path ID** | Identifies a detected OpenFlow switch. The OpenFlow data path identification for each detected OpenFlow switch. This ID also appears in the representation of the switch in the OpenFlow Topology screen. |
| **IP Address** | Identifies the IP address associated with an OpenFlow data path instance. |
| **Negotiated Version** | The version of OpenFlow in use with the corresponding data path. |

### 3.11.2.2 Summary for data path view

This view includes the following related to the selected device:

- Manufacturer
- Hardware and software version
- Serial number and device description
- Device identification (Data Path ID) and IP address
- TCP port on the device
- Negotiated OpenFlow version (latest OpenFlow version common to both the controller and the switch)
- OpenFlow table and buffer information
- OpenFlow capabilities on the device

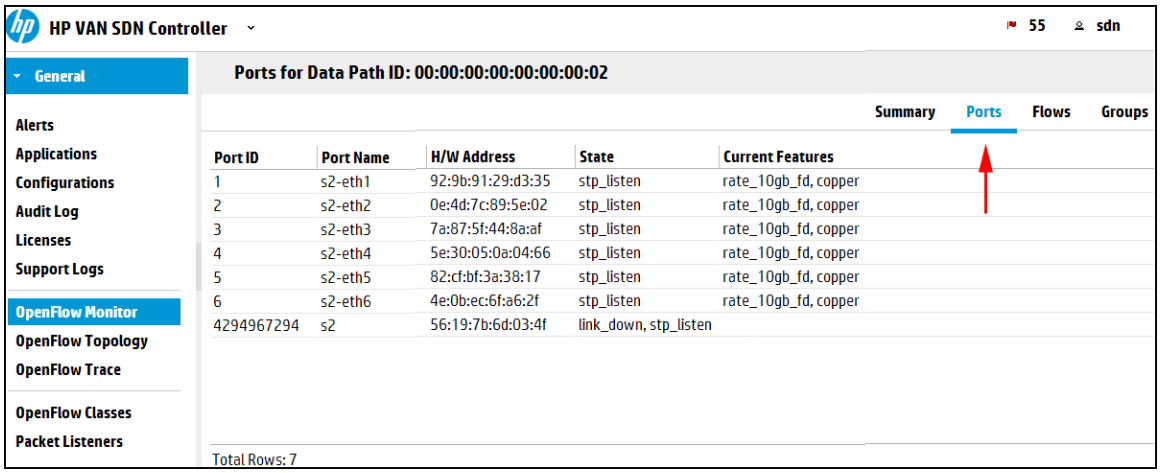
**Figure 7 Summary for data path view**




### 3.11.2.3 Ports for data path display

This view includes information on the ports used for OpenFlow traffic on the selected device.

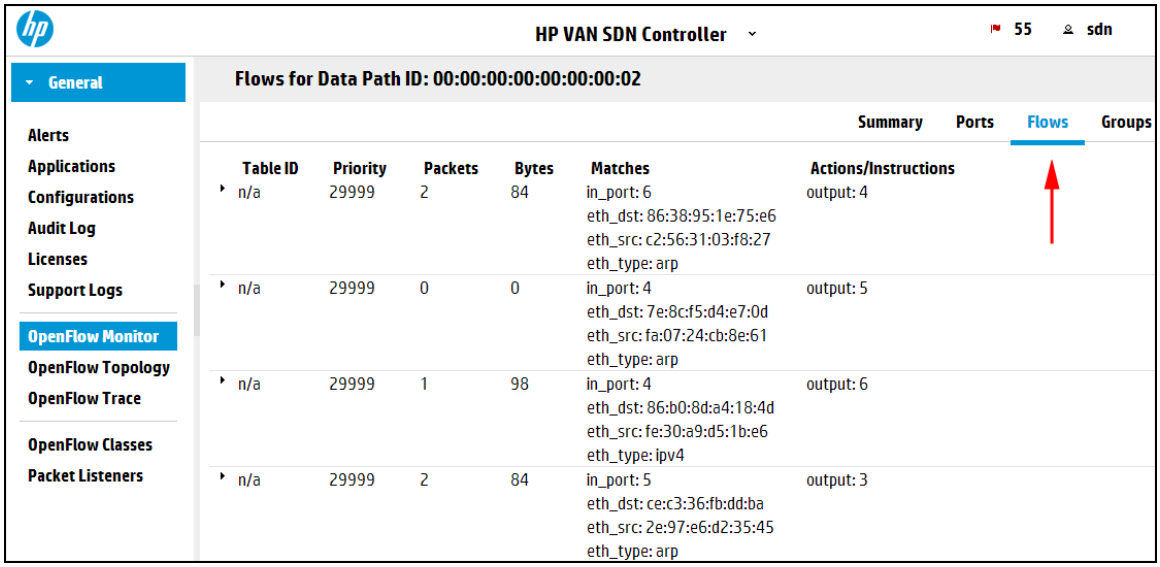
### Figure 8 Ports view for a specific OpenFlow device




## 3.11.2.4 Flows for data path display

This view includes the current flows on the selected OpenFlow device. For a given flow, traffic meeting the requirements specified in the "Matches" field is directed as specified in the corresponding "Actions/Instructions" field.

### Figure 9 Flows view for a specific OpenFlow device




**NOTE:** The **Table ID** applies to OpenFlow 1.3 and greater, but not to OpenFlow 1.0.

## 3.11.3 Discovering changes in the topopology

Click **Refresh** to update the display for topology changes, such as a newly discovered OpenFlow device or the loss of a device that has failed.

## 3.11.4 Viewing information about a specific device

To view information about a specific device, click the Data Path ID for that device and then click the button for the view you want to display.

For a graphical view of Data Path ID assignments to individual OpenFlow switches, see OpenFlow topology screen.

## 3.12 OpenFlow topology screen

The **OpenFlow** screen displays a topology of discovered switches and end nodes in the controller domain. The viewer creates and updates a graph of the network, and computes the broadcast tree to avoid loops and broadcast storms. The shortest path is computed using Dijkstra's graph search algorithm. The viewer:

- Displays a topology of discovered switches and end nodes.
- Identifies the ports discovered on a given switch.
- Identifies the shortest path between two nodes.
- Provides node identification options (MAC or IP address label).
- Provides a view of switch port identifiers, active flow rules, and a tool for testing flow rule options.

**CAUTION:** Do not allow a loop between the OpenFlow and non-OpenFlow portions of your network unless you enable Spanning Tree Protocol on the non OpenFlow devices operating in the network

**NOTE:** In a topology where two or more controlled switches connect to the same uncontrolled switch, the controller will not learn the location of hosts connected to the uncontrolled switch.

### 3.12.1 Displaying the network toplogy

The **OpenFlow Topology** screen includes the switches and end-nodes in the controller domain.

**Figure 10 Topology viewer**

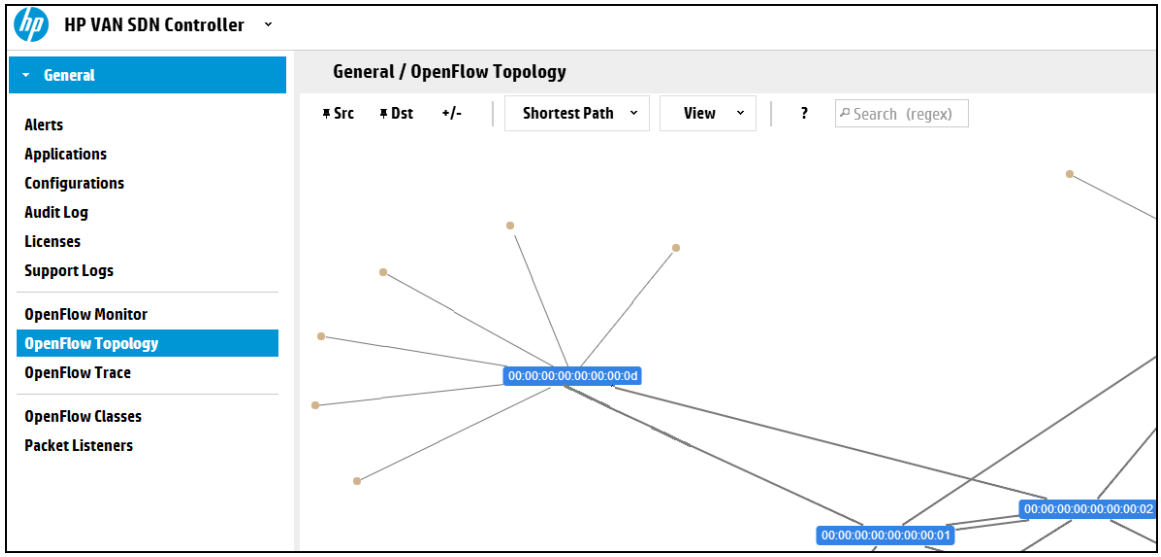
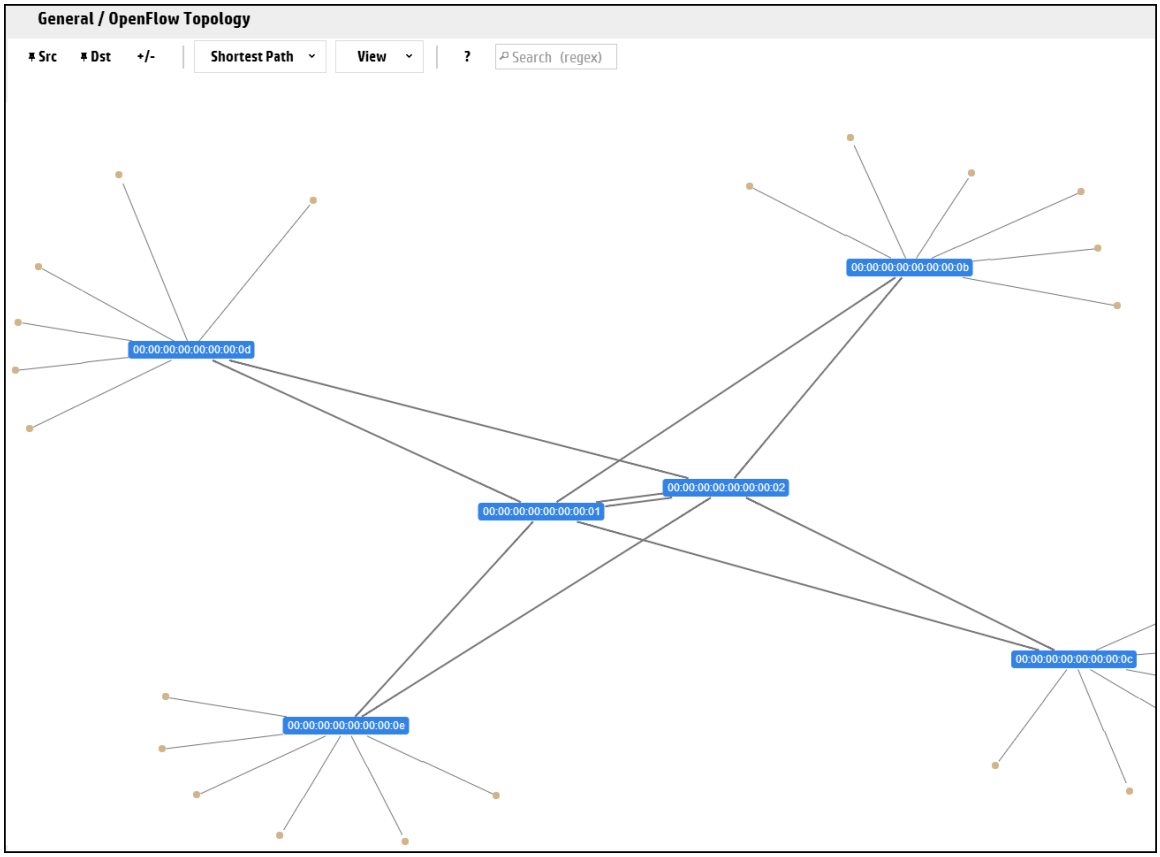


**Figure 11 Default topology view with switch and end-nodes**




### 3.12.1.1 Configuring how the OpenFlow network topology is displayed

Both of the following tools provide control for different parts of the **OpenFlow Topology** display:

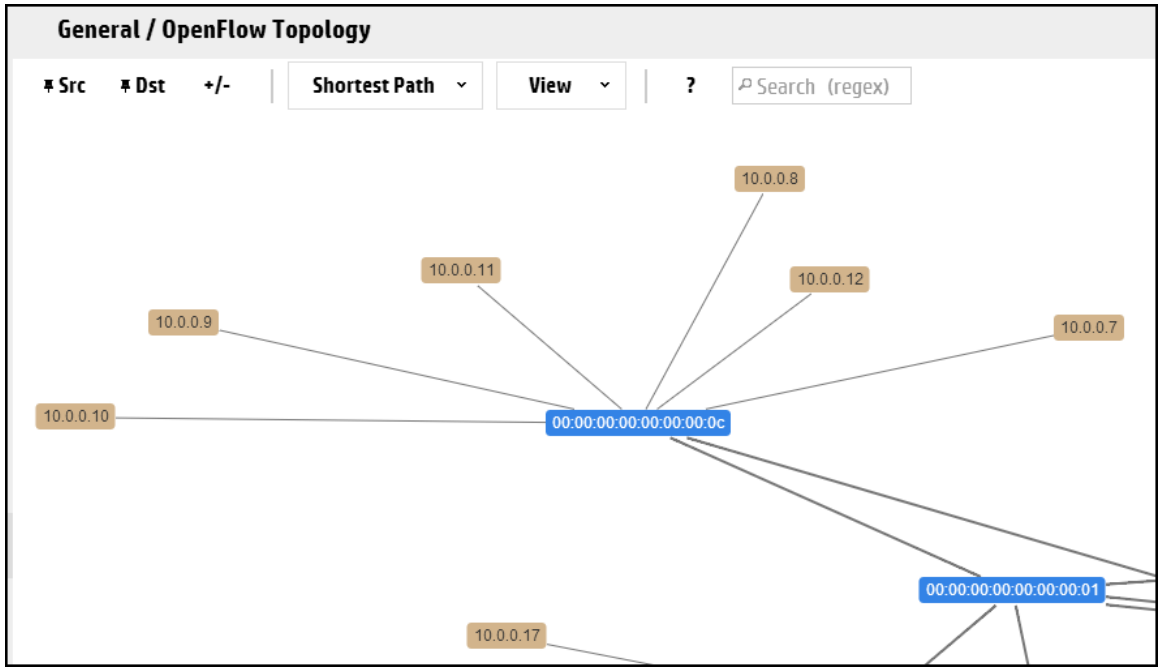
- The **?** icon for a list of keyboard shortcuts you can use to change the display.
- The **View** menu for:
  - Port labels on switches
  - Switch datapath details
  - A tool for selecting Packet selection criteria

End nodes can be labelled with one of the following:

- No Label (default)
- IP Address
- MAC Address

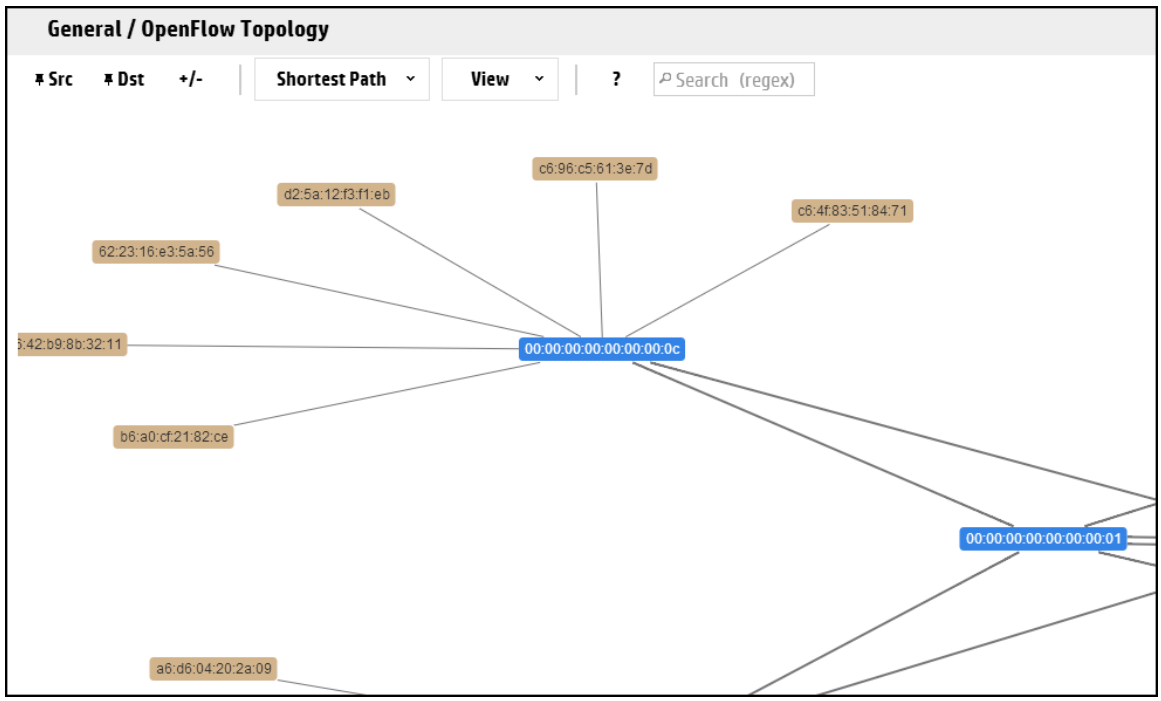
For example, to show the IP addresses of the end-nodes in the OpenFlow topology, click anywhere in the topology display, then press **N**. The end-node IP addresses appear as labels in the topology diagram:

### Figure 12 End-node IP address labeling




Press **N** again to display the end-node MAC addresses as labels in the topology diagram:

### Figure 13 End-node MAC addresses as labels




Press **N** again to return to the unlabeled end-node view.

Switches are always labelled with their data path ID. You can also:

- Add port labels to the links between switches and between switches and end nodes.
- Identify flow details and options. (See "Identifying flow details and flow options" (page 43).)

- "Pin" the switches and end nodes in the topology display.
- "Collapse" the topology display to show only the number of end nodes connected to each switch, instead of showing all end nodes (the default) which can present a cluttered display where a large number of end nodes are connected to the OpenFlow switches.

In the topology display:

- To display or remove port numbers for the links, press **P** or select **View→Ports**.
- To pin or unpin the switches and end nodes, press **X** or select **View→Pin All**.
- To hide or show all switch end nodes, press**G** or select **View→Collapse All**.

**Figure 14 Switch ports labels**

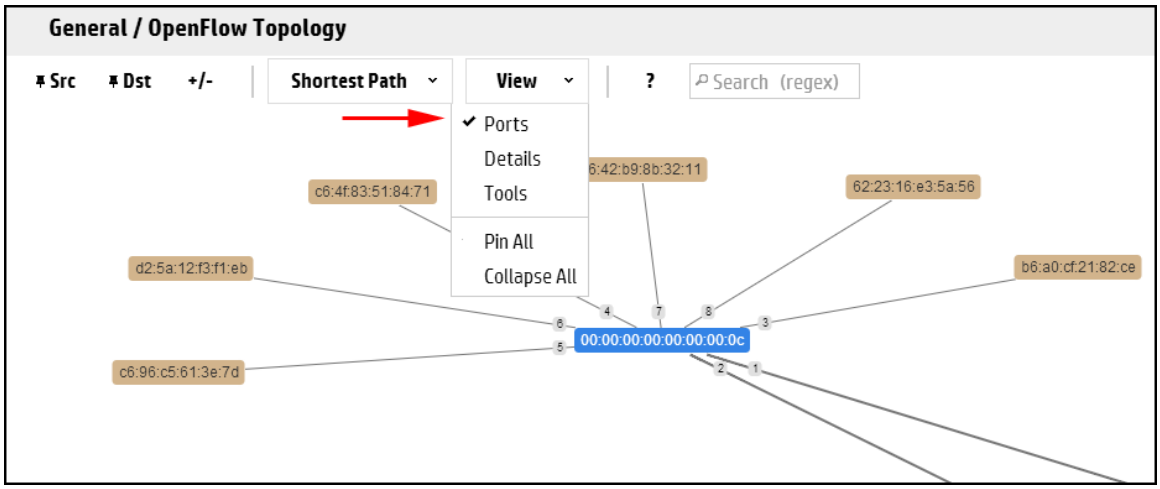
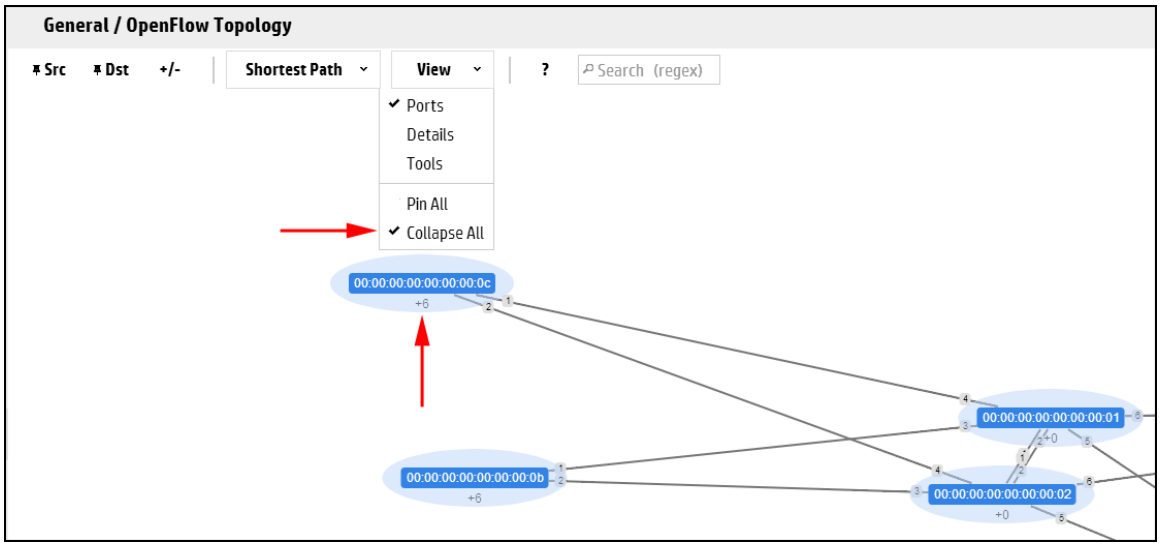



**Figure 15 Collapse All option**




The number appearing under the Data Path ID for a switch in the topology diagram indicates the number of detected end nodes connected to the switch.

To toggle between hiding or showing all switch end nodes, click anywhere in the topology display and then press **G**.

To toggle between hiding or showing the end nodes for a particular switch, select the switch and then press **C**.

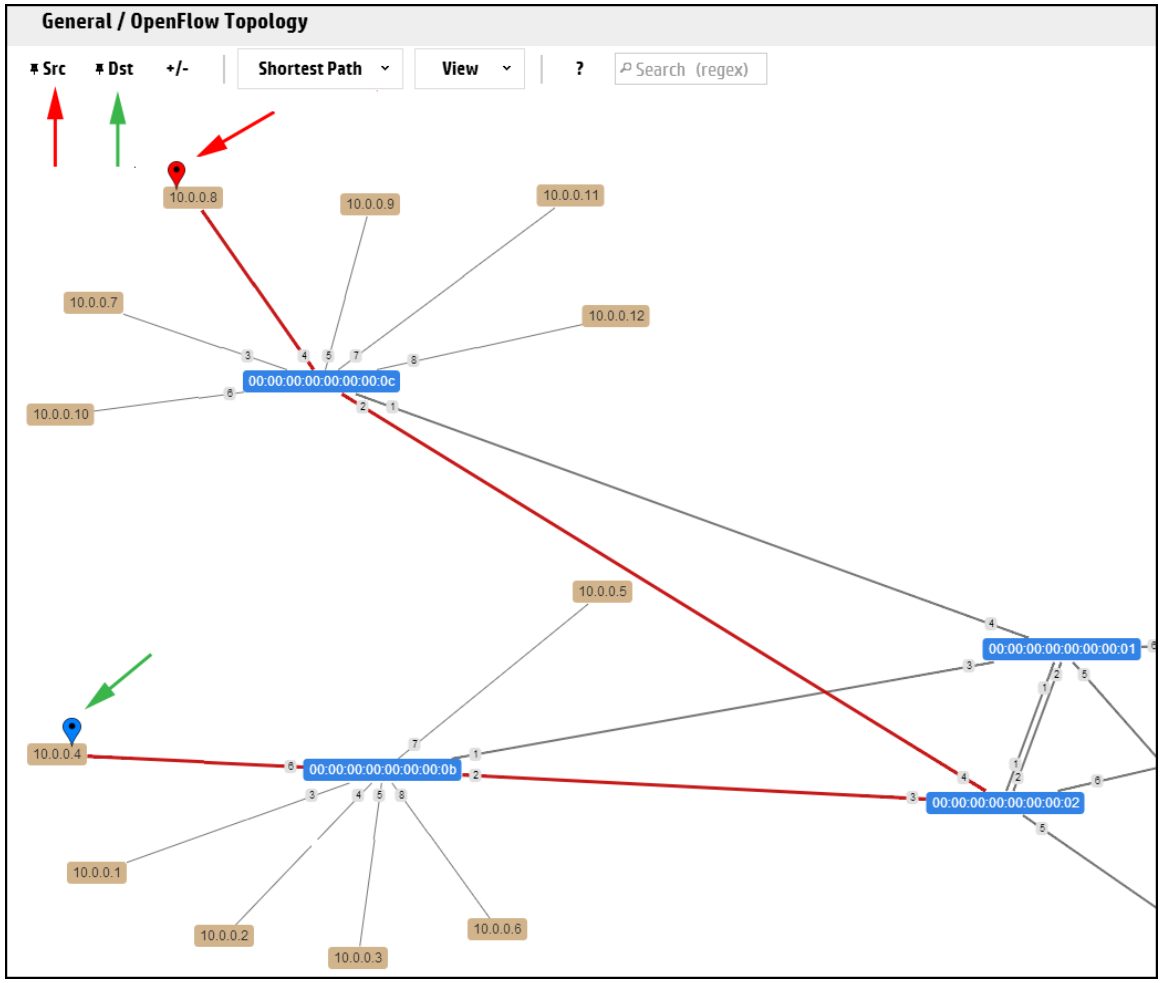
### 3.12.1.2 Viewing the shortest path between two nodes

1. Select the source node and press **S** or click **Src**.

2. Select the destination node and press **D** or click **Dst**.

The controller displays the path between the two nodes as a red line (see Figure 16 (page 43)).

**Figure 16 Locating the shortest path between two nodes**




To exchange source and destination nodes, press **A**.

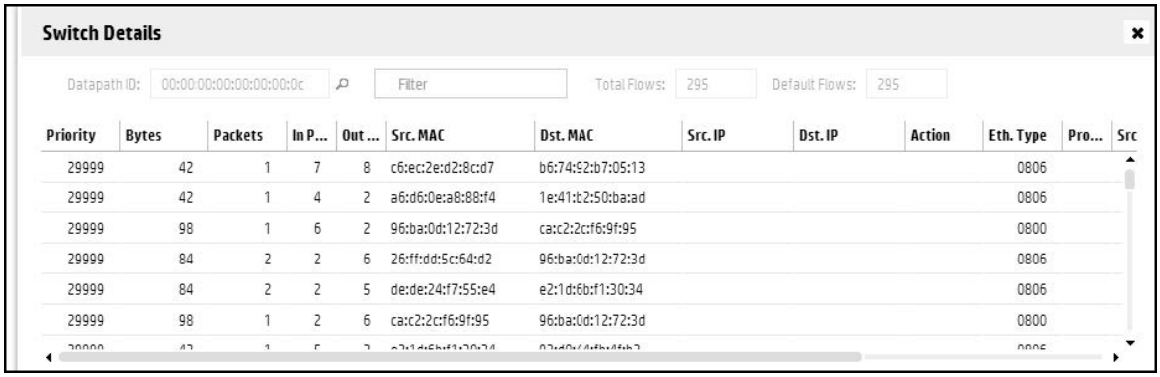
To clear the source and destination flags, press **Z**.

### 3.12.1.3 Identifying flow details and flow options

- Do one of the following:
  - Select **Shortest Path→Follow Flow**
  - Select a switch in the shortest path and press **I**, then select the switch again and press **T**.

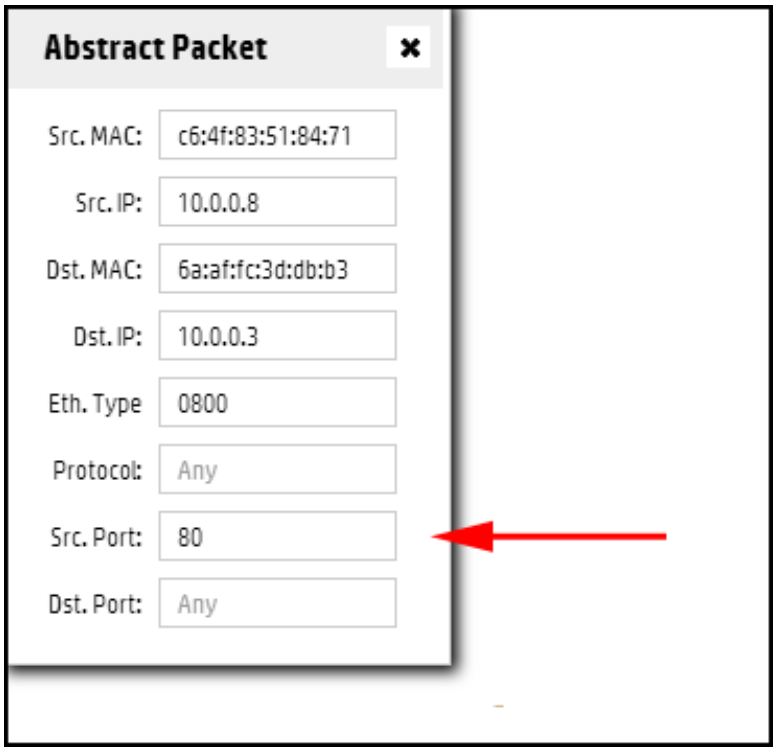
The **Switch Details** window displays the flow details and the **Abstract Packet** window displays selection criteria for packets moving between the Source-Destination node pair.

Figure 17 Flow details for the selected source-destination end nodes




Using the fields in the **Abstract Packet** window, search for flow rules for packets having criteria dictating a path other than shortest path, for example, by entering port 80 for HTTP packets.

Figure 18 Searching for flows for specific packet types




## 3.13 OpenFlow trace display

This troubleshooting tool logs OpenFlow conversations captured in messages to and from the controller and the OpenFlow devices it manages.

You can export the captured messages in the trace log to a CSV (Comma-Separated Values) file that can be opened by applications such as Excel that are designed to accommodate this file type. This enables you to create a filter to display only the messages from the specific data paths you want to examine.

### 3.13.1 About the trace log

The number of events that can be held in the trace log is limited by system memory. For this reason, HP recommends that you export to a remote storage location any trace log content you want to retain, and to clear the controller trace log whenever its content is not needed on the controller itself.

## 3.13.2 OpenFlow trace display details

| Screen component | Description |
|---|---|
|  | Starts trace logging.<br>In the default configuration, the trace stops after ten seconds have passed. (To change the trace interval, see "Changing the OpenFlow trace interval " (page 48).) |
|  | Stops trace logging before the end of the configured trace interval.<br>Trace logging stops automatically at the end of the configured trace interval.<br>Multiple consecutive traces can be held in the trace log. To add additional trace results, start another trace. |
|  | Clears (resets) the current trace log.<br>To preserve the contents of the trace log before clearing it, see "Exporting the OpenFlow trace log" (page 46). |
|  | Displays details of the selected trace event. |
| **Export** | Copies the trace log into a CSV (comma-separated values) file. See see "Exporting the OpenFlow trace log" (page 46). |
| **Time** | The time the message event was generated. |
| **Event** | The event type. For example:<br>CkPt Indicates a check point in the trace log, such as the starting or stopping of a trace operation.<br>Rx Indicates an OpenFlow message recieved by the controller (from a datapath).<br>Tx Indicates an OpenFlow message sent from the controller (to a datapath). |
| **DPID** | The DPID (data path ID) of the data path associated with the event. |
| **Message** | The trace message. |

## 3.13.3 Starting, stopping, or clearing OpenFlow trace

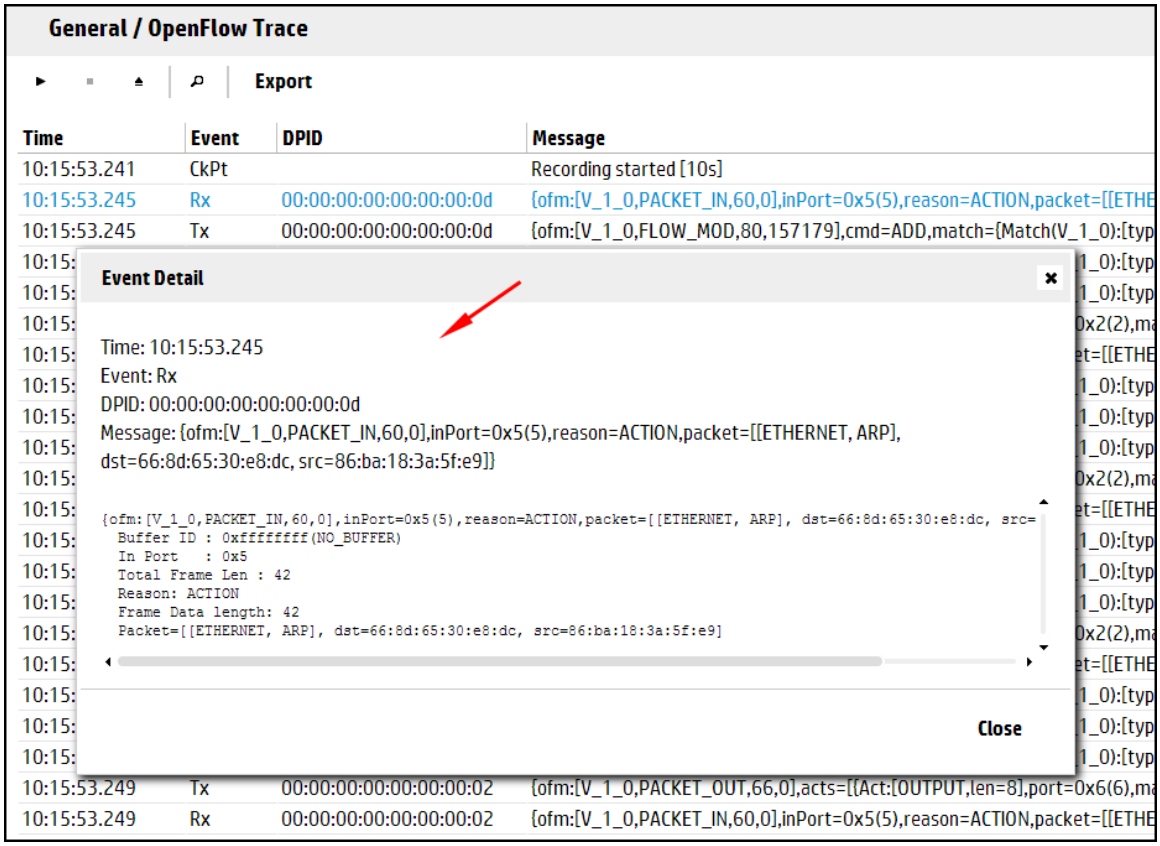
Use the buttons above the **Time** field to control trace operations (see "OpenFlow trace display details" (page 45)).

## 3.13.4 Displaying trace event details

1. Select the event you want to examine.
2. Click  . Alternatively, double-click on the event.

   The **Event Detail** dialog box is displayed.

Figure 19 Displaying event details




3. To close the **Event Detail** window, click **Close**.

## 3.13.5 Exporting the OpenFlow trace log

Exporting an OpenFlow Trace Log places the trace content in a CSV file that is stored in the default downloads folder specified in your web browser settings.

For more information about CSV files, see RFC 4180.

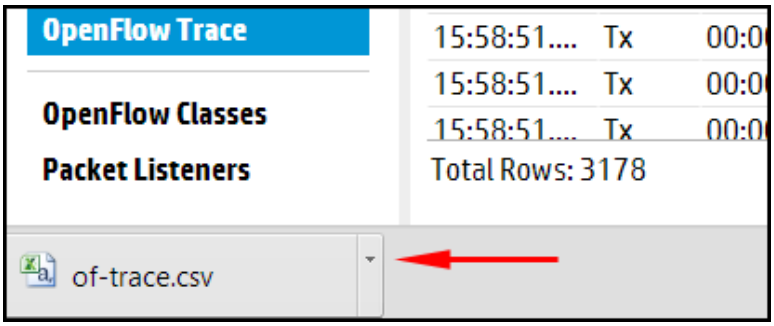
**NOTE:** This section shows how to export and access OpenFlow Trace Log files using Google Chrome. You may experience different results than shown here, depending on your web browser and its configuration.

1. Click **Export**. This action places the trace log contents into a CSV file in the default downloads folder in the system on which the controller is running. Check your web browser for an indication that the file has been created.
2. To display and filter the CSV file content, see "Filtering the OpenFlow trace log in a CSV file" (page 47).

## 3.13.6 Filtering the OpenFlow trace log in a CSV file

1. Open the CSV file in the default folder. For example, using Google Chrome, open the menu adjacent to the file name (`of-trace.csv`) and select **Show in folder**.

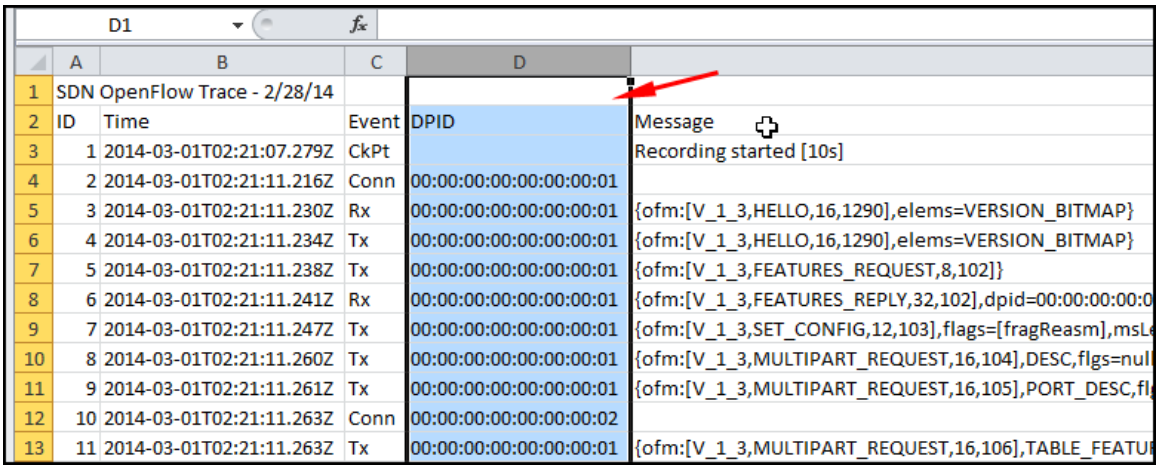
**Figure 20 Accessing the stored CSV file**




In the resulting folder listing, locate the `of-trace.csv` file and open it using an application, such as Excel, that enables you to read the log messages and configure a filter. For example, to investigate the messages collected for data path 00.00.00.00.00.00.00.02:

2. Select the DPID (Data Path ID) column.

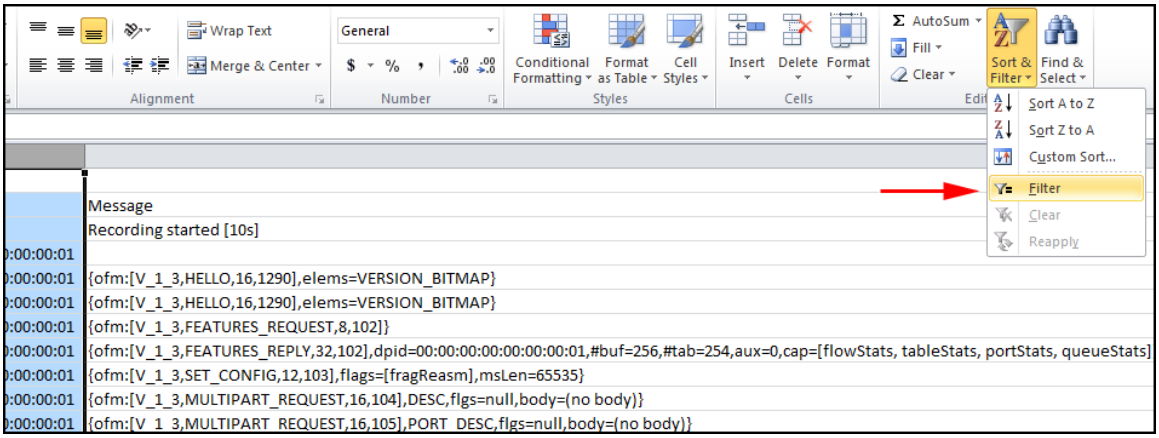
**Figure 21 DPID column**



| | A | B | C | D | |
|---|---|---|---|---|---|
| 1 | SDN OpenFlow Trace - 2/28/14 | | | | |
| 2 | ID | Time | Event | DPID | Message |
| 3 | 1 | 2014-03-01T02:21:07.279Z | CkPt | | Recording started [10s] |
| 4 | 2 | 2014-03-01T02:21:11.216Z | Conn | 00:00:00:00:00:00:00:01 | |
| 5 | 3 | 2014-03-01T02:21:11.230Z | Rx | 00:00:00:00:00:00:00:01 | {ofm:[V_1_3,HELLO,16,1290],elems=VERSION_BITMAP} |
| 6 | 4 | 2014-03-01T02:21:11.234Z | Tx | 00:00:00:00:00:00:00:01 | {ofm:[V_1_3,HELLO,16,1290],elems=VERSION_BITMAP} |
| 7 | 5 | 2014-03-01T02:21:11.238Z | Tx | 00:00:00:00:00:00:00:01 | {ofm:[V_1_3,FEATURES_REQUEST,8,102]} |
| 8 | 6 | 2014-03-01T02:21:11.241Z | Rx | 00:00:00:00:00:00:00:01 | {ofm:[V_1_3,FEATURES_REPLY,32,102],dpid=00:00:00:00:0 |
| 9 | 7 | 2014-03-01T02:21:11.247Z | Tx | 00:00:00:00:00:00:00:01 | {ofm:[V_1_3,SET_CONFIG,12,103],flags=[fragReasm],msL |
| 10 | 8 | 2014-03-01T02:21:11.260Z | Tx | 00:00:00:00:00:00:00:01 | {ofm:[V_1_3,MULTIPART_REQUEST,16,104],DESC,flgs=null |
| 11 | 9 | 2014-03-01T02:21:11.261Z | Tx | 00:00:00:00:00:00:00:01 | {ofm:[V_1_3,MULTIPART_REQUEST,16,105],PORT_DESC,fl |
| 12 | 10 | 2014-03-01T02:21:11.263Z | Conn | 00:00:00:00:00:00:00:02 | |
| 13 | 11 | 2014-03-01T02:21:11.263Z | Tx | 00:00:00:00:00:00:00:01 | {ofm:[V_1_3,MULTIPART_REQUEST,16,106],TABLE_FEATUI |

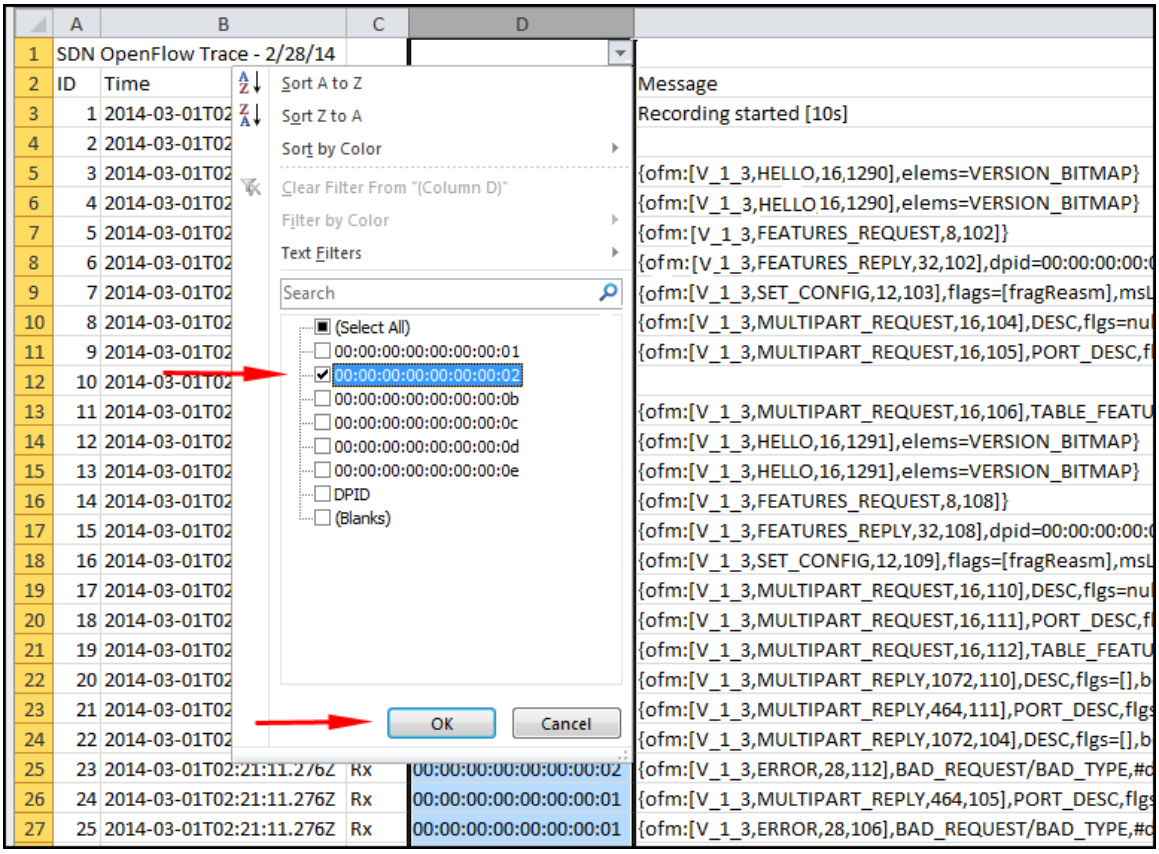
3. Set the filter.

**Figure 22 Setting the filter**



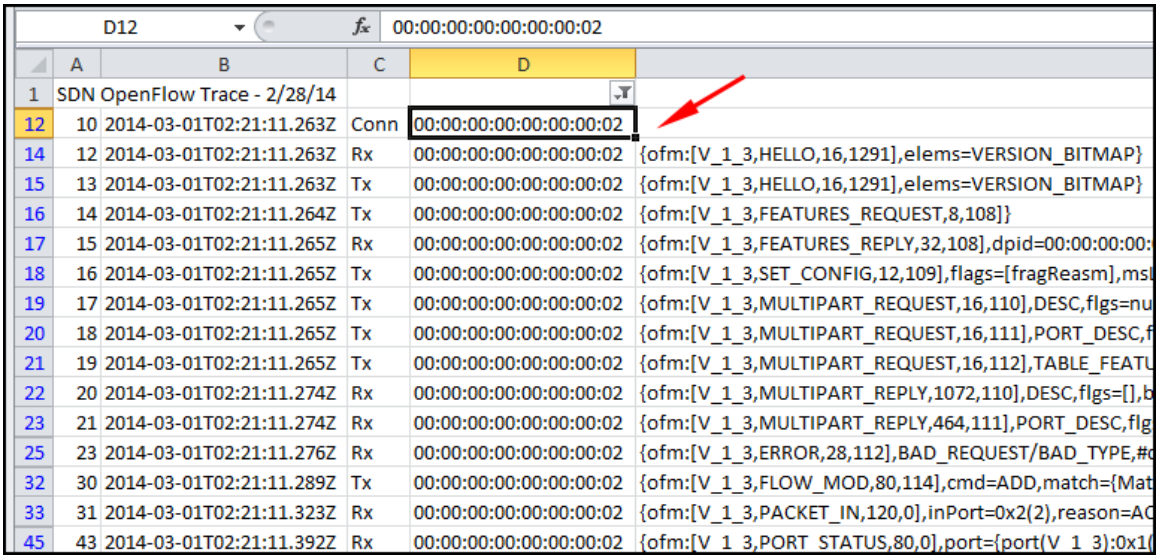

4. Apply the filter by checking the box for data path 00.00.00.00.00.00.00.02.

### Figure 23 Applying the filter




5. In the resulting display, only the data filtered to data path 00:00:00:00:00:00:00:02 appears.

### Figure 24 Filtered trace log




## 3.13.7 Changing the OpenFlow trace interval

The default trace interval is ten seconds. To change the interval:

1. From the navigation menu, select **Configurations**.
2. Open the `com.hp.sdn.ctl.of.impl.TraceManager` component.
3. Click **Modify**.

4. In the **Value** field, enter the desired duration in seconds for active trace recording.
5. Click **Apply** to set the new time span for active trace recording, and return to the OpenFlow Trace view.

## 3.14 OpenFlow classes display

The OpenFlow classes display shows the OpenFlow classes that applications have registered with the controller. For more information about OpenFlow classes, see "About OpenFlow classes" (page 49).

### 3.14.1 About OpenFlow classes

When multiple applications share the same resource—the flow tables of OpenFlow switches—how can their priorities relative to each other be determined and how can their actions be coordinated? If flow table modification priorities are directly coded into each application, applications can end up directly competing with other applications for the highest priorities, which can result in conflicts in general network traffic control and unintended results when you implement a solution that has multiple SDN applications attempting to act on the same packets. In addition, many environments make it difficult to trace the origin of flow modification requests installed in switches.

The HP VAN SDN Controller uses OpenFlow classes to dynamically manage the priorities of the OpenFlow rules being deployed to the network, thus enabling applications to execute their business logic in a more orderly fashion.

1. For each class of flow modification message the application can send, the application must register an OpenFlow class with the controller. The OpenFlow class must specify the types of match fields, types of actions, and (optionally) the relative position (higher than or lower than) for this class with respect to other flow classes.
2. The controller adds a unique base cookie to be used with each future flow modification to be validated against this OpenFlow class, and assigns an actual priority for the OpenFlow class. This actual priority is based on the logical priorities of all of the OpenFlow classes of all the applications that are registered with the controller.
3. When the application sends a flow modification message, it must set the match and action to be the same fields as specified in the OpenFlow class and, instead of providing an actual priority, the application sets the logical priority as assigned by the flow class, and a cookie that is derived from the base cookie of the OpenFlow class.
4. Before sending the flow table modification message to the switch, the controller evaluates the requested flow modification against the registered OpenFlow classes and replaces the logical priority provided by the application with an actual priority.

In addition to enabling the controller to manage priorities for multiple applications, OpenFlow classes enable the controller to validate flow modifications an application makes against a set of expected flow modification requests. This capability means that the behavior of an application must match the intent that the application disclosed when it registered with the controller:

- The flow match must contain exactly the fields and field types that were disclosed when the application registered with the controller. The controller validates field types but not field value.
- The action or instruction must fall into the category that was disclosed during registration.

  An action is classified into one of the following categories:

  FORWARD
  DROP
  PROCESS
  STEAL
  COPY

- The upper 16 bits of the flow modification cookie must match the upper 16 bits of the base cookie that was issued during registration.

## 3.14.2 Controller enforcement levels for OpenFlow classes

The following table lists the enforcement levels that the controller can use for applications that send flows to switches.

| Enforcement level | Description |
|---|---|
| `none` | The controller does not manage flow modification priorities or validate flow modification requests:<br>• Applications that do not register OpenFlow classes with the controller are permitted to send flow modifications to switches.<br>• The controller does not validate flow modifications, even for applications that register OpenFlow classes with the controller.<br>• The controller does not replace logical priorities with actual priorities for flow modification requests from any applications. |
| `weak` | (Default) The controller manages flow modification priorities and validates flow modification requests for applications that register OpenFlow classes:<br>• Applications that do not register OpenFlow classes with the controller are permitted to send flow modifications to switches.<br>• The controller validates flow modifications from registered applications against the OpenFlow classes that are registered.<br>• The controller replaces logical priorities with actual priorities for registered applications only. |
| `strict` | The controller manages all flow modification priorities and validates all flow modification requests:<br>• Applications that do not register OpenFlow classes with the controller are not permitted to send flow modifications to switches.<br>• The controller validates all flow modifications against the OpenFlow classes that are registered.<br>• The controller replaces logical priorities with actual priorities for all applications. |

## 3.14.3 OpenFlow classes display details

The OpenFlow classes screen displays the OpenFlow classes that are currently registered with the controller:

| Screen component | Description |
|---|---|
| **Refresh** | Refreshes the list. |
| **Flow Class ID** | The symbolic name for the flow class. The prefix identifies the application that registered the class; the suffix uniquely identifies the class. |
| **Priority** | The actual priority the controller assigns to flows of this class. |
| **Cookie** | The base value of the cookie assigned to this OpenFlow class. The application that registered this class must use this base cookie when constructing flows that belong to this class. |
| **Match Fields** | The types of match fields that are expected to be specified in flows that belong to this class. |
| **Actions** | The general category of the action or instruction a flow that belongs to this class is expected to include. For a list of categories, see "About OpenFlow classes" (page 49). |
| **Description** | Short description of what the OpenFlow class does. The application describes the OpenFlow class when it registers the class with the controller. |

### 3.14.4 Changing the enforcement levels for OpenFlow classes

To change the enforcement level the controller applies to applications sending flows to switches, change the value for the `flow.mod.enforcement` key of the `com.hp.sdn.ctl.of.impl.ControllerManager` configuration component.

For more information about configuration components, see "Configurations screen" (page 25).

For information about the enforcement levels the controller can apply, see "Controller enforcement levels for OpenFlow classes" (page 50).

## 3.15 Packet listeners display

The controller applications (and SDN applications) register packet listeners with the controller. The order of processing an incoming packet is determined by the roles (Advisor, then Director, then Observer), and then altitudes within a role (in decreasing value, with 0 the lowest altitude). An incoming packet (OpenFlow Packet-In message) is wrapped in a Message Context (which also holds a Packet-Out reply) which is passed to each packet listener in turn.

### 3.15.1 Packet listeners display details

The packet listeners screen displays the packet listeners that are currently running on the controller.

<table>
<tr><th>Screen component</th><th>Description</th></tr>
<tr><td>Refresh</td><td>Refreshes the information on the screen.</td></tr>
<tr><td>Role</td><td>The role of the packet listener. Roles are one of the following:
<table>
<tr><th>Role</th><th>Description</th></tr>
<tr><td><code>ADVISOR</code></td><td>Examines the incoming packet. Might add processing hints to the message context, but does not modify the packet out message.</td></tr>
<tr><td><code>DIRECTOR</code></td><td>Processes the packet. Might add actions or instructions to the packet-out message. Can instruct the controller to block the packet, or to send the packet out.</td></tr>
<tr><td><code>OBSERVER</code></td><td>A passive observer who might examine the incoming packet and any packet-out response.</td></tr>
</table>
Packets are given to packet listeners with role of <code>ADVISOR</code> first, <code>DIRECTOR</code> second, and <code>OBSERVER</code> third. Every packet listener is guaranteed to see the packet-in message. Depending on the action taken by higher altitude Directors, a lower altitude Director may be too late to influence the packet processing.</td></tr>
<tr><td>Altitude</td><td>The weight or priority this packet listener should have relative to other packet listeners that have the same role. The controller gives packet listeners with higher numbers priority over packet listeners with lower numbers.</td></tr>
<tr><td>Average (ms)</td><td>The average time, in milliseconds, that the packet listener spent processing a packet.</td></tr>
<tr><td># Samples</td><td>The number of packets processed by that packet listener since the packet listener registered.</td></tr>
</table>

# 4 License Registration and Activation

## 4.1 Overview

**NOTE:** SDN applications can require licenses that are separate from the licenses for the controller. Typically, you must have both a license for the controller and a license for each application. For HP SDN applications, you register the license, obtain the license key, and activate the license on the controller using the same methods you use to register and activate controller licenses. For information about obtaining license keys for an application, see the administrator guide for the application.

### 4.1.1 License registration and activation process

**NOTE:** To maintain license registration and activation across an HP VAN SDN Controller software update, refer to "License types, usage, and expiration" (page 52).

After you have downloaded and installed the controller software, as described in the *HP VAN SDN Controller Installation Guide*, you can begin the license registration and activation process. The basic steps are:

1. Preparing for license registration and activation:
   a. Verify registration prerequisites
   b. Identify the Install ID displayed in the controller GUI.
2. Registering and activating a license:
   a. Use the HP My Networking portal to enter your order information, register a license, and obtain a license key
   b. Use the license key to activate the license on the controller
3. Managing licenses:
   - Transfer licenses:
     1. Uninstall licenses to prepare for transfer
     2. Transfer licenses to a new platform
     3. Use new license keys to activate the licenses on the target controller.

### 4.1.2 License types, usage, and expiration

The following licenses are available for the HP VAN SDN Controller:

- **High Availability "Add Controller" license** (HP VAN SDN Ctrl HA E-LTU)—Enables the controller to form a team for increased availability. The following guidelines apply:
- ◦ The minimum number of team members for an HP VAN SDN Controller team is three.
  ◦ When forming a team, only one HP VAN SDN Controller base license is required, along with at least two High Availability licenses, all on the same Master controller. Once a team is formed, Add Nodes licenses can be added to the team leader for increased support. In addition, you must:
    – Use non-previously licensed controller installations to form the team.
    – Use a new hardware platform (or Virtual Machine) with a new installation of the HP VAN SDN Controller.
    – Run the same software version on all controllers.
- **Application Licenses**—Refer to the administrator guide for the specific application.

# 4.2 Preparing for license registration

## 4.2.1 Verifying registration prerequisites

Before beginning the license registration and activation process, be sure you have:

- Obtained an HP **My Networking** portal user account.
- Obtained the order number or product registration ID, and e-mail address from your HP VAN SDN Controller license order confirmation.
- Installed the HP VAN SDN Controller software and have the controller running, as described in the *HP VAN SDN Controller Installation Guide*.

## 4.2.2 Identifying the install ID

Each controller installation generates a unique Install ID that is used for licensing activities.

To view the Install ID using the UI, select **Licences** from the navigation menu. In the **Licenses** screen, the Install ID appears before the list licenses.

# 4.3 Registering and activating a license

Using your Install ID, you must now register your license on the **My Networking** portal. Doing this results in a license key, which enables you to activate the license on the controller.

**NOTE:** If you are registering licenses in addition to the base controller license, HP recommends you do so in the following order:

1. Register the base controller license.
2. Register any Add Nodes licenses, and then activate the last license key generated.
3. Register any High Availability licenses, and then activate the last license key generated.
4. Register any application licenses you have acquired.

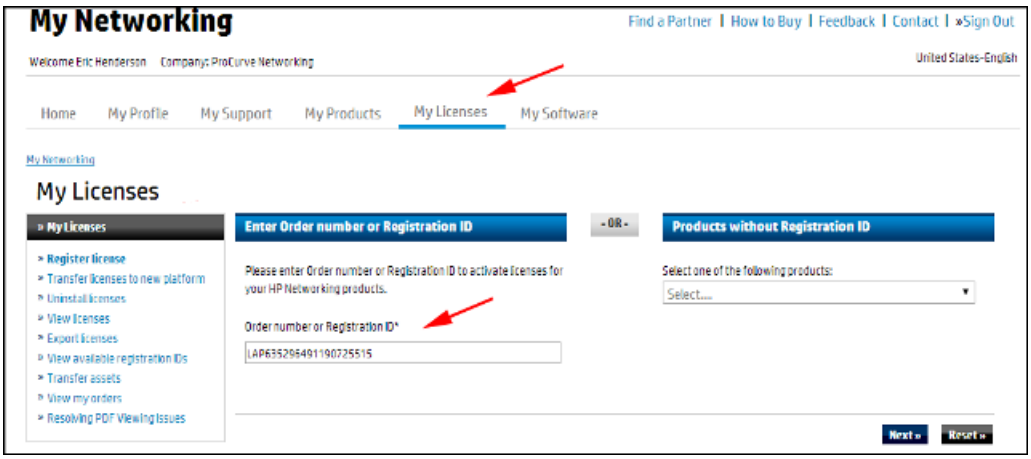
# 4.4 Registering your license and obtaining a license key

To register your license and obtain a license key:

1. Log on to the **My Networking** portal at http://www.hp.com/networking/mynetworking.
2. Select **My Licenses**.

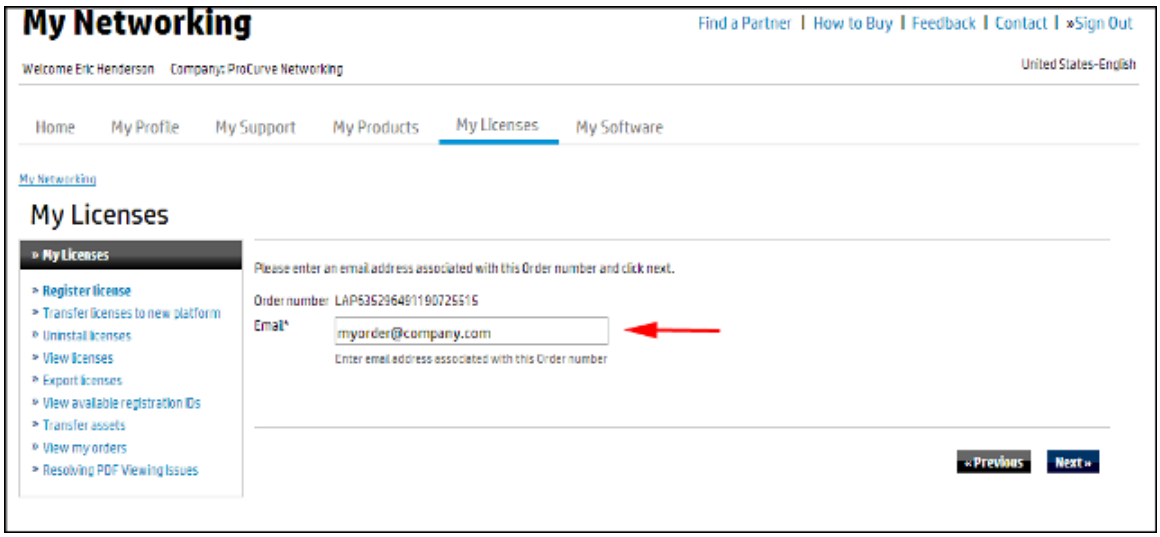
   Locate the **Order number or Registration ID** field, as shown in Figure 25 (page 53).

**Figure 25 Entering an order number or registration ID**



3. Enter your order number or registration ID in the field provided (above), and then click **Next**.
   - If you enter a registration ID, go to "step 5" (page 54).
   - If you enter an order number, the `Email` field appears, as shown in Figure 26.

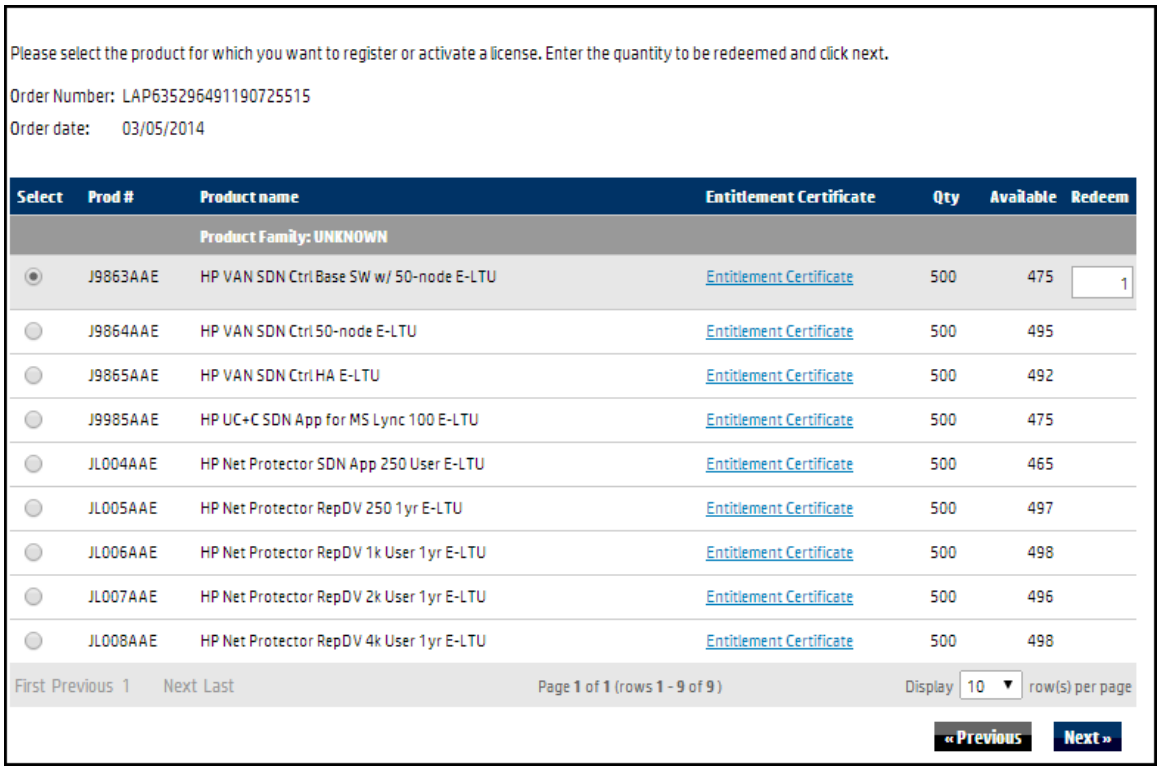
**Figure 26 Entering an e-mail address**




4. In the **Email** field, enter either the "Ship to" or "Sold to" e-mail address listed in your sales order confirmation, and then click **Next**.

   A license selection screen appears, as shown in Figure 27.

**Figure 27 Selecting licenses**



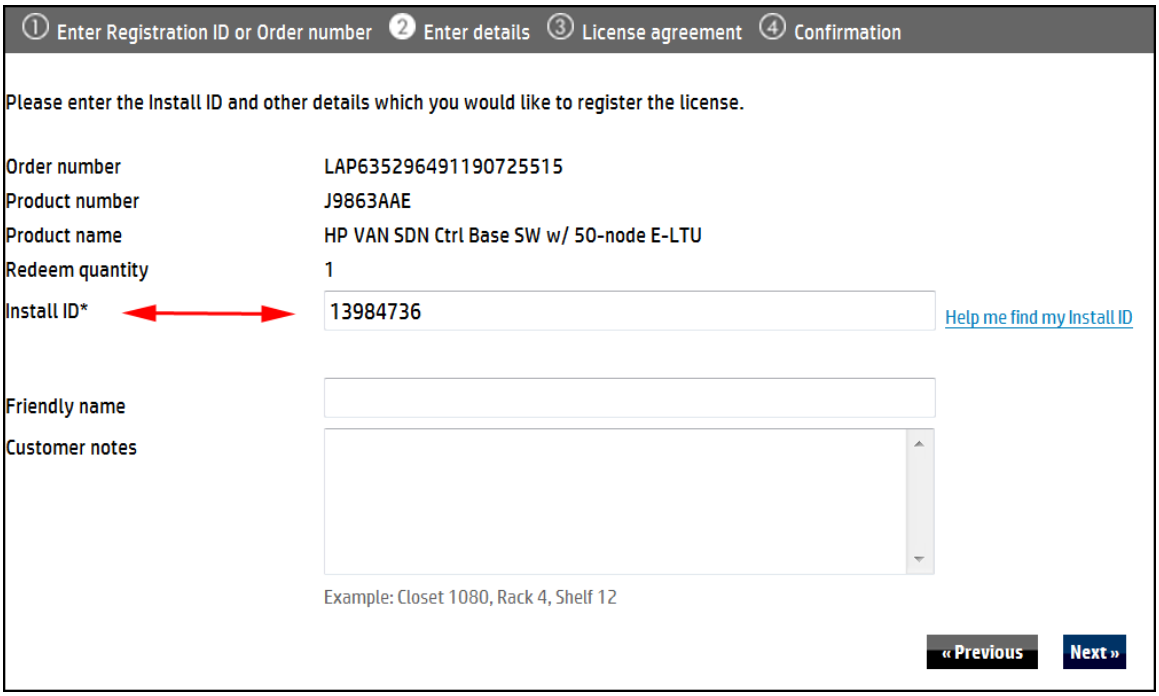

5. Select the license type, enter the quantity to be registered to your Install ID, and then click **Next**.

**NOTE:**

- For an **HP VAN SDN Ctrl Base SW w/ 50–node E-LTU** license, the quantity must be 1.
- For **HP VAN SDN Ctrl 50–node E-LTU** or **HP VAN SDN Ctrl HA E-LTU** licenses, quantity is the number of licenses to be installed with a single Install ID.
- For information on using this process for an application license, see the administrator guide for that application.

The registration details screen appears, as shown in Figure 28.

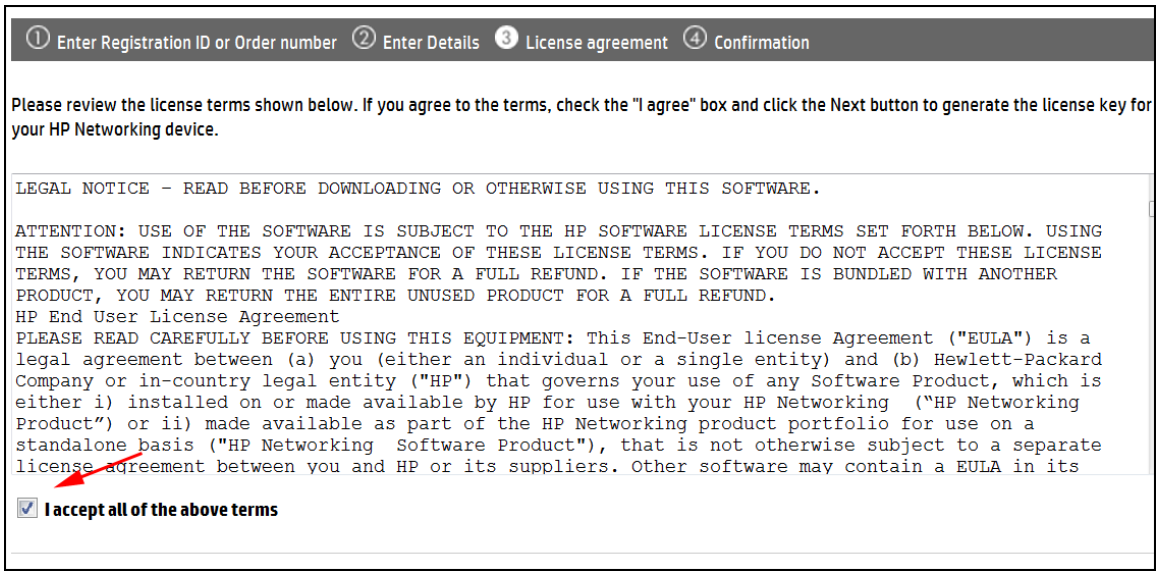
**Figure 28 Entering the install ID**




6. In the **Install ID** field, enter your Install ID number. (See "Identifying the install ID" (page 53).
7. Optional: Enter a **Friendly name** and **Customer notes** for this license.
8. Click **Next**.

   The end user software license agreement screen appears, as shown in Figure 29.

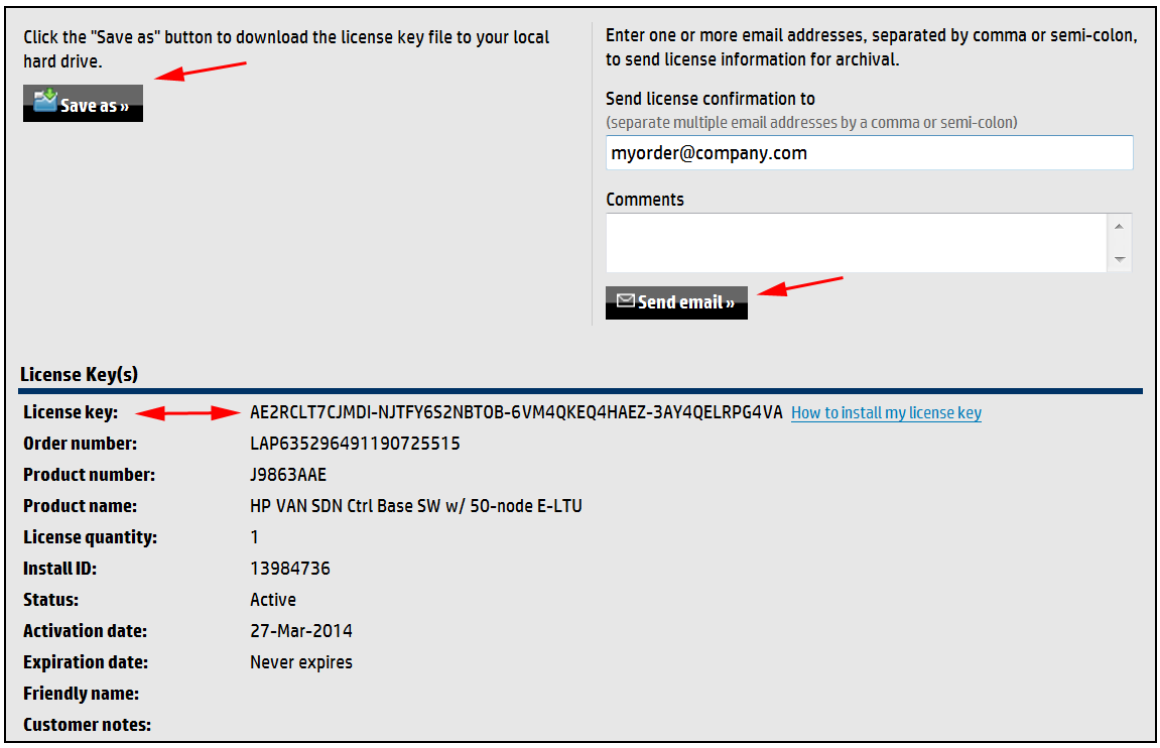
### Figure 29 Accepting the license agreement




9. To continue after reading the license agreement, select **I accept all of the above terms**, and then click **Finish**.

   The confirmation screen appears, as shown in Figure 30.

### Figure 30 Reviewing your registration



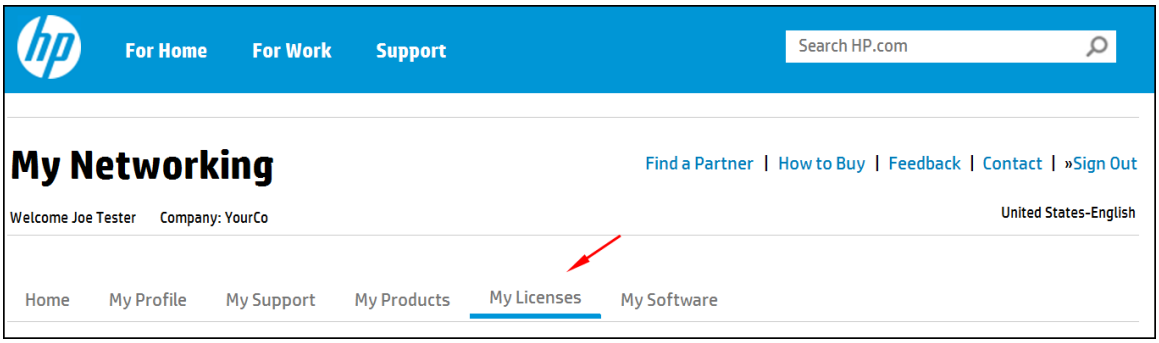

10. Review your license registration details, and record the **License key** listed.
11. Optional: To download the license key file, click **Save as**, and then save it to your local hard drive.

12. Optional: To e-mail the registration details:
    a. Enter one or more e-mail addresses, separated by a comma or semi-colon in the field provided.
    b. Optional: Enter **Comments** about this license.
    c. Click **Send email**.
13. Optional: If you want to register additional licenses for this order:
    a. Click **Register more for this order** to return to the license selection screen shown in Figure 27.
    b. Repeat steps "5" (page 54) through 13 until you have registered all licenses.

To view your license information:

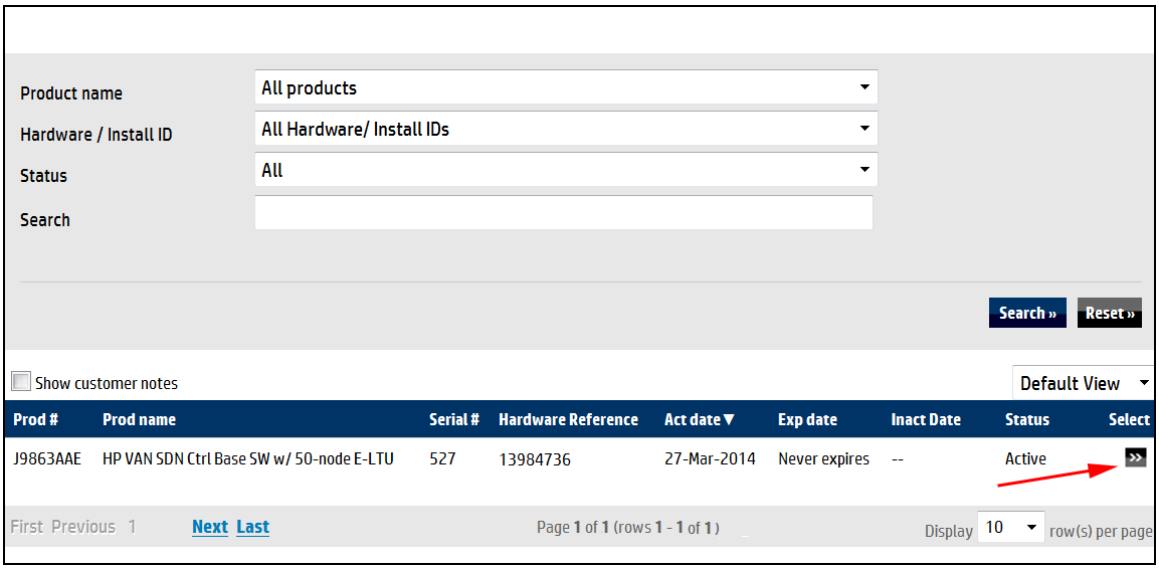
1. Click on **My Licenses** on the **My Networking** portal.

**Figure 31 My Licenses tab**




2. Click on **View Licenses** to see a screen similar to the following.

**Figure 32 Viewing licenses**




3. To view the information for the license you just loaded, click on the Select button for that license. You will then see a screen similar to the following:

Figure 33.

Figure 33 Viewing your license and other information


Record the license key in the above screen for use when you activate the license on the controller.

## 4.5 Activating a license on the controller

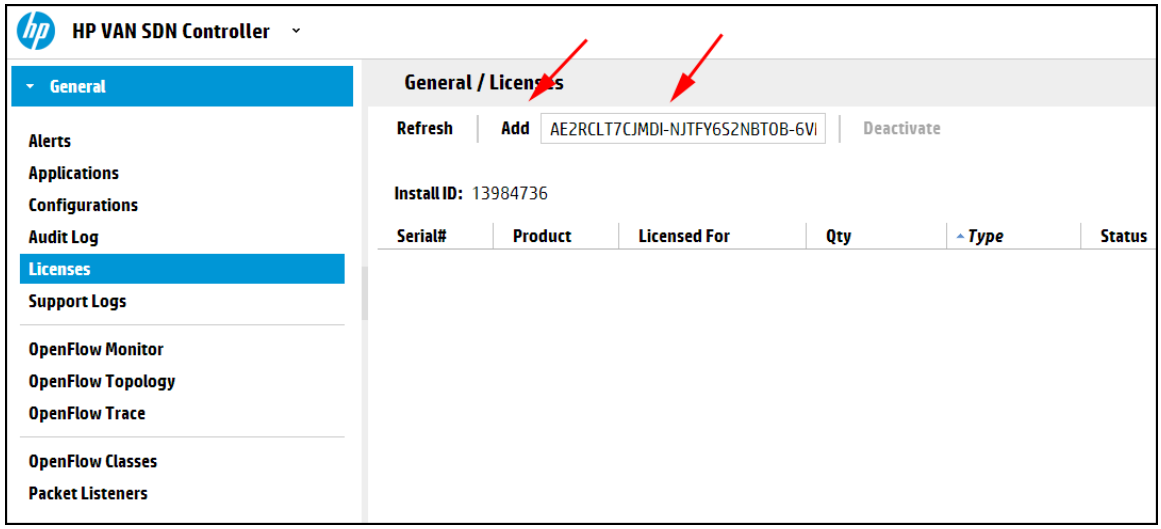
To activate a license on the controller, you must add the license key. If the controller has no licenses listed, enter the license key for the HP VAN SDN Ctrl Base SW w/50–node E-LTU before you add any other license keys.

Use the following procedure to add and activate a license using the controller UI.

1. From the navigation menu, select **Licenses**.
2. On the **Licenses** screen, enter the license key you acquired in "Registering your license and obtaining a license key" (page 53) in the text box next to the **Add** button.

   Entering the key in the field enables the **Add** button.

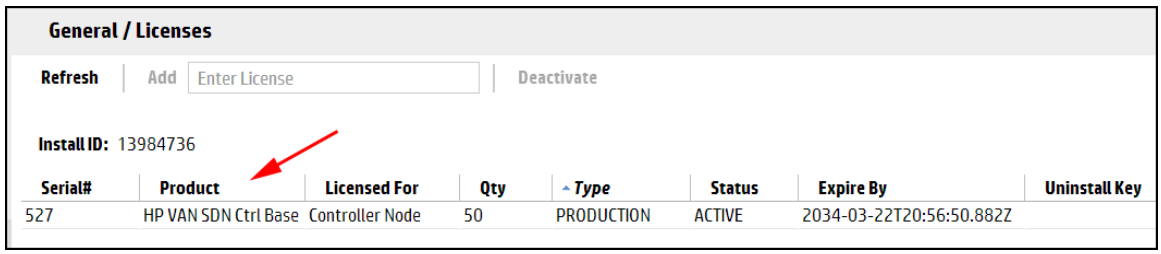
**Figure 34 Enter the License Key**




3. To activate the license, click on the **Add** button shown in Figure 34 (page 59).

   The active license is displayed in the table below the Install ID and the **Add** button is greyed out:

**Figure 35 Active License Displayed on License screen**




# 4.6 Managing licenses

## 4.6.1 Transferring licenses

You can transfer a license from one controller to another. To do so, you must first uninstall *all* licenses from the controller.

**NOTE:** Keeping a license on one controller while transferring one or more other licenses from the same controller to another controller is not permitted.

When upgrading to version 2.3, no special effort is required to preserve the licenses. Note that the license transfer mechanism is only required when you want to switch the SDN Controller currently running hardware. You must install the SDN Controller on the new hardware and transfer the licenses to that new hardware before retiring the old hardware.

### Before you transfer licenses

Before you transfer licenses, you must first:

- Uninstall all licenses, as described in "Uninstalling licenses to prepare for transfer" (page 60).
- Obtain an Install ID for each destination controller, as described in "Identifying the install ID" (page 53).

### 4.6.1.1 Uninstalling licenses to prepare for transfer

When you deactivate a license, the controller generates an Uninstall Key for that license, which you will need when you transfer the license. Be prepared to record the Uninstall Key for each license you deactivate. The Uninstall Key is a long text string. For example:

```
AE2RCLT7CJMDI-MAGAQHS2NBTOB-6VM4QKEQ4HAEZ-3AY4QELRPG4AA-3EMHQELRPGAYQ
```

To uninstall a license using the controller UI, use the following procedure.

1. From the navigation menu, select **Licenses**.
2. Select the license to uninstall.
3. Click **Deactivate**.

   Click **OK** when the deactivation prompt appears:
4. Record the Uninstall key appearing in the **Uninstall Key** field for that license.
5. Repeat the preceding steps for each of the remaining licenses on the controller.

### 4.6.1.2 Transferring licenses

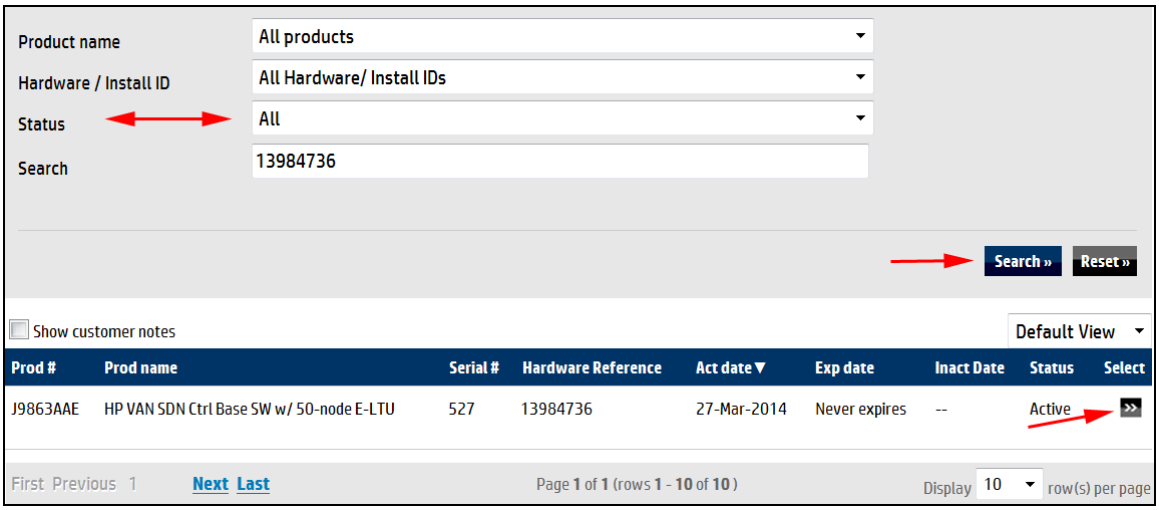
After you have uninstalled all of the licenses for a controller, you can transfer them to another controller.

To transfer licenses:

1. Log on to the **My Networking** portal at http://www.hp.com/networking/mynetworking.
2. From the **My Licenses** section, select **Transfer licenses to a new platform**.
3. In the **Search** field, enter the Install ID for the controller from which you uninstalled the license, and then click **Search**.

   The transfer license screen displays a list of associated licenses, as shown in Figure 36.

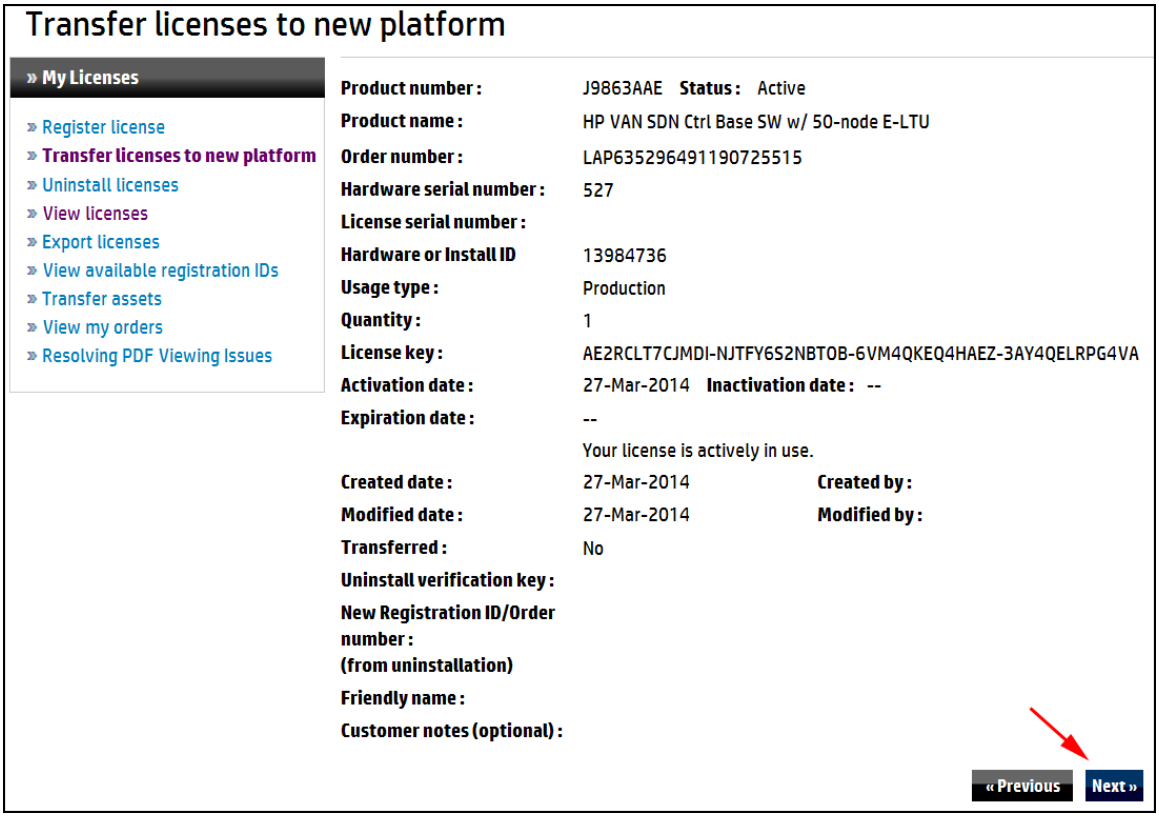
**Figure 36 Selecting licenses to transfer**




4. Click the **Select** icon next to the license to be transferred.

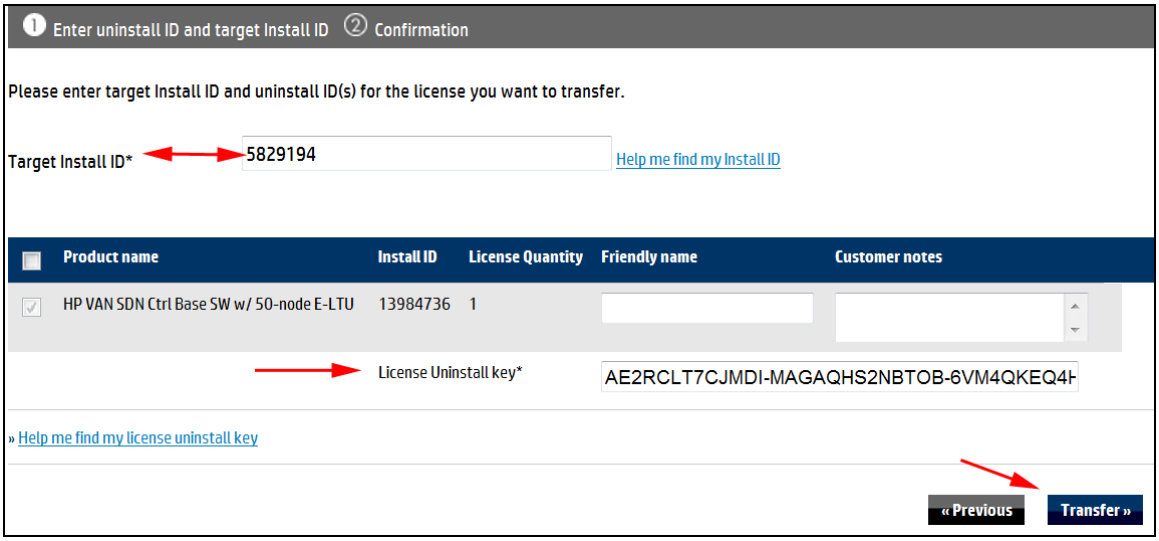
   The license details screen appears, as shown in Figure 37.

### Figure 37 Reviewing details before transfer




5. Verify that this is the license you want to transfer, and then click **Next**.
   The target install ID screen appears (Figure 38).

### Figure 38 Entering target install and uninstall IDs



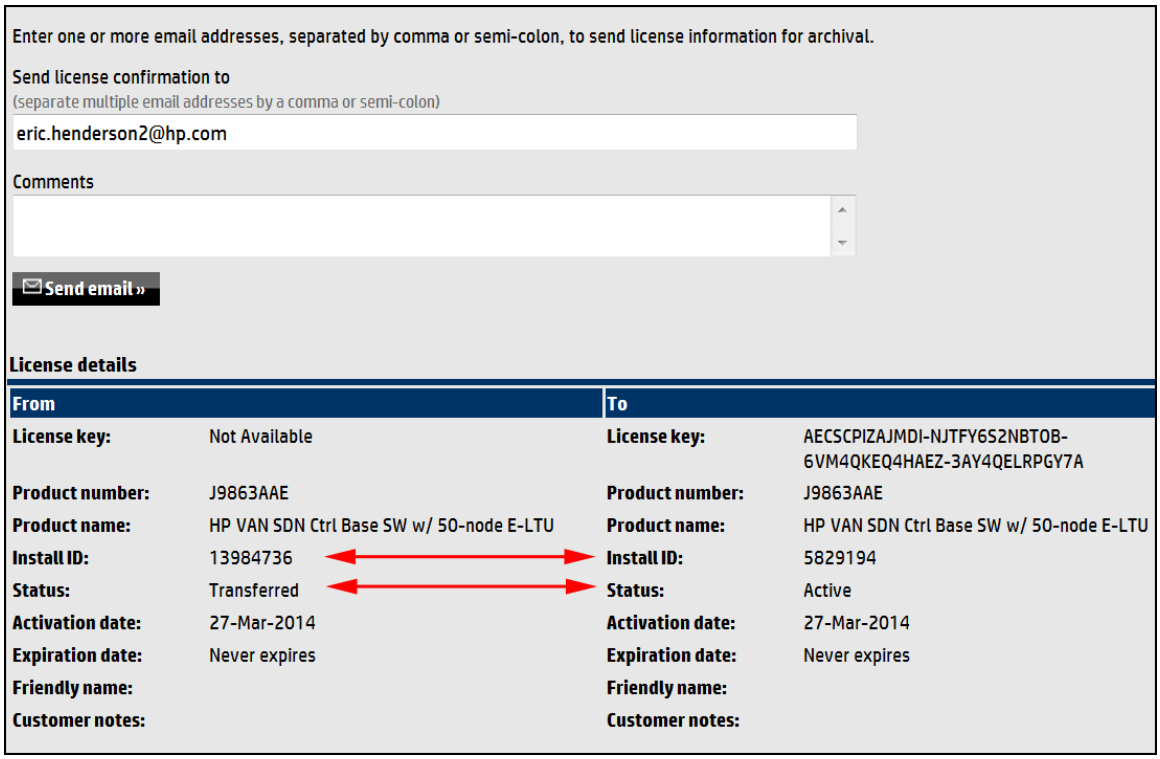

6. In the screen in Figure 38, do the following:
   1. In the **Target Install ID** field, enter the Install ID of the controller to which you want to transfer the license.
   2. In each Uninstall field, enter a license uninstall key. (For more on acquiring uninstall keys, see Section 4.6.1.1.)

**NOTE:** In order for the transfer process to succeed, you must enter an **Uninstall** value for every registered license.

3. Click on the **Transfer** button in the lower-right corner of the screen.

New license registration information displays on the license transfer confirmation screen and license details screen, as shown in Figure 39.

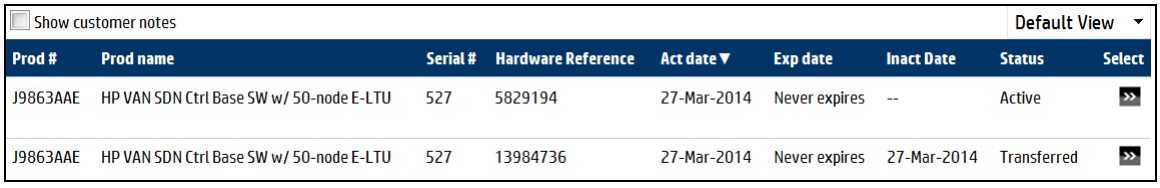
### Figure 39 Viewing license transfer confirmation and details screens




7. Review the confirmation screen details.
8. For each license you are transferring, record the new license key so that it will be available when you add and activate the license on the new controller.
9. Optional: To e-mail transferred license details:
   a. Enter one or more e-mail addresses, separated by a comma or semi-colon in the field provided.
   b. Optional: Enter **Comments** about this license transfer.
   c. Click **Send email**.

The license screen displays the status of the original licenses as **Transferred**, and the new Install IDs as **Active**, as shown in Figure 40.

### Figure 40 Review transferred license status screens




To register the transferred licenses on the new controller, see "Activating a license on the controller" (page 58).

# 5 SDN Controller authentication

## 5.1 SDN Controller security guidelines

The HP VAN SDN controller communicates with different components, both internal and external to the controller, via secure channels. This section documents these channels, their defaults, and how to configure them in a deployment environment.

## 5.2 SDN Controller authentication

The SDN Controller identifies itself via Public-Key Infrastructure (PKI) for its communication with external subsystems and other controllers. It uses a Java keystore and truststore to keep its private key and public key respectively. For REST APIs, the controller does *not* rely on the truststore to establish trust. Instead, it uses token authentication to authenticate the client. The client must present a valid token via the *X-Auth-Header* to authenticate itself with the controller. Token authentication is discussed more under "SDN Controller keystore and truststore locations and passwords " (page 64).

The controller ships with a self-signed certificate. Therefore, it is recommended that the self-signed certificate be replaced by a certificate signed by a reputable Certificate Authority (CA). Also, the default password for the keystore and truststore should be changed as well.

## 5.3 Creating SDN Controller keystore and truststore

1. Login to the system running the SDN Controller and stop the controller.
2. As the SDN user (i.e. `sudo - sdn`), do the following:
3. Back up your default `/opt/sdn/admin/keystore` and `/opt/sdn/admin/truststore` to a safe location.
4. Create a new keystore using the following commands:

   ```
   cd /opt/sdn/admin
   ```

   ```
   rm keystore truststore
   ```

   ```
   keytool -genkey -alias serverKey -keyalg rsa -keysize 2048 -keystore keystore
   ```

   You must specify a fully qualified domain for your server for the "first and last name" question as some CAs, such as VeriSign, expect it.
5. Generate a CSR (Certificate Signing Request) for signing:

   ```
   keytool -keystore keystore -certreq -alias serverKey -keyalg rsa -file sdn-server.csr
   ```
6. Send the `sdn-server.csr` to a CA to be signed.

   The CA will authenticate you and return a signed certificate and its CA certificate chain. We assume the signed certificate from the CA is named `signed.cer` and the CA's certificate is `root.cer`. If `root.cer` is from your own internal CA, then you need to import `root.cer` into your browser as an authority.
7. Import the signed root certificate into your keystores:

   ```
   keytool -importcert -trustcacerts -keystore keystore -file root.cer -alias CARoot
   ```

   ```
   keytool -importcert -trustcacerts -keystore truststore -file root.cer -alias CARoot
   ```

8. Replace your self-signed certificate in your `serverKey` entry with the signed certificate from your CA (`signed.cer`).

   ```
   keytool -importcert -keystore keystore -file signed.cer -alias
   serverKey
   ```

9. If you are operating a team of controllers in your environment, turn off self-signing for inter-controller communication:

   Under /opt/sdn/virgo/repository/usr, change the "selfsigned" value to *false* for the following component:

   `com.hp.sdn.misc.ServiceRestComponent.properties`

10. If you set up a different password than the default "skyline" password for your keystore, you will need to edit `/opt/sdn/virgo/configuration/tomcat-server.xml` and change the `keystorePass` value in the `<Connector port="8443"…>` tag to the new keystore password.
11. Start the controller. Continue to the next section if you are using a different keystore and truststore password than the default "skyline" password.

## 5.4 SDN Controller keystore and truststore locations and passwords

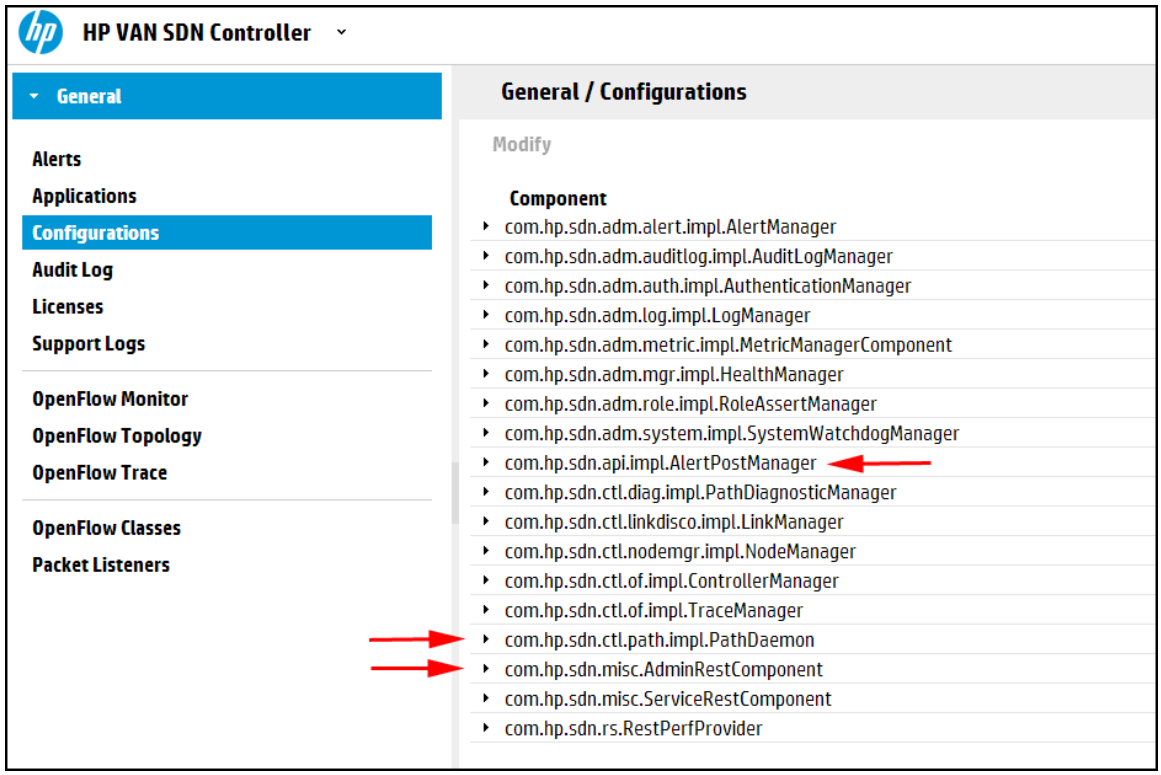
The SDN Controller keystore and truststore are referenced by several components, and thus need to be updated for these components:

- `com.hp.sdn.api.impl.AlertPostManager`
- `com.hp.sdn.misc.AdminRestComponent`
- `com.hp.sdn.misc.ServiceRestComponent`

To change these configuration of these components:

1. From the navigation menu, select **Configurations**.
2. Select one of the three components listed above.
3. Select **Modify**.
4. Repeat for the other two components.

Figure 41 Components that reference controller keystore and truststore




The values for keystore and keystore.password contain the keystore location and encrypted keystore password respectively. The values for truststore and truststore.password contain the truststore location and encrypted truststore password respectively.

## 5.5 Configuration encryption

Sensitive information such as tokens and passwords are stored encrypted on the SDN Controller. However, to encrypt and decrypt these properties, the controller requires a master key that is passed into the controller upstart script via an environment variable. To change the default master key (recommended):

1. First, stop these services:

   ```
   sudo service sdnc stop
   sudo service sdna stop
   ```

2. Then change the default master key:

   ```
   sudo /opt/sdn/admin/sdnpass old_master_key new_master_key
   ```

## 5.6 Openflow Controller TLS

The Openflow controller component relies on PKI to establish mutual trust (2-way SSL) between itself and the Openflow switches that it manages. It is recommended that the Openflow keystore and truststore used for Openflow switch communication be separate from the SDN Controller's keystore and truststore used for north-bound communication.

### 5.6.1 Creating Openflow Controller keystore and truststore

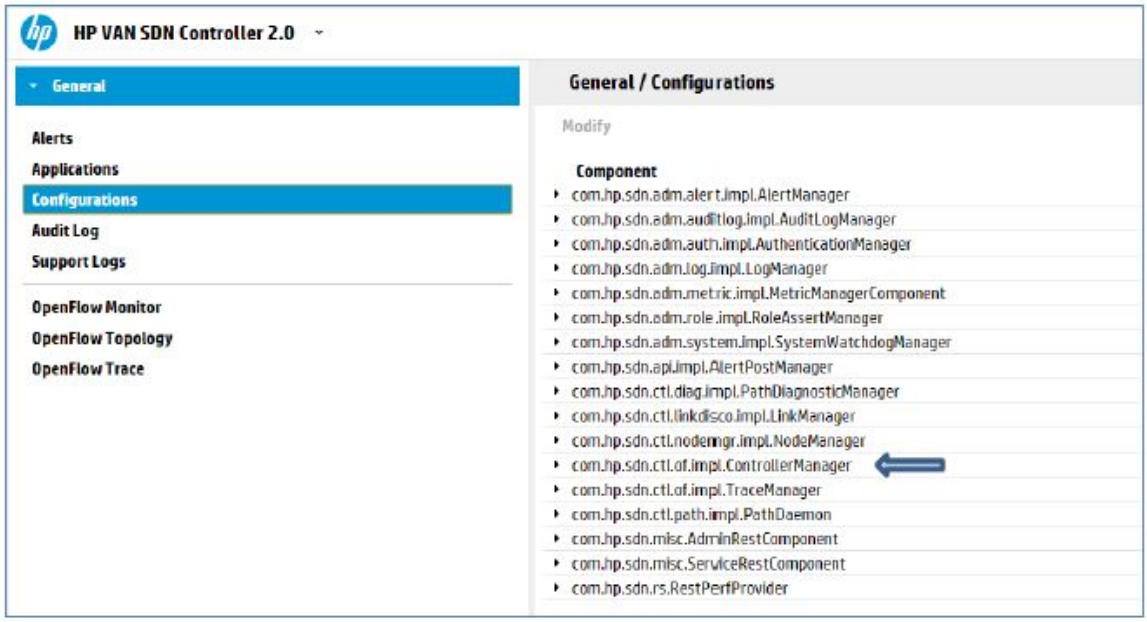
The process for creating the Openflow keystore and truststore is similar to the steps outlined under "Creating SDN Controller keystore and truststore" (page 63), and therefore is not repeated here. The store names for both the Openflow keystore/truststore and the SDN Controller's keystore/truststore should be different. Please note that both the Controller and Device certificates

must be signed by the **same** CA, so that the TLS connection will be established. See your switch's manual for information about configuring TLS on your switch.

### 5.6.2 Openflow Controller keystore and truststore locations and passwords

The Openflow Controller's configurations for keystore/truststore are located in the com.hp.sdn.ctl.of.impl.ControllerManager configuration. The keystore and keystore.password properties capture the location of the keystore and the password of the keystore respectively. Similarly, the truststore and truststore.password capture the location of the truststore and the password of the truststore respectively.

**Figure 42 Components that reference OpenFlow keystore and truststore**




A controller restart is required if these configurations are changed.

## 5.7 REST authentication

The SDN Controller relies on token-based authentication to authenticate its REST APIs. In other words, all REST APIs except the /auth and /rsdoc APIs require an authentication token embedded in an "X-Auth-Token" header to be included with each REST request. The /auth API allows you to obtain a token, while the /rsdoc API provides live REST API documentation information about the controller's REST API. The next section describes how to obtain a token from the /auth API.

### 5.7.1 Openstack Keystone

The SDN Controller uses Openstack Keystone as an identity management for managing users, generating tokens, as well as token validation. Upon installation, the SDN Controller creates the following users and roles:

- User: sdn – This is the primary user that operates different SDN REST and UI operations. The sdn user has roles sdn-user and sdn-admin.
- User: rsdoc – This is the primary user that is associated with API documentation operations. The rsdoc user has sdn-user role.
- The Keystone version in use is based on the Folsom release. If a later Keystone version is in use:
  - Ensure that it supports the Keystone v2.0 REST API.
  - Configure the token provider to use the UUID token (instead of PKI tokens). This is configurable via /etc/keystone/keystone.conf.
  - For keystone configuration details, see:
    http://docs.openstack.org/developer/keystone/configuration.html

The SDN Controller currently does not enforce role-based permissions (RBAC); however, it may do so in the future. Also, applications installed on the SDN Controller may choose to enforce RBAC per their security requirements.

To authenticate, one needs to present username/password to the /auth API as below (using curl as an example):

```
curl -sk -H 'Content-Type:application/json' -d
'{"login":{"user":"sdn","password":"password","domain":"sdn"}}'
https://<controller-ip>:8443/sdn/v2.0/auth
```

**CAUTION:** Credential information (user name, password, domain, and authentication tokens) used in cURL commands may be saved in the command history. For security reasons, HP recommends that you disable command history prior to executing commands containing credential information.

The above call returns this example JSON data structure that includes the authentication token, which, by default, expires in 24 hours:

```
{
"record": {
"domainId": "62e312edff47413fad7e1d7fa6ac7bc7",
"domainName": "sdn",
"expiration": 1377917359000,
"expirationDate": "2013-08-30 19-49-19 -0700",
"token": "54a6f80a9ae243db89bfa05de4ced51d",
"userId": "bca3dea8a28b457e99e899ae16b79634",
"userName": "sdn"
}
}
```

**CAUTION:** Please guard this token information, as it can be used as an API key to gain access to your SDN Controller REST APIs.

To gain access to the REST API, include the token in the X-Auth-Token header as in the following curl example:

```
curl -sk -H "X-Auth-Token:54a6f80a9ae243db89bfa05de4ced51d"
https://controller-ip:8443/sdn/v2.0/systems
```

One can continue using the same token for different SDN Controller APIs within the default 24-hour period since token creation. If desired, one can change this default 24-hour timeout in the `/etc/keystone/keystone.conf` file. (See the *OpenStack Keystone Administration Guide* for more information). The `CachedTokenTTL` value under the configuration properties `com.hp.sdn.adm.auth.impl.AuthenticationManager` needs to match the timeout set by Keystone as well to allow efficient caching of tokens.

### 5.7.2 Service and admin tokens

The Service token is used for internal communication between controllers and is not exposed to the user. Likewise, the Admin token is used for the communication between the controller and the Keystone server and is not exposed to the user.

That said, the values for these tokens can be changed via the UI under the Configurations for AuthenticationManager. Note that for the Service token, all controllers in a team must have the same Service token to communicate successfully. Likewise, for the Admin token, both the controller token value and the Openstack Keystone "admin_token" in */etc/keystone/keystone.conf* must match for authentication to work.

## 5.8 Controller code verification

All controller code is signed by HP. Validating the certificate via jarsigner should return an HP X.509 certificate similar to the following:

```
X.509, CN=Hewlett-Packard, OU=HPGlobal, OU=Digital ID Class 3 - Java
Object Signing, O=Hewlett-Packard, L=Andover, ST=Massachusetts, C=US
[certificate is valid from 11/14/12 4:00 PM to 11/15/14 3:59 PM]
X.509, CN=VeriSign Class 3 Code Signing 2010 CA, OU=Terms of use at
https://www.verisign.com/rpa (c)10, OU=VeriSign Trust Network,
O="VeriSign, Inc.", C=US
[certificate is valid from 2/7/10 4:00 PM to 2/7/20 3:59 PM]
[CertPath not validated: null]
```

If a controller jar or war file is tampered with, the jar verification fails, and the container does not start up.

If an application is not signed by HP, or has its certificate trusted by the controller (see section below), the application is not allowed to run on the controller.

### 5.8.1 Adding certificates to the jar-signing truststore

To deploy other signed applications onto the controller, use the Java keytool to import the public certificate that was used to sign the application jars and/or zips into the controller jar-signing truststore (`/opt/sdn/admin/sdnjar_trust.jks`):

```
keytool -importcert -keystore /opt/sdn/admin/sdnjar_trust.jks -file
signed_app.cer -alias mysignedcert
```

The controller needs to be restarted for the new truststore to take effect.

### 5.8.2 Running the SDN Controller Without Jar-Signing Validation

The SDN Controller enforces jar-signing validation by default. For an experimental/development environment where unsigned applications need to be deployed, jar-signing validation can be turned off altogether:

1. Use the following command to stop the SDN Controller:

   ```
   sudo service sdnc stop
   ```

2. Modify the `/opt/sdn/virgo/bin/dmk.sh` script to add the following option to the list of `JMX_OPTS`:

   `-Dsdn.signedJar=none`

   For example:

```
cd $KERNEL_HOME; exec $JAVA_EXECUTABLE \
$JAVA_OPTS \
$DEBUG_OPTS \
$JMX_OPTS \
-XX:+HeapDumpOnOutOfMemoryError \
-XX:ErrorFile=$KERNEL_HOME/serviceability/error.log \
-XX:HeapDumpPath=$KERNEL_HOME/serviceability/heap_dump.hprof \
-Dsdn.signedJar=none \
-Djava.security.auth.login.config=$AUTH_LOGIN \
-Dorg.eclipse.virgo.kernel.authentication.file=$AUTH_FILE \
```

3. Start the SDN Controller:

   `sudo service sdnc start`

To enable jar-signing validation, remove the line containing the `-Dsdn.signedJar=none` option from the `/opt/sdn/virgo/bin/dmk.sh` script and restart the controller.

## 5.9 Revoking Trust

### 5.9.1 Revoking trust via truststore

The controller components rely on the public certificates in the respective truststore to establish trust with a given identity. Therefore, revoking trust from a client with a given public certificate amounts to removing its certificate from the respective truststore. To remove a given certificate from the truststore:

- List the certificates in your truststore:

  `keytool –list –v -keystore truststore [-storepass password]`

- Delete certificate from truststore:

  `keytool –delete –alias cert-aliastruststore`

### 5.9.2 Revoking trust via CRL

For the controller's REST API, a CRL (Certificate Revocation List) may also be specified to allow blacklisting of certain clients. This is done by modifying the `/opt/sdn/virgo/configuration/tomcat-server.xml` file to include the CRL file location in the SSL connector:

```
<Connector port="8443" protocol="HTTP/1.1" SSLEnabled="true"
maxThreads="150" scheme="https" secure="true"
clientAuth="false" sslProtocol="TLS"
keystoreFile="../admin/keystore"
keystorePass="skyline"
crlFile="location_of_CRL file"/>
```

For the change to take effect, restart the controller.

## 5.10 SDN administrative REST API

The main SDN Controller daemon (SDNC) is accompanied by an ancillary daemon process (sdna), which runs under user sdnadmin in order to grant it access to some elevated privileges.

The administrative REST API can be used to securely perform various management functions in a privileged context. It would be undesirable for the main SDN Controller process to possess those privileges as it may be hosting execution of third-party code.

The SDN Administrator daemon can be accessed via the REST API vi HTTPS on port 8081. The access is secured through either token-based authentication or basic authentication, against the locally running keystone server, which is the same as the main SDN Controller REST API.

The following set of features are accessible through the administrative REST API:

- SDN Controller daemon (sdnc) stop/start/restart
- Adding/removing the team leader IP alias (required only when in team mode)
- Downloading the ZIP bundle of log files
- Uploading upgrade Debian bundles and installing/removing Debian packages
- Uploading upgrade ZIP bundles and executing upgrade commands
- System reboot

The install process adds a number of sudoers entries for the sdnadmin user. These are as follows:

- `/sbin/ifconfig`
- `/sbin/reboot`
- `/usr/bin/service`
- `/usr/bin/at`
- `/usr/bin/dpkg`

All, or any, of the above entries can be blocked or removed from the sudoers configuration. The `/sbin/ifconfig` entry is only required when running in teamed mode. Otherwise the controller cannot migrate the team IP address from node to node as team leader changes.

The sdna daemon can be completely disabled by stopping the daemon by using the `sudo service sdna stop` command and then removing the `/etc/init/sdna.conf` file.

## 5.11 Virgo admin UI access

The Virgo admin UI is configured to only be accessible via a local host. Access to this UI can be made via http://localhost:8080/admin. This should not be used under normal circumstances, but can be useful for debugging purposes.

To change the credentials of this console, get root console access to the machine(s) running the HP VAN SDN Controller and edit the following file:

`/opt/sdn/virgo/configuration/org.eclipse.virgo.kernel.users.properties`

This file includes the following two entries:

```
user.admin=sdn
role.admin=admin
```

where `role.admin` defines the user and `user.admin` defines the password. This file needs to be owned by `user:sdn`, `group:sdn`. Changes to this file require a restart of the controller to recognize the new credentials.

To disable access to the Virgo Admin UI, either remove the following file or move it to a safe location outside the pickup directory.

## 5.12 Virgo console access

This allows Virgo administrative access via ssh/telnet. This service is disabled by default. The following file configures these properties and requires the controller to restart to recognize the new settings:

```
/opt/sdn/virgo/pickup/
org.eclipse.virgo.management.console_3.6.2.RELEASE.jar
```

## 5.13 JMX console

The JMX console is only enabled for local access. This is used by the controller for metering and can also be used for debugging.

To enable JMX console remote access, edit `/opt/sdn/virgo/bin/dmk.sh`. The following line determines whether JMX allows remote access or not:

```
-Dcom.sun.management.jmxremote.local.only=true \
```

Any changes to this file require a controller restart to recognize the change.

## 5.14 Security practices

### 5.14.1 Security procedure

1. Update the following passwords:
   - Keystore
   - Truststore
   - Jarsigning
   - Admin Token
   - Service Token
   - Authentication Manager
2. Log into `http://<cont_IP>:/8443/sdu/ui` as the SDN user.
3. Select **Configurations**.
4. Select the component `com.hp.sdn.ctl.of.impl.AuthenticationManager`.
5. Select **Modify**.
6. Set the AdminToken to the newly chosen Keystore (authentication) admin token.
7. Set the ServiceToken to the newly chosen internal communication secret.
8. Set the KeystorePass to the value that you will be using to secure the SSL Keystore.
9. Set the TruststorePass to the value that you will be using to secure the SSL Truststore.
10. Update the Keystore Admin Token in the file `etc/keystore/keystore.conf`.

    Change the Admin Token from `admin_token=ADMIN` to `admin_token=<AdminTokenSetInControllerConf>`.
11. Update the Keystore password to match the password changed in Step 1 using the following:

    ```
    keytool-storepasswd-storepassskyline-
    new<KeystorePassFromControllerConfig>-keystore/opt/sdn/admin/keystore.
    ```
12. Update the Keystore's internal serverkey to match the keystore's password using the following:

    ```
    keytool-keypasswd-alias serverkey-storepass
    <KeystorePassFromControllerConfig>-keystore skyline-new
    <KeystorePassFromControllerConfig>-keystore/opt/sdn/admin/keystore.
    ```
13. Update the Truststore password to match the Truststore password in Step 1 using the following:

    ```
    keytool-storepasswd-storepass skyline-new
    foobar-keystore/opt/sdn/admin/truststore.
    ```
14. Update the jar signing keystore password (named sdnjar_trust.jks) using the following:

    ```
    keytool-storepasswd-storepass skyline-new
    <newpass4sign>-keystore/opt/sdn/admin/sdnjar_trust.jks.
    ```

    This password does not have to match the others.

15. Update `opt/sdn/virgo/bin/dmk.sh` to insert environment variables that set the sdnjar_trust.jks values in the controller.
    a. Under the line containing "XX-HeadDumpPath..." add `—DSDN.trustpas=<NEWPASS4SIGN>.`
    b. Restart the Keystone service (sudo service keystore restart).
16. Restart the controller.

## 5.14.2 Recommended administrative rules

Observing these rules can help to prevent unauthorized access to the controller:

- Do not enable shell history on your controller.
- Do not allow other users besides `sdn` and `sdnadmin` to have access to your controller system.
- Do not store your authentication token in plain text, such as a non-encrypted cookie.
- Do not use self-signed certificates in a production environment.
- Do not alter contents under `/opt/sdn/Cassandra` and `/opt/sdn/Hazelcast`.
- Do not delete any of the following `iptables` rules as shown below:

  ```
  iptables -L Chain INPUT (policy ACCEPT)
  ```

**Table 1 IP tables Rules**

| Target | prot opt source | Destination |
|---|---|---|
| REJECT | tcp –anywhere | anywhere tcp dpt:5700 reject-with icmp-port-unreachable |
| ACCEPT | tcp – 127.0.0.0/8 | anywhere tcp dpt:9160 |
| REJECT | tcp –anywhere | anywhere tcp dpt:9160 reject-with icmp-port-unreachable |
| ACCEPT | tcp – 127.0.0.0/8 | anywhere tcp dpt:7199 |
| REJECT | tcp –anywhere | anywhere tcp dpt:7199 reject-with icmp-port-unreachable |

# 6 Hybrid mode for controlling packet-forwarding

## 6.1 Overview

The hybrid mode setting determines which packet-forwarding decisions are made by controlled OpenFlow switches and which of these decisions are made by the controller itself.

- If hybrid mode is enabled (the default setting), the controller delegates normal packet forwarding to the controlled switches, but overrides these switches for non-standard packet-forwarding decisions required by installed applications for specific packet types. In this mode the controller relies on the controlled switches to resolve loops and determine forwarding paths by using traditional networking mechanisms (such as STP, OSPF).
- If hybrid mode is disabled, the controller makes the forwarding decisions for all packets in the OpenFlow-controlled network. In this state, the controller resolves network loops and determines forwarding paths.

Managing hybrid mode includes the following:

1. Viewing and (if needed) changing the hybrid mode configuration.
2. Coordinating the controller hybrid mode with the OpenFlow switch settings.

**NOTE:** In all cases, the controller only monitors or directs packets within OpenFlow instances. The controller cannot direct or monitor packets outside of OpenFlow instances.

**NOTE:** For information on the switches that support can be used with the controller when hybrid.mode is true, see the *HP VAN SDN Controller and Applications Support Matrix*.

## 6.2 Viewing and changing the hybrid mode configuration

1. Start the web interface on the controller.
2. Click on the Configurations tab.
3. Select the `com.hp.sdn.ctl.of.impl.ControllerManager` component.
4. Click on the Modify key.
5. Select the hybrid mode **Value** field.

**Figure 43 Open the Controller Manager configuration**

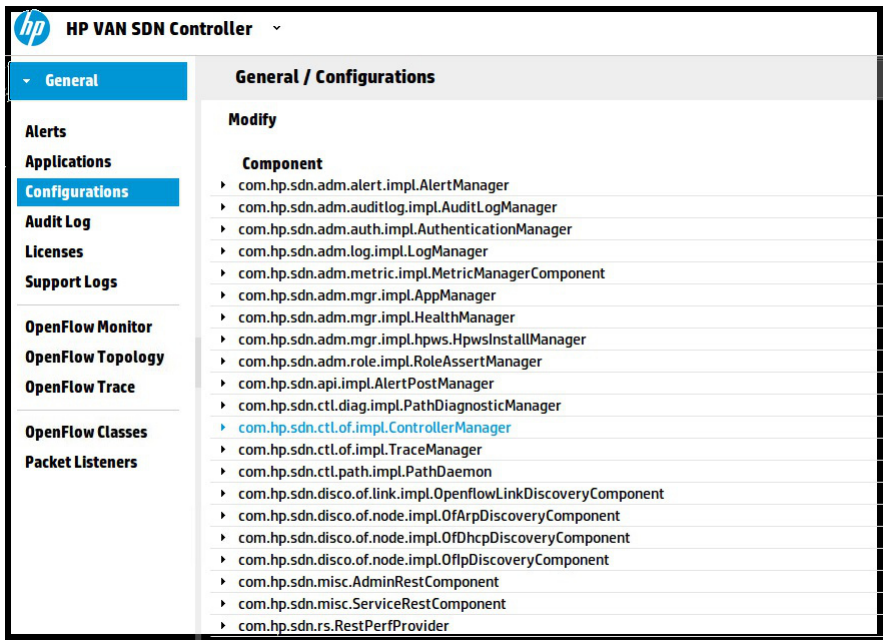
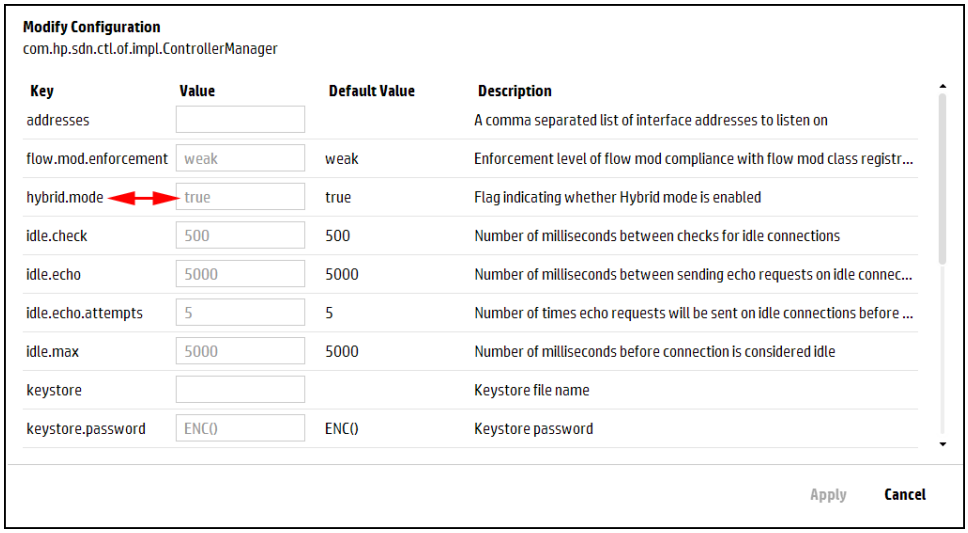


**Figure 44 Select the hybrid.mode Value field**




In Figure 44 (page 74), the hybrid.mode field shows the current setting. Continue with the following steps if you want to change the setting.

6. Set hybrid.mode to one of the following:
   - true (the default): Enables hybrid mode. The controller makes packet-forwarding decisions required by installed applications.
   - false: Disables hybrid mode The controller makes all forwarding decisions. (Release 2.0 of the HP VAN SDN Controller operates only in this mode – pure OpenFlow mode. )
7. Restart the controller. In a controller team environment, restart all controllers in the team.
   a. Close any instance of the web interface in which the controller may be running.
   b. Using the command prompt at the root access on the Ubuntu system (sudo), restart the controller with the following:

      ```
      ~$ sudo service sdnc restart
      ```

**NOTE:** In a controller team environment, a configuration change on one controller propagates to the other controllers on the team. However, to implement a hybrid mode configuration change, it is necessary to restart the controller. If the controller is operating in a team environment, it is necessary to restart each controller in the team, as described above.

**NOTE:** You can also use the REST API to set or reset hybrid mode. See the "configs REST API" section in the *HP VAN SDN Controller REST API Guide*

# 6.3 Coordinating controller hybrid mode and OpenFlow switch settings

## 6.3.1 Supporting hybrid mode on OpenFlow switches

The OpenFlow configuration on individual HP switches must support the controller hybrid mode setting. Table Table 2 (page 74) shows the correspondence between the hybrid mode configuration on the controller and the per-instance passive/active configuration on HP OpenFlow switches.

**Table 2 Hybrid mode support on ProVision switches**

| Hybrid Mode Settings | ProVision OpenFlow Instance Configuration |
|---|---|
| Enabled (true) | passive |
| Disabled (false) | active |

See the OpenFlow documentation for the specific switch.

See the latest OpenFlow documentation for HP switches for details on how to configure passive/active mode (where applicable) and for how such switches behave if they lose their control-plane connection to the controller.

### 6.3.2 Configuring controller settings to support hybrid mode

Network-related settings on the controller must agree with the controlled switches. Failure to achieve agreement between the controller's network-related settings and the settings in the controlled switches may result in unpredictable network behavior. Table 3 (page 75) lists the specific network-related controller settings that should agree with managed switches.

**Table 3 Controller settings to support hybrid mode**

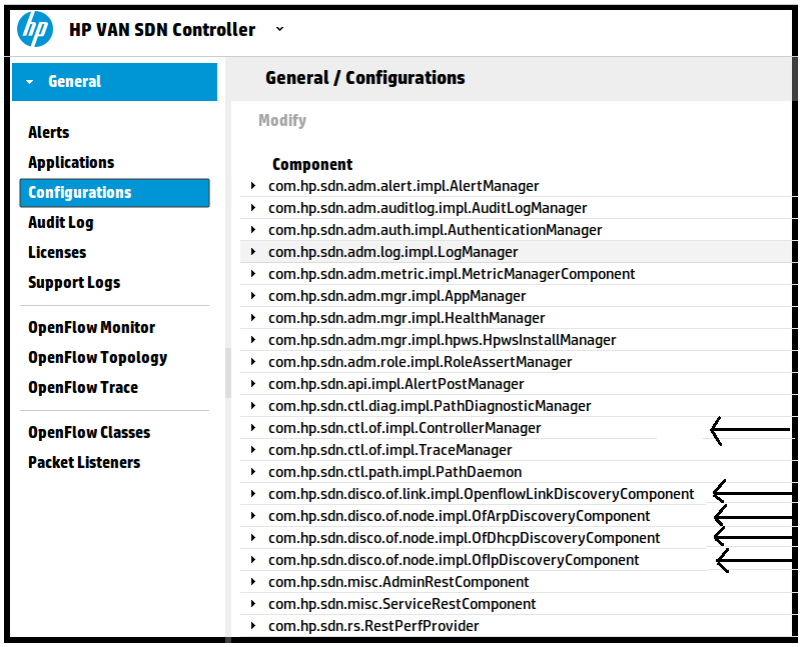
| Controller Configurations Component | Key | Comments |
|---|---|---|
| com.hp.sdn.ctl.of.impl.ControllerManager | hybrid.mode | Enable this setting if you want your controller to operate in hybrid mode (service restart required).<br>**NOTE:** Path Diag Tool will not work with flowmod strict mode as that wasn't designed to allow PDT to manipulate flow priority. |
| com.hp.sdn.disco.of.link.impl.OpenflowLinkDiscoveryComponent | multihop.poll.interval | The age.multihop.links when set to true makes multihop.poll.interval valid. So whatever interval is set for this key becomes the polling interval for multi-hop links. Using polling interval use can control how fast the multi-hop links need to be purged from controller if they are no longer active in the network. If age.multihop.inks flag is set to false then multi-hop links are not polled for their liveliness and never get purged from controller even if they have gone down. |
| | age.multihop.links | Flag indicating whether multihop link aging is enabled. Enable this setting if there are switches in the network that are not controlled by the controller, but the topology across these switches must be visible to the controller. That is, if any controlled OpenFlow switches in the same OpenFlow instance are separated by non-OpenFlow switches, use this setting. |

## Table 3 Controller settings to support hybrid mode *(continued)*

| Controller Configurations Component | Key | Comments |
|---|---|---|
| | | **NOTE:** Anytime user changes values for either age.multihop.links or multihop.poll.interval the "OpenFlow Link Discovery" app needs to be bounced so that those newly changed values take into effect. |
| com.hp.sdn.disco.of.node.impl.OfDhcpDiscoveryComponent | dhcp.age | Set this value equal to or greater than your network's DHCP lease time. Timeout (in minutes) for nodes learned via DHCP. |
| com.hp.sdn.disco.of.node.impl.OfArpDiscoveryComponent | arp.age | OpenFlow end-host discovery via the ARP protocol. Timeout (in minutes) for nodes learned via ARP. |
| com.hp.sdn.disco.of.node.impl.OfIpDiscoveryComponent | Ip.age | OpenFlow end-host discovery via the IP protocol. Timeout (in minutes) for nodes learned via IP. |
| | learn.ip | Whether or not the controller will discover nodes from all IP packets it receives. |

To view or reconfigure any of the above controller configuration components, click on the component, then click on the Modify button. For more on this topic, see the "Configurations" section in chapter 2 of this guide.

## Figure 45 Configuration components to modify for hybrid mode support



**NOTE:** For information about version support for ip-control-table-mode command options, see *HP VAN SDN Controller and Applications Support Matrix*.

For information about version support for hardware-only mode, see *HP VAN SDN Controller and Applications Support Matrix*.

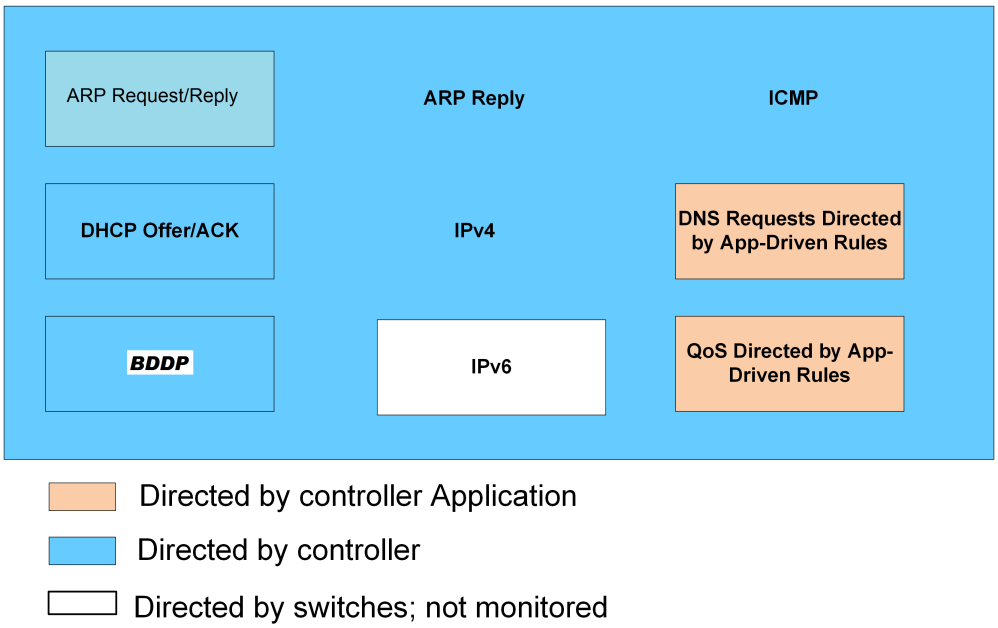
**NOTE:** OpenFlow 1.0 is the default version of OpenFlow for HP ProVision switches. OpenFlow does not allow the controller to optimize flow location in hardware tables. For concerns about line-rate data plane performance, configure all managed switches to use OpenFlow 1.3. Failure to properly configure the switch in this way may cause packet loss or other problems associated with high switch CPU utilization.

Uncontrolled switches in an OpenFlow Hybrid network are not visible to or controlled by the HP VAN SDN Controller. Uncontrolled switches are either controlled by another controller (outside the team) or not controlled at all (traditional networking). Traffic by such switches is independently managed.

The VAN SDN Controller Path Diagnostic Tool is useful only when hybrid mode is disabled. When hybrid mode is enabled, the controller does not monitor or direct all flows in the network. As a result, the path diagnostic tool (PathDiagnosticManager) does not have visibility into all flows on the network, and should not be used.

## 6.4 Controller packet-forwarding when hybrid mode is disabled

**Figure 46 Controller operation with hybrid mode disabled**

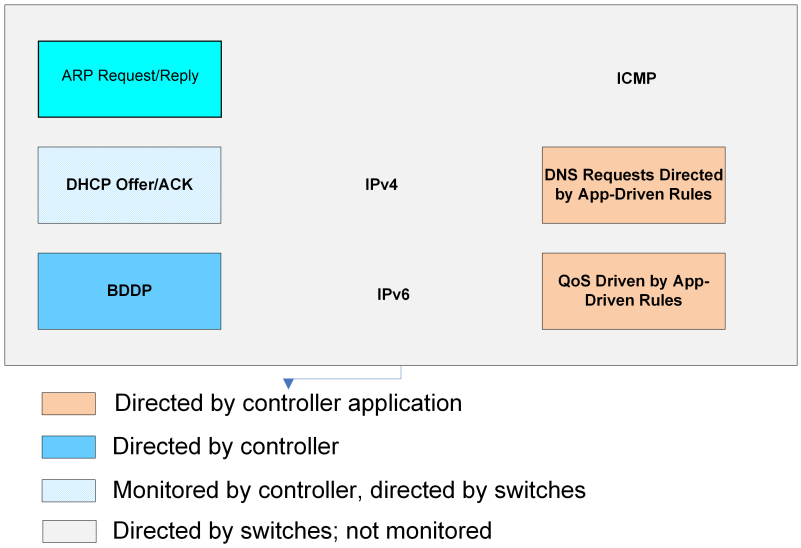



When hybrid mode is disabled (set to "false"), the controller examines and directs the packets in all flows for the given OpenFlow instance. The controller forwarding decisions for flows in a given instance are based on the requirements of the installed applications. The forwarding decision is communicated to controlled switches through OpenFlow. In instances where the controller has not provided the switch with a rule for how to forward a packet type, the switch sends the packet to the controller and waits for the controller to provide forwarding instructions.

Hybrid mode is commonly disabled in networks that are either used for experimental OpenFlow work (such as developing a controller application) or for networks that are completely new and designed to be fully controlled by OpenFlow.

## 6.4.1 Controller packet forwarding when hybrid mode is enabled

**Figure 47 Controller operation with hybrid mode enabled**




When hybrid mode is enabled (the default), the specific packet types for which the controller monitors and overrides switch forwarding rules depends on the applications installed and running in the controller. That is, the controller overrides normal packet forwarding rules in the OpenFlow switch with application-specific forwarding rules, such as:

- copying ARP request/reply and DHCP offer/ACK packets to the controller so that it can discover end-hosts
- stealing BDDP packets to the controller so that it can discover inter-switch links
- changing the priority on Lync packets to improve instant messaging speed
- monitoring DNS requests to detect dangerous end-host behavior

Packets in flows that the controller does not examine or direct are forwarded through normal switching operations without controller intervention.

**NOTE:** HP recommends that hybrid mode be enabled when controlling traditional, established networks where applications-related traffic is responsible for only a subset of the overall traffic load on the network. Hybrid mode is commonly enabled in established networks where new applications are installed and running on the controller, creating a need to override normal switching behavior for specific flows.

## 6.4.2 Learning more about hybrid mode

For more on hybrid mode as it relates to OpenFlow, see the latest OpenFlow Switch Specification on the Open Networking Foundation website. For a list of HPN switches that support OpenFlow operation, see the latest edition of the *HP VAN SDN Controller and Applications Support Matrix*.

# 7 Team configuration

Standalone controller operation provides management for the OpenFlow switches in a network. However, it does not provide high availability (HA), with the result that a controller failure leaves the network in an unmanaged state. Configuring a team of controllers and a corresponding controller region creates a high availability network with failover capability, resulting in a continuously managed network in the event that a controller in the team goes down. Controller teaming also provides centralized controller configuration and monitoring. This chapter describes how to configure a controller team. See "Regional configuration " (page 88) to configure a region for a controller team.

**NOTE:** Teaming operation requires the High Availability "Add Controller" license (HP VAN SDN Ctrl HA E-LTU). For licensing information, see "License registration and activation process" (page 52).

## 7.1 High availability

The default configuration of the SDN Controller is the system's eth0 interface. When a controller team is formed via REST with the team IP Address, an alias will be configured automatically by the system and will attach to the eth0 interface by default. If the SDN Controller has multiple Ethernet interfaces a different interface can be required for the team IP Address. In this case the configuration */etc/sdn/admin/options* may be changed using vim or emacs to reflect the desired configuration.

```
sdncontroller:/opt/sdn/admin# cat options
export ADMIN_OPTS="-Dcom.hp.sdn.admin.interface=eth0"
```

Once the change has been made, the SDNA service must be restarted as shown with the following command.

```
sdncontroller:/opt/sdn/admin# service sdna restart
sdna stop/waiting
```

This change must be made for every active controller within the team and does not require that the team to be deleted via REST.

To view the team IP Address designation from the SDN Controller console or SSH session, use ifconfig.

```
sdncontroller:$ ifconfig
    eth0   Link encap:Ethernet HWaddr ac:16:2d:9a:62:60
        inet addr:172.17.3.17 Bcast:172.17.15.255 Mask:255.255.240.0
        inet6 addr: fe80::ae16:2dff:fe9a:6260/64 Scope:Link
        UP BROADCAST RUNNING MULTICAST MTU:1500 Metric:1
        RX packets:1151070 errors:0 dropped:284 overruns:0 frame:0
        TX packets:1134356 errors:0 dropped:0 overruns:0 carrier:0
        collisions:0 txqueuelen:1000
        RX bytes:684988786 (684.9 MB) TX bytes:882495744 (882.4 MB)
        Memory:f7f80000-f8000000
    eth0:0   Link encap:Ethernet  HWaddr ac:16:2d:9a:62:60
        inet addr:172.17.3.41 Bcast:172.17.15.255 Mask:255.255.240.0
        UP BROADCAST RUNNING MULTICAST MTU:1500 Metric:1
        Memory:f7f80000-f8000000
    lo     Link encap:Local Loopback
        inet addr:127.0.0.1 Mask:255.0.0.0
        inet6 addr: ::1/128 Scope:Host
        UP LOOPBACK RUNNING MTU:65536 Metric:1
        RX packets:116581 errors:0 dropped:0 overruns:0 frame:0
        TX packets:116581 errors:0 dropped:0 overruns:0 carrier:0
```

collisions:0 txqueuelen:0
RX bytes:32894518 (32.8 MB) TX bytes:32894518 (32.8 MB)

## 7.2 Team management

Each controller belonging to a team is a *team member*. To centralize team management and control, one controller is designated as the *team leader*. Teaming is configured on one controller and is automatically propagated to the other controllers in the team, regardless of which controller becomes the team leader.

Once a team is configured, the configuration and monitoring of team members and their associated OpenFlow switches is performed by the team leader. If the team leader goes down, another active controller becomes the team leader. If a team leader fails and then recovers, it resumes operation as only a team member.

## 7.3 Requirements for controller teams

- Team size: 3 controllers.
- All controllers in a team must be running the same software version.
- A team requires one IP address for each controller, plus one IP address assigned to the team. If the current team leader goes down, the failover process includes keeping the team IP address active on the new team leader.

**NOTE:** The IP address for each team member, including the team leader, is the IP address of the machine on which each controller is configured. The team IP address is a separate address determined by the Administrator.

Ensure that route configuration in the controller domain enables the controller team IP address to be reached from all areas of the domain.

## 7.4 Configuring a controller team

In the HP VAN SDN Controller, teaming is configured using the REST API. This section describes configuring a controller team using cURL commands.

### 7.4.1 Team configuration prerequisites

1. Install and start three standalone HP VAN SDN Controllers in the network. (See the latest *HP VAN SDN Controller Installation Guide*.)
2. Optional: To improve security, you can change the username and password from the default settings on each of the standalone controllers in step 1.
3. Select any one of the controllers to use for configuring the team.
4. On the selected controller, acquire an Authentication Token. Use the following cURL command, with the controller IP address, to acquire the token:

```
curl --noproxy controller_ip -X POST --fail -ksSfL --url
"https://controller_ip:8443/sdn/v2.0/auth" -H "Content-Type:
application/json" --data-binary '{"login": {"domain":
"domain","user": "user","password": "password"}}'
```

**CAUTION:** Credential information (user name, password, domain, and authentication tokens) used in cURL commands may be saved in the command history. For security reasons, HP recommends that you disable command history prior to executing commands containing credential information.

**NOTE:** The default domain and user settings are `sdn`. The default password setting is `skyline`.

Examples of cURL commands in this guide use the `--noproxy` option, which is appropriate where execution of cURL commands does not need a proxy to access controllers. If your network is set up such that a proxy is needed to access controllers, use the `--proxy` option. For details on cURL proxy options, visit http://curl.haxx.se/docs/manpage.html.

For example, in a controller using the default domain, user name, and password, the following command generates the authentication token 1759f214479e4ffd9504acb42123ef40:

```
curl --noproxy 192.15.135.187 -X POST --fail -ksSfL
--url "https://192.15.135.187:8443/sdn/v2.0/auth"
-H "Content-Type: application/json"
--data-binary '{"login": {"domain": "sdn","user": "sdn","password": "skyline"}}'
{"record":{"token":"1759f214479e4ffd9504acb42123ef40",
"expiration":1381982391381982399000,"expirationDate":"2014-10-16 20-59-59 -0700",
"userId":"b00cb0e94c9441d58011f980cf9635ae","userName":"sdn","domainId":
"a6701f6593d84fa5b8f23f9ab4ed69db","domainName":"sdn"}}
```

5. Determine the team configuration parameters:

| Parameter | Value |
|---|---|
| Team IP Address | The team IP address is different from the individual controller IP addresses. It is used as a virtual address for connecting to the team leader. |

## 7.4.2 Configuration procedure

1. Select any active controller to initially configure the team.
2. Enter the following cURL command:

   ```
   curl --noproxy member-ip --header X-Auth-Token:auth_token--fail -ksS
   --request POST --url https://ip-addr:8443/sdn/v2.0/team --data-binary
   '{"ip":"team-ip","members": [{"ip":"member-1-ip"},
   {"ip":"member-2-ip"}, {"ip":"member-3-ip"}]}}'
   ```

   **NOTE:** The *member-ip-addr* should be the IP address of the controller chosen to configure the team.

3. After executing the command in step 2, the team elects a team leader. The team leader then configures all team members and normal controller operation begins in the domain. The team creation command does not block until the team creation is complete. You will need to check the status of the system to verify the team was successfully created.

### Example 1 Configuration example

This example shows a team of controllers configured with the following team member values:

| Team IP Address | Member IP Addresses |
|---|---|
| 192.0.2.100 | 192.0.2.119<br>192.0.2.125<br>192.0.2.127 |

Domain: `sdn` (the default domain name)

Username: `myname`

Password: `mypass`

**NOTE:** It is not mandatory that the team IP address be in the same subnet as the member IP addresses. Other IP aliases can be used if the appropriate IP routes are present for the addresses to be reachable and usable.

1. Enter the following cURL command to acquire the authentication token:

**CAUTION:** Credential information (user name, password, domain, and authentication tokens) used in cURL commands may be saved in the command history. For security reasons, HP recommends that you disable command history prior to executing commands containing credential information.

```
curl --noproxy 192.0.2.119 -X POST --fail -ksSfL
--url "https:// 192.0.2.119:8443/sdn/v2.0/auth"
-H "Content-Type: application/json"
--data-binary '{"login": {"domain": "sdn","user": "myname","password": "mypass"}}'
{"record":{"token":"10f728e477cb4612b07069f339d0ca29","expiration":
1381119301000,"expirationDate":2013-12-06 21-15-01-0700",
"userId":"51802e12d16345fe9a4389290c1a04e2","username":"sdn","domainId":
"d45eca9bde1b4dc78bd7dff69ee9440d","domainName":"sdn"}}
```

2. Configure the controller team by using the above team values and token to enter the following curl command:

**NOTE:** The IP address used in this step should be the same as used in step 1.

```
curl --noproxy 192.0.2.119 --header X-Auth-Token:
10f728e477cb4612b07069f339d0ca29 --fail -ksS --request POST
--url https://192.0.2.119:8443/sdn/v2.0/team
--Data-binary '{"team":{"ip":"<team-ip>","members":
```

[{"ip":"<*member-1-ip*>"},

{"ip":"<*member-2-ip*>"},

{"ip":"<*member-3-ip*>"}]}}'

Completing the above steps creates and enables the team.

#### Possible responses

Since team creation is asynchronous, the response is always 202 unless the ream configuration (JSON) is not valid or there is a problem configuring the local controller. Possible codes are:

202 Accepted
400 Bad request

401 Unauthorized
503 Service unavailable

In case the team is not created in a quorum or if the team is partially created an alert will be posted.

### Example of the alert description for team partially created

"Team partially created: [Successes: 192.168.1.1, 192.168.1.2], [Failures: 192.168.1.3]"

The error for failures is not part of the alert, however an entry to the log files will be added with such errors.

### Example of the alert description for team creation failed in a quorum

"Team could not be created on a quorum"

To fix the controllers where the create operation failed, the user will have to destroy the team and create it again.

## 7.5 Displaying team configuration

1. Acquire an authentication token for the team leader. (See step 4 of “Team configuration prerequisites” (page 80).)

2. Using the token acquired in the preceding step, execute this cURL command to view the team configuration:

```
curl --noproxy member-ip
--header "X-Auth-Token:auth_token"
--fail -ksSfL --request GET
--url https://member-ip:8443/sdn/v2.0/team
```

For example:

```
curl --noproxy 192.0.2.100
--header "X-Auth-Token:auth_token"
--fail -ksSfL --request GET
--url https://192.0.2.100:8443/sdn/v2.0/team
```

The resulting team configuration output includes the following:

```
{
 "team": {
  "ip": "192.0.2.100",
  "revision":0
  "members": [
  {
   "ip": "192.0.2.119"
  },
  {
   "ip": "192.0.2.125"
  },
  {
   "ip": "192.0.2.127"
  }
 ]
}
}
```

In the json format, the above appears in the following layout:

```
{"team":{"ip":"192.0.2.100","members":
[{"ip":"192.0.2.119"},
{"ip":"192.0.2.125"},
{"ip":"192.0.2.127"}]}}
```

## 7.6 Disbanding a team

Disbanding a team returns the teamed controllers to standalone operation.This action initiates the team delete. The REST call may return before the delete has completed. The admin needs to check the system to see the running state of the system.

**NOTE:** Before disbanding a team, delete the region configuration for that team. See "Deleting a region" (page 91).

1. Acquire an authentication token for the team leader. (See step 4 of "Team configuration prerequisites" (page 80).)
2. Using the token acquired in the preceding step, execute this cURL command to disband the team:

```
curl --noproxy <team-ip> --header "X-Auth-Token:<auth_token>
" --fail
-ksSfL --request DELETE --url
https://<member-ip>:8443/sdn/v2.0/team
```

The resulting output includes the following:

### Possible responses

Since team deletion is asynchronous, the response is always 202 unless there is a problem configuring the local controller as standalone. Possible codes:

202 Accepted
400 Bad request
401 Unauthorized
503 Service unavailable

In case the team is not deleted in a quorum or if the team is partially deleted an alert will be posted.

### Example of the alert description for team partially deleted

"Team partially deleted: [Successes: 192.168.1.1, 192.168.1.2], [Failures: 192.168.1.3]"

The error for failures is not part of the alert, however an entry to the log files will be added with such errors.

### Example of the alert description for team deletion failed in a quorum

"Team could not be deleted on a quorum"

To fix the controllers where the delete operation failed, the user will have to execute the delete operation again on the failed controllers.

## 7.7 Controller fault tolerance

The threshold for controller fault tolerance is $2n+1$, where $n$ is the number of failed controllers allowed in an active team. HP VAN SDN Controller teaming supports a team of three controllers. In a team of three controllers, $n = 1$; one controller in a team of three can fail without suspending team operation. If one such controller does go down, a stateful failover occurs, in which the remaining two members resume together from the point of failure, and the team continues to operate. As long as any two of the teamed controllers in the network are active, the network remains in a managed state. If a second controller in the team fails, then $n$ exceeds the maximum allowed, and the remaining controller transitions to a SUSPEND state. When a controller is suspended because it is in the minority, it will return a 503 error to any REST API calls. When at least two controllers in the team become active, a new team manager is elected and the team operation resumes.

**NOTE:** In teamed controller operation, maintaining the integrity of the controller state information requires that a minimum of two controllers in a team of three must be active at all times. The failure of all but one of the controllers places the entire team in a SUSPEND state, and the domain serviced by the team becomes unmanaged. (The remaining teamed controller does not operate in standalone mode.)

A controller may also transition to Suspended state because of healthy reasons. The following summarizes the controller states:

- Active: The controller is healthy and part of a cluster with quorum (At least two controllers in a team of three).
- Suspended: The controller is unhealthy or part of cluster with no quorum (at most one controller in a team of three).
- Unreachable: If the connection between two controllers is broken then they see each other as unreachable.

Considerations:

- A system never sees itself as unreachable. Unreachable is a state for the remote controllers.
- Health does not affect cluster quorum. If in a team of three controllers two are unhealthy, as long as there is a link between controllers the third one will be active. A controller transitions to suspended state if quorum is lost to protect data consistency.

## 7.8 Error log for team configuration

**Table 4 Error log for team configuration**

| Log message | Description |
|---|---|
| Build version not consistent on all the systems. | Not all systems on the team have the same controller build version. Update the team as needed to have the same build version. |
| Invalid configuration. | The team configuration JSON is not valid. |
| Local member must be part of the team configuration. | If the members list from the JSON configuration does not include the system where the team is being created (The local system). |
| Team size must be greater than zero. | |
| A team has already been created. | Teaming is already running on the system. |
| Team could not be created on a quorum. | Team configuration has failed on a majority of systems. e.g. a team of three systems has experienced failures on two systems. |
| Team could not be deleted on a quorum. | A team delete has failed on a quorum number of systems. |
| Team not configured on this system. | An attempt has been made on a standalone controller to disband a team. |
| Programming team alias *ip-address* failed. | See "Team alias node" (page 87). |
| Unprogramming team alias *ip-address* failed. | See "Team alias node" (page 87). |
| Recovering from Partial Team Creation | In case the team is not successfully created in all controllers, it is not possible to fix the failed controllers without disbanding the team. To recover from this failure it is recommended to delete the team, fix the problem in the controllers where the create operation failed, and try again. |
| Recovering from Partial Team Deletion | If the team is not successfully deleted in all controllers, the failed controllers might go to suspended mode because they might not have quorum – they won't be able to connect |

**Table 4 Error log for team configuration** *(continued)*

| Log message | Description |
|---|---|
| | to those controllers where the operation was a success. To recover from this failure it is recommended to delete the team on each failed controller so configuration files are removed and so the controllers transition to standalone mode. |

**Table 5 Success log**

| Message | Description |
|---|---|
| Team created. | |
| Team created with the following configuration: [Team IP: <team ip>, [Members<member list>]. | |
| Team disbanded. | |
| Programmed Team alias: <team ip>. | |
| Unprogrammed Team alias: <team ip>. | |

**Table 6 Team IP error log**

| Message | Description |
|---|---|
| Exception while checking alias: <team ip>, <exception> | |
| Team alias: <team ip> already programmed | |
| Exception while programing alias: <team ip>, <exception> | |
| Exception while unprograming alias: <team ip>, <exception> | |

## 7.8.1 Team alias node

An IP Address (North-Bound IP) alias is created on the node that is elected as team leader to allow a controller team to be accessible with a single IP Address no matter which controller is the leader. This IP Address is provided as part of the team configuration when creating a team. If the elected node stops being team leader, the team IP Address must be removed from the aliases because this address must be reassigned to the actual team leader. If assigning or removing an alias fails, one of the following messages appears in the Alert log:

- Programming team alias *ip-address* failed
- Unprogramming team alias *ip-address* failed

In either of these instances, the condition is logged and the team continues to operate. In this case you can manually program the team alias using the following commands:

### 7.8.1.1 Configuring the alias

```
sudo ifconfig Mask:network_masketh0:0 controller_ip netmask network_mask
eth0 up
```

### 7.8.1.2 Disabling the alias

```
sudo ifconfig Mask:network_mask eth0:0 controller_ipnetmask
network_masketh0 down
```

# 8 Regional configuration

## 8.1 Overview

This chapter describes the configuration needed to support High Availability (HA) for SDN Controllers to OpenFlow switches. This is done by creating *region* configurations in the controllers using the REST APIs provided by the Role Orchestration Service (ROS).

Putting the region configurations in place in a controller team ensures seamless failover and failback among the configured controllers for the specified network devices in a region. That is, when a master controller experiences a fault, the Role Orchestration Service ensures that a slave controller immediately assumes the master role over the group of network devices to which the failed controller was in the master role. Once the failed controller recovers and rejoins the team, the Role Orchestration Service ensures restoration of this controller's role; that is, the rejoining controller takes back the role for which it was configured with respect to the other network devices. If the controller was configured to operate as the master in a region, then it would be restored to the master role. If it was configured to operate in the slave role, it would resume operation in the slave role.

Once the region definition(s) are in place, the ROS ensures that a master controller is always available to the respective network element(s) even if the configured master fails or there is a disruption of the communication channel between the controller and the network device(s).

**NOTE:** All region configuration operations (create, update, refresh, and delete) using the REST API require that every controller specified in the region, including the master controller and all slave controllers, be in an active state. If any controller in the region is in a "down" state, then the region configuration operations are disallowed

### 8.1.1 Failover

ROS triggers the failover operation in two cases:

- Controller failure: The ROS detects a controller failure in a team through notifications from the teaming subsystem. If ROS determines that the failed controller instance was a master for any region, it immediately elects one of the backup (slave) controllers to assume the master role over the affected region.
- Device disconnect: The ROS instance in a controller is notified of a communication failure with network device(s) through the Controller Service notifications. It instantly communicates with all ROS instances in the team to determine if the network device(s) in question are still connected to any of the backup (slave) controllers within the team. If that is the case, it elects one of the slaves to assume the master role over the affected network device(s).

### 8.1.2 Failback

When the configured master recovers from a failure and rejoins the team, or when the connection from the disconnected device(s) with the original master is resumed, ROS initiates a failback operation in which the master role is restored to the configured master as defined in the region definition.

The next section provides details about the various REST operations that can be used to create, update, and delete region configurations.

**NOTE:** Examples of cURL commands in this guide use the `--noproxy` option, which is appropriate where execution of cURL commands does not need a proxy to access controllers. If your network is set up such that a proxy is needed to access controllers, use the `--proxy` option. For details on cURL proxy options, visit http://curl.haxx.se/docs/manpage.html.

## 8.2 Creating a region

A region should have a minimum of two controllers. This example illustrates the cURL command to use for creating a new region definition with the following controllers and devices:

| Master Controller | | Slave Controllers | | OpenFlow Switches |
|---|---|---|---|---|
| IP Address | Name | IPAddresses | Names | |
| 15.146.194.80 | Controller_1 | 15.146.194.103<br>15.146.194.38 | Controller_2<br>Controller_3 | 10.250.100.20<br>10.250.100.21 |

**NOTE:** In this example, assume the following token has been acquired:

`"X-Auth-Token:54a6f80a9ae243db89bfa05de4ced51d"`

To acquire the authentication token for a controller, see "License registration and activation process" (page 52).

```
curl --noproxy 15.146.194.80
--header "X-Auth-Token:54a6f80a9ae243db89bfa05de4ced51d"
--header "Content-Type:application/json" --fail -ksS
--request POST --url "https://15.146.194.80:8443/sdn/v2.0/regions/
--data-binary "{
\"region\": {
\"master\": {
\"ip\": \"15.146.194.80\",
\"name\": \"Controller_1\"
},
\"slaves\": [
{
\"ip\": \"15.146.194.103\",
\"name\": \"Controller_2\"
},
{
\"ip\": \"15.146.194.38\",
\"name\": \"Controller_3\"
}
],
\"devices\":
[
{
\"ip\": \"10.250.100.20\"
},
{
\"ip\": \"10.250.100.21\"
}
]
}
}"
```

**NOTE:** A region can have only one master and one or more slave controller(s).

## 8.3 Aquiring a region UID

The region ID is required for updating, refreshing, or deleting a region. The cURL command to use for acquiring a region is:

### Syntax

```
curl --noproxy <controller-ip> --header
"X-Auth-Token:<auth_token>" --header
"Content-Type:application/json" --fail -ksS --request GET
--url https://<controller-ip>:8443/sdn/v2.0/regions/
```

For example, the following command acquires the region ID (uid) for the controller team in the region created in "Creating a region" (page 89).

```
curl --noproxy 15.146.194.80 --header "X-Auth-Token:54a6f80a9ae243db89bfa05de4ced51d" --header
"Content-Type:application/json" --fail -ksS
--request GET --url https://15.146.194.80:8443/sdn/v2.0/regions/
{"regions":
[
{"uid":"f305338b-1253-401b-9ac3-a10b92666b45","master":
{"ip":"15.146.194.80","name":"controller_1"},
"slaves":
[{"ip":"15.146.194.38","name":"controller_3"},
{"ip":"15.146.194.103","name":"controller_2"}],
"devices":[{"ip":"172.16.21.23"},{"ip":"172.16.21.24"}]
```

## 8.4 Updating a region

You can update an existing region with more slave controllers or more devices. The cURL command for updating a region is:

```
curl --noproxy controller-ip --header "X-Auth-Token:auth_token" --header "Content-Type:application/json" --fail
 -ksS
--request PUT --url https://controller-ip:8443/sdn/v2.0/regions/region-id --data-binary "{
```

For example, to update the region created in "Creating a region" (page 89), with a new switch (10.250.100.22), you would insert the master controller authentication token and the region ID (uid) returned in the above example.

```
curl --noproxy 15.146.194.80
--header "X-Auth-Token:54a6f80a9ae243db89bfa05de4ced51d"
--header "Content-Type:application/json" --fail -ksS --request PUT
--url https://15.146.194.80:8443/sdn/v2.0/regions/f305338b-1253-401b-9ac3-a10b92666b45
--data-binary '{
\"region\": {
\"master\": {
\"ip\": \"15.146.194.80\",
\"name\": \"Controller_1\"
},
\"slaves\": [
{
\"ip\": \"15.146.194.103\",
\"name\": \"Controller_2\"
},
{
\"ip\": \"15.146.194.38\",
\"name\": \"Controller_3\"
}
],
{
\"devices\": [
\"ip\": \"10.250.100.20\"
},
{
\"ip\": \"10.250.100.21\"
},
{
\"ip\": \"10.250.100.22\"
}
]
}}'
```

## 8.5 Refreshing a region

In case of an inconsistency, and as a troubleshooting feature, you can initiate a re-assertion of the configured roles in a region by using the "refresh" cURL command. This command refreshes all devices in the region.

```
curl --noproxy controller-ip --header "X-Auth-Token:auth_token" --header
"Content-Type:application/json" --fail -ksS --request POST --url
https://controller_ip:8443/sdn/v2.0/regions/region_id/
```

**NOTE:** A refresh should be done only when the master controller in the region is up.

The following is the JSON structure for refreshing a selected OpenFlow device in a region. Using this additional command structure limits the refresh to the specified device. This is not needed if all devices in the region are to be refreshed:

```
{
"region_refresh": {
"devices": [
{
"ip": "10.250.100.20"
}
]
}
}
```

## 8.6 Deleting a region

To delete a configured region, use the following cURL command.

```
curl --noproxy controller-ip
--header "X-Auth-Token:auth_token"
--header "Content-Type:application/json" --fail -ksS
--request DELETE
--url https://controller_ip:8443/sdn/v2.0/regions/region_id/
```

# 9 Backing up and restoring

This chapter describes controller backup and restore actions using cURL commands. For the REST APIs related to backup and restore, go to `/restore and /backup` in the RSdoc facility on the controller. (Using a Google Chrome browser window on the controller, enter `https://system_ip_address:8443/api` .)

**NOTE:** You cannot use RSdoc to download or upload files.

**NOTE:** Only one backup, restore, upload, or download operation can be active at any time on a given controller or controller team. Parallel operations are not supported.

## 9.1 Backing up a controller

A controller backup takes a snapshot of the controller state, and includes the following in a single file:

- Controller databases
- License compliance history and metrics log data
- In a teaming environment, the teaming configuration
- User repository folder (for user-installed applications)
- Controller configuration folder
- Application data for applications that have implemented backup/restore functionality.

**NOTE:** Applications using Cassandra in a teamed mode cannot use the backup and restore services in the SDN Controller. In this case, off-the-shelf solutions are recommended, such as rsync or Amanda.

Examples of cURL commands in this guide use the `--noproxy` option, which is appropriate where execution of cURL commands do not need a proxy to access controllers. If your network is set up such that a proxy is needed to access controllers, use the `--proxy` option. For details on cURL proxy options, visit http://curl.haxx.se/docs/manpage.html.

### 9.1.1 Backup operation

A controller backup includes the controller configuration and databases in one *.zip file.

- Backups run in the background, and, except for locking the Cassandra database to prevent writes, do not interrupt system operation.
- Whether operating in a team or operating in standalone mode, each controller is backed-up as a single system.
- When the controller is deployed in a VM, standard VM backup/restore tools (such as Snapshot or Clone) can be used.
- When the controller is deployed on bare metal, standard Linux server-based backup/restore tools (such as rsync, LVM snapshot, and Amanda/Zmanda) can be used.
- To complete a teamed backup, no controller can be in a failed state. (A controller team must have three controllers.)
- On any controller or controller team, only one operation can run at any given time (backup, restore, upload, or download). Also, starting a new backup while another backup is being downloaded creates an error condition and halts the new backup.
- Only authenticated users are allowed to create and restore backups. In some cases the domain name is also required.

**NOTE:** The default domain name is sdn. The default username is also sdn. The default password is skyline.

The controller does not save a non-default domain, user name, or pass-word across a backup. Changing these settings to non-default values and later backing up the controller, resets these settings to their defaults in the backup file. Later restoring the backup to the controller resets the domain, user name, and password to their default settings in the controller.

For backup and restore of the Keystone configuration and database, see "Backing up and restoring the keystone configuration and database" (page 97).

- If uploading a backup fails, then no backup version remains on the system.
- Starting a new backup replaces any earlier backup remaining in the controller. If a backup is being downloaded when a new backup is started, the new backup halts.
- Metering time-series data is not encompassed by the controller backup process. There can be a large amount of data, possibly tens of GBs in size, which is keyed to time. Not only is the time series data impractical to back up because of its size, but upon restoring it there is a likelihood that some of the restored data will not be usable because it will be older than the sliding window of time that metrics are retained for on the controller. However, there is one metering file that is backed up and restored. It contains a mapping of metric descriptor information (such as the ID of the application that created a metric and the metric's primary tag, secondary tag, and name) to the UID that was assigned to each metric. When a restore is performed, this file is restored, and any existing metering time-series data is deleted because it might not match the restored file. The mappings that are restored may, depending upon time elapsed since the backup was taken, be used to assign the same UID to a metric created following the restore (and subsequent controller restart) that was assigned to the metric before the backup was taken. This provides continuity for a metric across the time spanned between backup and restore because all data for the metric is keyed to the same UID. Thus, while time-series data from before the restore was not retained during the restore, UIDs used to key time-series data that was exported to external tools or storage before the restore will continue to be used for the same metrics.

### 9.1.2 Backing up a controller

1. 1. Acquire the authentication token for the controller backup:

```
url --noproxy controller_ip X POST --fail -ksSfL
-url "https://controller_ip:8443/sdn/v2.0/auth"
-H "Content-Type: application/json" --data-binary '{"login":
{"domain": "domain","user":
"user","password": "password"}}'
```

△ **CAUTION:** Credential information (user name, password, domain, and authentication tokens) used in cURL commands may be saved in the command history. For security reasons, HP recommends that you disable command history prior to executing commands containing credential information.

2. Acquire the controller uid:

```
curl --noproxy controller_ip
--header "X-Auth-Token:auth_token" --fail -ksSfL --request GET
--url "https://controller_ip:8443/sdn/v2.0/systems"
```

3. Set the IP address of the controller using the following cURL command:

```
curl --noproxy controller_ip>
--header "X-Auth-Token:auth_token" --fail -ksSfL --request PUT
```

```
"https://controller_ip:8443/sdn/v2.0/systems/controller_uid"
--data-binary '{"system":{"ip":"controller_ip"}}'
```

4. Perform the actual backup using the following cURL command:

```
curl --noproxy controller_ip
--header "X-Auth-Token:auth_token" --fail -ksS --request POST
--url "https://controller_ip:8443/sdn/v2.0/backup"
```

5. Get the checksum to verify the backup file has not been corrupted. The REST command to get the checksum is as follows:

```
curl --noproxy <controller_ip> --header "X-Auth-Token:<auth_token>" --fail -ksS --request GET --url
"https://<controller_ip>:8443/sdn/v2.0/backup/checksum"
```

6. Check on the status of a backup.

```
curl --noproxy controller_ip
--header "X-Auth-Token:auth_token" --fail -ksSfL --request GET
--url "https://controller_ip:8443/sdn/v2.0/backup/status"
```

### 9.1.3 Downloading a backup from the controller to another location

The backup file should be downloaded to a secure location. Choose the correct name now; you cannot rename the files later or you will get a file corruption error when you attempt to upload it for a restore.

**NOTE:** The file name must begin with `sdn_controller_backup`.

- Download the Backup.zip File:

```
curl --noproxy controller_ip
--header "X-Auth-Token:auth_token" --fail -ksSfL --request GET
--url "https://system_ip:8443/sdn/v2.0/backup>path-and-file-name.zip
```

### 9.1.4 Recommended backup practices

- Do not run backup while making configuration changes. Instead, run the backup after completing configuration changes. Otherwise, an inconsistent system state could result with a subsequent restore.
- Always back up all of the controllers in a team after a configuration change. Just backing up a subset of the controllers is not sufficient.
- Back up all of controllers in a team at approximately the same time. (Team backups can be in sequence or in parallel). Do not allow days to pass in-between backups of different controllers in the same team.
- A completed backup should be downloaded from the controller to another location for safekeeping. Include the IP address in the backup filename, so you can easily determine which backup belongs to which controller in a team. Recommended file naming is:
  - sdn_controller_backup_*ip-address*.zip
- Store the backup files you take off each controller in the team together, so they can easily be retrieved for a future restore.

**NOTE:** If any controller in a team fails to complete the backup, start the backup over for all members of the controller team.

Examples of cURL commands in this guide use the `--noproxy` option, which is appropriate where execution of cURL commands do not need a proxy to access controllers. If your network is set up such that a proxy is needed to access controllers, use the `--proxy` option. For details on cURL proxy options, visit http://curl.haxx.se/docs/manpage.html.

# 9.2 Restoring a controller from a backup

## 9.2.1 Restore operation

**NOTE:** To restore a controller from a backup, it is necessary to re-install the controller.

- In a controller team environment each active controller is restored as a single system.
- When the controller is deployed in a VM, standard VM restore tools (such as Snapshot or Clone) can be used.
- When the controller is deployed on bare metal, standard Linux server-based backup/restore tools (such as rsync, LVM snapshot, and Amanda/Zmanda) can be used.
- If a backed-up controller in a team fails, use single-system restore to restore the controller. The HA synchronization updates the controller to the latest version.
- The controller blocks traffic over OpenFlow ports during a restore.

**NOTE:** The controller ceases to operate during a Restore operation.

## 9.2.2 System restore requirements

A system backup can be restored only to a system having the following:

- The same controller version that existed at the time the backup was taken.
- The same network settings (IP address) as were present at the backup.
- The same license ID as was in effect when the controller was installed.

**NOTE:** If you have modified any environment—specific settings in files such as `/opt/sdn/virgo/options` or `/etc/init/sdnc.conf`, ensure that the appropriate changes are made to these files after you re-install the controller and before you start the restore. For example, the network interface that the Virgo service uses (default: `eth0`) may be `eth1` or another setting on some systems.

## 9.2.3 Restoring a controller from a backup

1. Uninstall the controller(s) to be restored. If this is a rollback to a previous state, uninstall all controllers.
2. Before restoring a controller, set `CTL_RESTORE_INSTALL_MODE=True` in the `~/.sdn_install_options` file in the home directory. If this file is not present in the directory, create it with the `CTL_RESTORE_INSTALL_MODE` entry. If the file is already present, ensure that it includes the `CTL_RESTORE_INSTALL_MODE` entry. This entry directs the installer to perform the necessary changes to direct the controller to start in recovery/restore mode, during which OpenFlow activity is suspended for the subject controller.
3. Re-install the failed controller(s), making sure to use the same IP address configuration. During the re-installation, log messages similar to the following appear in the Audit Log:

```
root@mak:~/dev/controller/dist# dpkg -i hp-sdn-ctl_1.11_amd64.deb
Selecting previously unselected package hp-sdn-ctl.
(Reading database ... 212350 files and directories currently installed.)
Unpacking hp-sdn-ctl (from hp-sdn-ctl_1.11_amd64.deb) ...
Setup has detected a compatible jre-headless - 1.7.0_25
Creating system group 'sdn'...
...done.
Creating system user 'sdn'...
...done.
Creating system user 'sdnadmin'...
...done.
Configuring PostgreSQL database...
* Restarting PostgreSQL 9.1 database server [ OK ]
```

```
...done.
Adding SDN-related items to Keystone...
keystone stop/waiting
keystone start/running, process 11514
...done.
Setting up hp-sdn-ctl (1.11) ...
Certificate was added to keystore
CTL_RESTORE_INSTALL_MODE option is set
SDN controller will be started in restore mode
sdna start/running, process 11633
sdnc start/running, process 11636
Processing triggers for ureadahead ...
```

**CAUTION:** Do not re-install any applications before you complete the restore process. The restoration adds data from the backup file into the current database contents. If you re-install applications that are part of the controller backup, then those applications might end up with duplicate or conflicting entries in their database. If required, only re-install applications after you have completed all steps of the restore process.

4. Acquire the authentication token for the system restore:

   ```
   curl --noproxy <controller_ip>" -X POST --fail -ksSfL --url
   "https://<controller_ip>:8443/sdn/v2.0/auth" -H
   "Content-Type: application/json" --data-binary '{"login":
   {"domain": "<domain>","user": "<user>","password":
   "<password>"}}'
   ```

**CAUTION:** Credential information (user name, password, domain, and authentication tokens) used in cURL commands may be saved in the command history. For security reasons, HP recommends that you disable command history prior to executing commands containing credential information.

5. Acquire the controller uid:

   ```
   curl --noproxy controller_ip
   --header "X-Auth-Token:auth_token" --fail -ksSfL --request GET
   --url https://controller_ip:8443/sdn/v2.0/systems
   ```

6. Use the following cURL command to set the IP address:

   ```
   curl --noproxy controller_ip --header "X-Auth-Token:auth_token" --fail -ksSfL --request PUT
   "https://controller_ip:8443/sdn/v2.0/systems/controller_uid"
   --data-binary '{"system":{"ip":"controller_ip"}}'
   ```

7. Perform a single controller restore onto each controller needing restoration.
   a. Upload the backup files that will be restored:

      ```
      curl --noproxy controller_ip -X POST --fail -ksSfL
      --url "https://controller_ip:8443/sdn/v2.0/restore backup"
      -H "X-Auth-Token:auth_token"--data-binary @path-and-file-name.zip
      ```

      where *path-and-file-name* is the full path to the file and the filename. The filename **MUST** match the name you used during the backup.

   b. Initiate the restore:

      ```
      curl --noproxy controller_ip --header "X-Auth-Token:auth_token" --fail -ksS --request POST --url
      "https://controller_ip:8443/sdn/v2.0/restore"
      ```

8. For a controller team, wait for HA synchronization to complete to all the controllers and wait for the team to become connected. The team can take a few minutes to come back up. Be sure to verify that team status has all controllers as ACTIVE and one of the team members is a leader.

```
curl --noproxy controller_ip
--header "X-Auth-Token:auth_token" --fail -ksSfL --request GET
--url "https://controller_ip:8443/sdn/v2.0/systems
```

- If less than a quorum of controllers are restored, then those controllers are updated to the latest state of the running team via HA synchronization. (A quorum is $n/2+1$ where $n$ is the total number of controllers in a team. In a three-controller team, a quorum is two controllers.)
- If the entire team is restored, then each controller is reset to the previous backed-up state.

9. After the controller restore is complete, change the value of CTL_RESTORE_INSTALL_MODE to `false` in the `~/.sdn_install_options` file on each controller so that it does not impact a future installation. This is because a future installation of the controller may not involve starting in recovery mode. (This is the opposite of step 2 of "Restoring a controller from a backup " (page 95).)
10. It is possible to query the restore status by using the `get` command at `v2.0/restore/status`. Since the restore is not hitless, the REST query will fail until the controller has successfully restarted.

**NOTE:** To restore a controller team, restore each controller as a standalone controller. See "Distributed (team) backing up and restoring " (page 97).

**NOTE:** Attempting to restore a backup taken on any release prior to version 2.3 will not complete.

## 9.3 Distributed (team) backing up and restoring

In a team environment, all team members must successfully complete the backup.

A team backup consists of using the single-system backup process. All controllers in the team must be active, and all of the backups in the team should be done either serially at approximately the same time, or in parallel. To complete a teamed backup, no controller can be in a failed state. (A controller team must have three controllers.) In a team environment, all team members must successfully complete the backup for the backup to be successful.

A team restore consists of using the single-system restore process on each controller in the team. Like backups, a system restore in a team should be done either serially at approximately the same time, or in parallel.

**NOTE:** When restoring a team, be sure to re-install all of the controllers, before initiating the actual restore on any of the controllers.

Also, if backing up the team controllers was done serially, then the restore of the team controllers should be done in reverse order.

A controller that fails a restore operation is not allowed to rejoin the team, and must be re-added as a new controller.

There are reference scripts to automate the backup and restore of an entire team. See "Scripts" (page 121).

## 9.4 Backing up and restoring the keystone configuration and database

Backup/Restore for the Keystone configuration and database are separate actions from the controller Backup/Restore. The backup/restore does not backup any keystone related configuration/credentials therefore any changes made to keystone will be lost after the restore.

**NOTE:** These instructions apply to the default local Keystone instance (Keystone 2012.2) as specified in the *HP VAN SDN Controller Installation Guide*. If you are using a different Keystone installation, please follow the OpenStack instructions for backup/restore of the Keystone instance specific to your installation. For OpenStack documentation, visit http://docs.openstack.org.

# 10 Requirements for applications

## 10.1 Application requirements

Any application to be installed using application manager on the controller must meet the following requirements:

- It must be in a zip format.
- The zip file must be on the same system as the controller.
- It must contain an application descriptor file containing key value pairs of the attributes associated with the application.

## 10.2 Application descriptor file mandatory attributes

The application descriptor file must contain the following attribute key value pairs. If a key is missing or the key value is invalid, the application upload will fail and you will not be able to deploy this application.

- **id** – Unique string that identifies this application. No other application may have this value. It may contain alpha-numeric characters and the period, underscore, and dash characters. The id string should not start with a dash or period character and can't exceed 255 characters. HP recommends you use the same convention that Java uses for class paths. For example: `com.hp.sdn.app-name`.
- **name** – User visible name for this application. The value must follow the rules for a properly formatted Java properties file key value.
- **version** – OSGi version number. A valid OSGi version number is composed of the following:

  `major-#.minor-#.micro-#.alpha-numeric-qualifier`

  Note that not all elements are required. See the OSGi version documentation for the precise version string format rules. Typical examples might be: `6.24.0.build64` or `6.27`.

## 10.3 Application descriptor optional attributes

The following attribute key-value pairs are optional.

- **order** – Comma separated list of bundle symbolic names indicating the order each bundle should be started in. The first bundle in the list is started by OSGi first, the last bundle in the list is started last.
- **scoped** – `true/false`. Defaults to `false`. If true, all services (APIs) supplied by the application are private to the application. Note: OSGi declarative services cannot be used in the application when scoped is set to true.
- **atomic** – true/false. Defaults to true. If true, all parts/components of the application are treated as an atomic unit by OSGi, when starting/stopping/deploying the application. For example, if one of the application bundles/components fails to start, then none of the bundles/components that make up the application will start.
- **vendor** – User visible name of the vendor that created this application. The value must follow the rules for a properly formatted Java properties file key value.
- **description** – Description for this application. The value must follow the rules for a properly formatted Java properties file key value.

## 10.4 Application zip file content criteria

The application zip file contains all of the component files that make up an OSGi application. In order for the Application Manager to accept this as a valid application, certain criteria must be met:

- Must contain one file with a ".descriptor" extension containing the key-value pairs described above.
- Must contain at least one bundle (JAR), PAR, or WAR file.
- All application component files must be valid OSGi artifacts. That is, all JAR, PAR, and WAR files must contain a manifest file with valid OSGi meta-data in it.
- The application must be self-contained, in that any third party dependency not already delivered by the SDN Controller must be included with the application. Note that in most cases you must convert the third party JARs into OSGi bundles or embed the third party content in the application. The details on how to accomplish this is beyond the scope of this manual and you should consult the appropriate OSGi/Virgo reference documentation.
- By default, all JAR files must be signed by a trusted authority. Note that this can be disabled in the controller. See "Running the SDN Controller Without Jar-Signing Validation " (page 68).
- You may also sign the application zip file itself. Verifying that application zip files have been properly signed, have not been modified, and use a trusted certification can be enabled through the the AppManager "verifyZips" property value in "Configurations". If enabled, only applications that are signed by a trusted authority can be downloaded to the controller.
- The application must be properly signed by an authority that is recognized by the SDN Controller. For the SDN Controller to recognize a trusted authority, the public certificate used to sign the jar and/or zip files must be placed into the /opt/sdn/admin/sdnjar_trust.jks keystore.

A Virgo Plan file will be used if provided, but is not required. The Application Manager will only deploy JAR, PAR, WAR, Plan, and ".properties" files. Other files in the application zip file are ignored unless they are declared as an artifact in a Plan file.

## 10.5 Application state and OSGi artifacts

In the default state, or when an application has been started, it is in the ACTIVE state and is servicing requests. Application states include the following:

**Table 7 Application States**

| State | Description |
|---|---|
| ACTIVE | The application is running and servicing requests. |
| STAGED | A new application has been downloaded to the controller and is ready to be installed. |
| UPGRADE_STAGED | A new version of an existing running application has been downloaded to the controller and the new version is ready to be installed (upgrade/downgrade). |
| INSTALLING | A transitive state indicating a new application is in the process of being installed. |
| UPGRADING | A transitive state indicating the existing application is being stopped and a new version of the application is being installed. |
| CANCELING | A transitive state indicating a non-installed version of an application is being deleted from the controller. |
| DISABLING | A transitive state indicating the application is in the process of being disabled (stopping). |
| DISABLED | The application is disabled (stopped). A disabled application is not automatically started when the controller restarted. |
| ENABLING | A transitive state indicating the application is being started. |

## Table 7 Application States *(continued)*

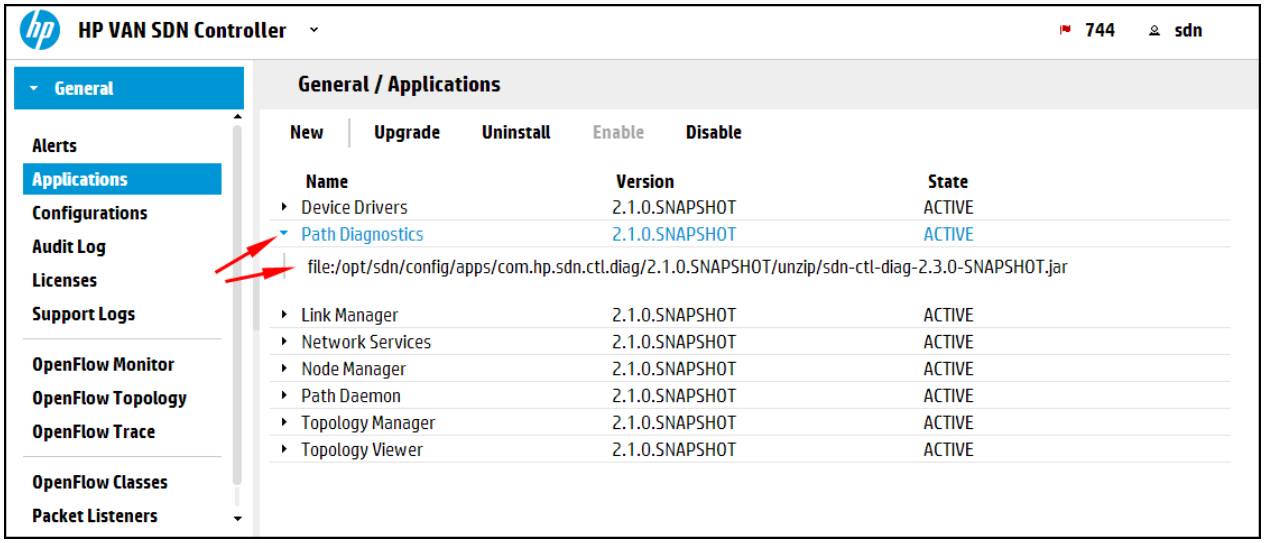
| State | Description |
|---|---|
| UNINSTALLING | A transitive state indication an application is being stopped and completely removed from the controller. |
| RESOLVED | The application is stopped and not servicing requests. An application can only be in this state when it is stopped externally to the SDN Controller (e.g. the virgo console). |

## Table 8 Error condition management

| State | Description |
|---|---|
| NEW > STAGEDNEW > UPGRADE-STAGED | If an error condition occurs when "staging" the application, then it actually does not exist. (Error conditions in this stage clean up after themselves.) |
| STAGED > ACTIVE | If an OSGi deployment exception is encountered, the application is moved to DISABLED if it fails to deploy as it is. If a File I/O or URI exception is encountered, the application remains in the installing state. |
| UPGRADE-STAGED > ACTIVE | If an exception is encountered (OSGi deployment, File I/O, or URI), rollback attempt is made, as listed below. (Depending on the original exception, not all options may be possible).<br>1. Calls AppStore.deleteStore on the upgraded version of the application.<br>2. Attempts to redeploy the original version of the application. |
| ANY STATE – UNINSTALLED | If any exception is encountered, the application remains in UNINSTALLING state |
| ANY STATE – DISABLED | If an exception is encountered, remains in DISABLING state. |
| DISABLED > ENABLED | If an OSGi deployment exception is encountered, the application is moved to the DISABLED state if it fails to deploy as it is. If any other exception is encountered (file I/O or URI), the application remains in the ENABLING state. |

To access the link to the OSGi artifacts for an application, click on the bullet for the application in the web GUI. For example, clicking on the bullet for the "Path Diagnostics" application displays the link to identity of the associated OSGi artifacts:

## Figure 48 Links to OSGi artifacts associated with individual applications



# 11 Troubleshooting

## 11.1 License troubleshooting

Table 9 lists recommended solutions for possible error messages that may display during the controller license registration and activation process.

**Table 9 Error messages and recommended solutions**

| Symptom | Possible cause and recommendation |
|---|---|
| **Redeem quantity error**<br>• You see an error message that your license has a maximum redeem quantity. | You specified a license quantity that exceeds what your license type supports.<br>1. Return to the **My Network** portal license selection screen.<br>2. Enter the correct quantity in the **Redeem** column for your license type:<br>• For an HP VAN SDN Ctrl Base SW w/ 50–node E-LTU license, the quantity must be 1.<br>• For HP VAN SDN Ctrl 50–node E-LTU or HP VAN SDN Ctrl HA E-LTU licenses, quantity can be any quantity on your sales order.<br>For information about installing an application license, see the administration guide for the specific application. |
| **Install ID errors**<br>• You see an error message that your Install ID format is invalid. | You entered an invalid ID, or have not entered an ID.<br>1. Carefully check your Install ID. See Identifying the install ID.<br>2. Return to the license registration details screen and enter a valid value in the **Install ID** field. |
| • You see an error message that your Install ID is required. | The Install ID has not been entered in the portal during the registration process. To acquire and enter the install ID, see "Identifying the install ID" (page 53)and Figure 28 (page 55). |

## 11.2 Host location not learned by controller

In a topology where two or more controlled switches connect to the same uncontrolled switch, the controller does not learn the location of hosts connected to the uncontrolled switch.

## 11.3 Unexpected network or service problems

Network or service problems can occur if you change the `hybrid.mode` configuration of the controller without also restarting the controller and disabling, then re-enabling each controlled OpenFlow instance in the OpenFlow switches. See "Hybrid mode for controlling packet-forwarding" (page 73) for information about changing the `hybrid.mode` configuration.

## 11.4 Application management exceptions

### Table 10 Application management exceptions

| |
|---|
| • ApplicationDisableException: Indicates that an application cannot be disabled.<br>  ◦ Occurs when an app is STAGED or UPGRADE_STAGED, or something else has gone wrong (specified in error message)<br>  ◦ HTTP code: 500 |
| • ApplicationEnableException: Indicates that an application cannot be enabled.<br>  ◦ Occurs when an app is not DISABLED, or something else has gone wrong (as specified in the error message).<br>  ◦ HTTP code: 500 |
| • ApplicationInstallException: Indicates that an app cannot be installed.<br>  ◦ Occurs when an application is not STAGED, or something else has gone wrong (as specified in the error message).<br>  ◦ HTTP code: 500 |
| • ApplicationStartException: Indicates that an application cannot be started.<br>  ◦ Occurs when an app is not RESOLVED, or something else has gone wrong (as specified in the error message).<br>  ◦ HTTP code: 500 |
| • ApplicationStopException: Indicates that an app cannot be stopped.<br>  ◦ Occurs when an application is not ACTIVE, or something else has gone wrong (as specified in the error message).<br>  ◦ HTTP code: 500 |
| • ApplicationUninstallException: Indicates that an application cannot be uninstalled.<br>  ◦ Occurs when something has gone wrong as (as specified in the error message).<br>  ◦ HTTP code: 500 |
| • ApplicationUpgradeException: Indicates that an application cannot be upgraded.<br>  ◦ Occurs when an application is not UPGRADE_STAGED, or that something has gone wrong (as specified in the error message).<br>  ◦ HTTP code: 500 |
| • ApplicationUploadException: Indicates that an application cannot be uploaded to the controller.<br>  ◦ Seen when an IO error occurs while uploading the application to the controller.<br>  ◦ HTTP code: 500 |
| • ApplicationValidationException: Indicates that an application zip file fails validation. Validation can be from file format to invalid contents to failed signed jar verification (if enabled).<br>  ◦ HTTP code: 400 |

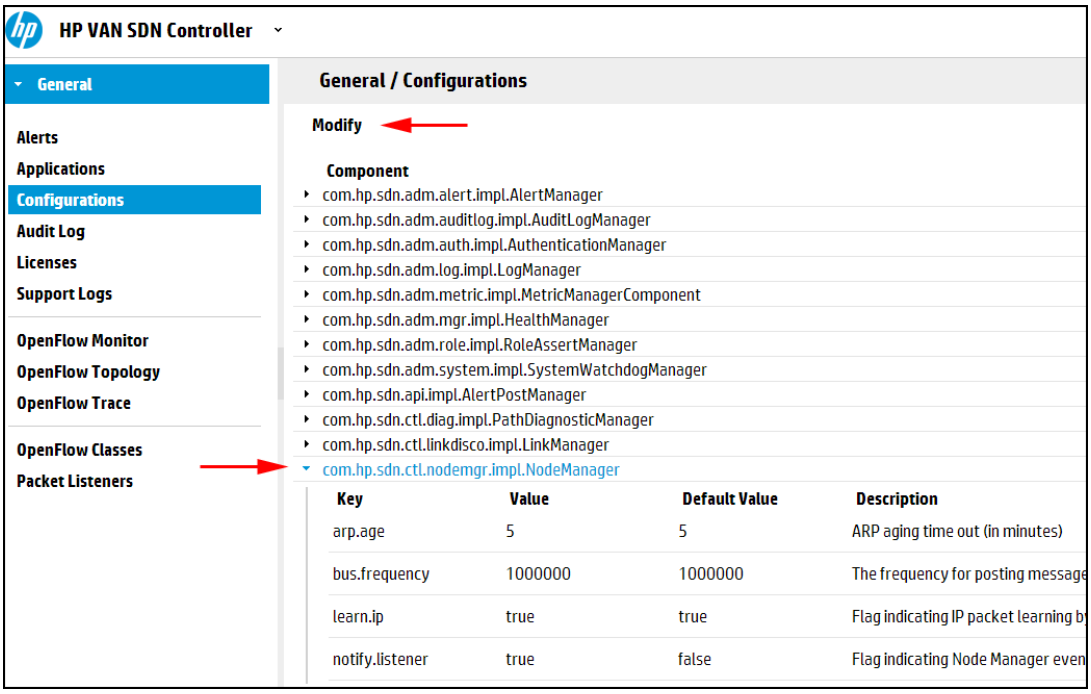
# 11.5 Performance testing

## Measuring flows (packets) per second

For measuring flows-per-second for performance testing, disable the additional processing required by `learn.ip` key of the `com.hp.sdn.ctl.nodemgr.impl.NodeManager` component by setting the value of the key to `false`.

1. From the navigation menu, select **Configurations**.
2. Select the `com.hp.sdn.ctl.nodemgr.impl.NodeManager` component.
3. Click **Modify**.

**Figure 49 Display the learn.ip option**




4. For the `learn.ip` key, enter `false` in the **Value** box.
5. Click on the **Apply** button to set the new learn.ip configuration and close the window.

**NOTE:** When flow measurement tasks are complete, set the `learn.ip` key to `true` (its default value). Flow measurement results can vary based on the type of server used for the controller and on the server configuration.

## 11.6 Application management errors

- If the Application Management framework is able to detect a failure to start an application in the OSGi runtime environment, the application is automatically moved to the DISABLED state.
  - Correct the OSGi runtime conditions.
  - Enable the application.
- If an unexpected error condition occurs when manipulating an application (file I/O exception, missing files, etc) the application is left in a transitive state.
  - An application can only be uninstalled when it is trapped in a transitive state.
  - Examine the log files to determine the source of error and correct.
  - Uninstall the application then upload and install the application again.
- If the Application Framework is able to detect a failure to start an upgraded version of an application.
  - The upgrade version of the application is removed from the SDN server.
  - An attempt is made to restart the previous version of the application (if it was active).

## 11.7 Path diagnostic application via REST command line API

This section describes a method tor troubleshooting switch connectivity issues in OpenFlow switch environments. This includes two components:

- A packet generator to send test packets of supported protocols via the controller from one end node to another across an OpenFlow domain.
- A path analyzer providing generated test packet information to help determine which path the test packets take, and helps in identifying the point of failure; that is, the switch that is not forwarding the traffic as expected on the path.
- The procedures in this section can be done using Use a REST-based tool such as RSdoc.

### 11.7.1 Communication problems

Unable to reach a specific end host for a particular type of service; that is, the end hosts cannot communicate with each other using a particular traffic flow. For example, a user is unable use the FTP services hosted by particular server.

### 11.7.2 Packet generator troubleshooting

#### 11.7.2.1 Packet generator troubleshooting procedure

1. Collect the source and destination end host configuration details.
2. Register a packet that will be injected into the network for tracing the path.
3. Set an observation post on the switch where the destined end host is connected.
4. Inject the registered packet onto the network.
5. Query the observation post in step 3.
6. If the observation post has not received the registered packet, set an observation post on the switch that is next-hop from the source switch.
7. Inject the registered packet into the network.
8. Query the observation post in step 3.
9. Repeat steps 3 – 8 to determine the switch data path ID where the packet is being dropped.

### 11.7.2.2 Run the packet generator process

1. Authenticate using the following cURL command:

   ```
   curl --noproxy controller_ip -X POST --fail -ksSfL --url "https://
   controller_ip:8443/sdn/v2.0/auth" -H "Content-Type: application/json
   --data-binary '{"login":{"domain": "sdn","user": "sdn","password":
   "skyline"}}
   ```

2. Collect the source and destination end host details using NodeManager REST API via RsDoc/CLI
   For example: https://*controller-ip-addr*:8443/sdn/v2.0/net/nodes


```
For example: https://controller-ip-addr:8443/sdn/v2.0/net/nodes
"nodes":
[
{
  "ip": "10.0.0.6",
  "mac": "22:4d:a4:05:22:dc",
  "vid": 0,
  "dpid": "00:00:00:00:00:00:00:06",
  "port": 1
},
{
  "ip": "10.0.0.3",
  "mac": "ce:9c:38:8f:c5:57",
  "vid": 0,
  "dpid": "00:00:00:00:00:00:00:03",
  "port": 1
},
{
  "ip": "10.0.0.5",
  "mac": "8e:f4:3c:47:27:09",
  "vid": 0,
  "dpid": "00:00:00:00:00:00:00:05",
  "port": 1
},
{
  "ip": "10.0.0.1",
  "mac": "76:3d:0c:d3:5e:a5",
  "vid": 0,
  "dpid": "00:00:00:00:00:00:00:01",
  "port": 1
},
{
  "ip": "10.0.0.9",
  "mac": "fe:f8:54:82:bb:39",
  "vid": 0,
  "dpid": "00:00:00:00:00:00:00:09",
  "port": 1
},
{
  "ip": "10.0.0.2",
  "mac": "9e:1a:cc:cb:43:7f",
  "vid": 0,
  "dpid": "00:00:00:00:00:00:00:02",
  "port": 1
},
{
  "ip": "10.0.0.10",
  "mac": "ee:22:95:a5:d5:22",
  "vid": 0,
  "dpid": "00:00:00:00:00:00:00:0a",
  "port": 1
},
```

```
{
  "ip": "10.0.0.8",
  "mac": "e6:12:8e:f9:03:64",
  "vid": 0,
  "dpid": "00:00:00:00:00:00:00:08",
  "port": 1
},
{
  "ip": "10.0.0.7",
  "mac": "12:94:57:f7:cb:66",
  "vid": 0,
  "dpid": "00:00:00:00:00:00:00:07",
  "port": 1
},
{
  "ip": "10.0.0.4",
  "mac": "82:a3:85:71:63:bf",
  "vid": 0,
  "dpid": "00:00:00:00:00:00:00:04",
  "port": 1
}
]
}
```

3. Register a packet which needs to be injected in the network for tracing the path. For example TCP packet with destination port as 21.

   `POST https://controller_ip:8443/sdn/v2.0/diag/packets`

   Request body:

```
{"packet": {
"type": "TCP",
"eth": {
"eth_dst": "00:00:00:00:00:05",
"eth_src": "00:00:00:00:00:06",
"eth_type": "IPv4"
},
"ip": {
"ipv4_dst": "10.0.0.5",
"ipv4_src": "10.0.0.6",
ip_proto": "TCP",
"ip_dscn": "CS0",
"ip_scn": "NOT_ECT"
},
"tcp": {
"tcp_dst": 21,
"tcp_src": 12345
}
}
}
Response:
output -
{
"packet": {
"uid": "2096432597", // uid to be used all subsequent invocation
"eth": {
"eth_type": "0x0800(IPv4)",
"eth_src": "00:00:00:00:00:06",
"eth_dst": "00:00:00:00:00:05"
},
"ip": {
"ip_proto": "TCP",
"ipv4_src": "10.0.0.6",
"ipv4_dst": "10.0.0.5",
```

```
"ip_ident": 0,
"ip_dscp": "CS0",
"ip_ecn": "NOT_ECT"
},
"tcp": {
"tcp_src": 12345,
"tcp_dst": 20
}
}
}
```

4. Set the observation post on the switch where the destined end host is connected.

   post /diag/observations.

   **NOTE:** An alert is generated for an operation such as setting or removing an observation post. These alerts can be viewed by using the Alert Log in the controller UI.

   Destination end host ( 00:00:00:00:00:05 ) is connected to switch having dpid as 00:00:00:00:00:00:00:01 . Set up an observation post here using below json as request parameter

```
{"observation": {
 "dpid": "00:00:00:00:00:00:00:01", // connected switch from /nodes
 "packet_uid": "2096432597" //uid from the create /register packet .
}
}
output -
{
 "observation": {
 "dpid": "00:00:00:00:00:00:00:01",
 "packet_uid": " 2096432597"
}
}
```

5. Inject the packet onto the network

   post /diag/packets/{packet_uid}/action

   Use the above URI for generating the packet on to the network.

   Parameters:

   packet_uid 2096432597 //uid from the create /register packet .

   output -

   Response Body: 2096432597

   Response Code: 200

6. Query the observation post

   get /diag/observations

   parameters :

   packet_uid 2096432597 //uid from the create /register packet .

   Output:

```
{
"observations": [
{85
"dpid": "00:00:00:00:00:00:00:01",
"match":[
{
"in_port":9
},
{
```

```
"in_phy_port":9
}
],
"packet_uid": "2096432597",
"status": "OK",
"type": "TCP",
}
}
```

7. If the packet has reached the destined observation post , it means the connectivity is between the source and the end host is good.

   For example, user sees the "status": "OK", // inference packet reached the observation above.

8. In case the destined observation post has not received the trace packet , it means it is being dropped by one of the intermediate hops.
9. Get the next hop by providing the source switch datapath id and packet uid and set the observation post on determined next hop. If it is unable to determine next hop , it implies that packet is being dropped at the given switch datapath id.

   get /diag/packets/{packet_uid}/nexthops

   Parameters

   packet_uid 2096432597 //uid from the create /register packet .

   Source switch dpid : 00:00:00:00:00:00:00:02

   Output :

```
{
"nexthops": [
{
"dpid": "00:00:00:00:00:00:00:01",
"port": "0x2"
}
]
}
```

10. Inject the packet on to the network.
11. Query the observation post.
12. Repeat step 7,8,9,10 to determine the switch data path ID where the packet is being dropped.

# 12 Support and other resources

To learn how to contact HP, obtain software updates, submit feedback on documentation, and locate links to HP SDN websites and other related HP products, see the following topics.

## 12.1 Gather information before contacting an authorized support representative

If you need to contact an authorized HP support representative, be sure to have the following information available:

- If you have a Care Pack or other support contract, either your Service Agreement Identifier (SAID) or other proof of purchase of support for the controller and any HP SDN applications
- The HP VAN SDN Controller version and installed licenses
- The HP SDN application product names, versions, and installed licenses
- If you use a virtual machine for the operating system, the hypervisor virtualization platform and version
- Messages generated by the controller and applications
- Other HP or third-party software in use

## 12.2 How to contact HP

- See the Contact HP Worldwide website to obtain contact information for any country:
  http://www8.hp.com/us/en/contact-hp/ww-contact-us.html
- See the contact information provided on the HP Support Center website:
  http://www8.hp.com/us/en/support.html
- In the United States, call +1 800 334 5144 to contact HP by telephone. This service is available 24 hours a day, 7 days a week. For continuous quality improvement, conversations might be recorded or monitored.

## 12.3 Get connected to the HP SDN online user forum

The HP SDN community forum interactive online forum enables you to share your experiences and pose and answer questions related to using the HP VAN SDN Controller and SDN applications.

To join the discussion, see the SDN forum:

http://www8.hp.com/us/en/support.html

## 12.4 Software technical support and software updates

HP provides 90 days of limited technical support with the purchase of a base license for the HP VAN SDN Controller.

Some HP SDN applications have a trial period, during which limited technical support is provided for 90 days. Other HP SDN applications do not have a trial period and you must purchase a base license for the application to receive 90 days of limited support. Support for the controller and each HP SDN application is purchased separately, but you must have a base license for the controller to receive support for your licensed HP SDN application.

- For information about licenses for the controller, see the *HP VAN SDN Controller Administrator Guide*.
- For information about licenses for HP SDN applications, see the information about licensing in the administrator guide for the application.

### 12.4.1 Care packs

To supplement the technical support provided with the purchase of a license, HP offers a wide variety of Care Packs that provide full technical support at 9x5 or 24x7 availability with annual or multi-year options. To purchase a Care Pack for an HP SDN application, you must have a license for that application and a license for the controller.

For a list of Care Packs available for the controller and HP SDN applications, see:

http://www.hp.com/go/cpc

Enter the SDN license product number to see a list of Care Packs offered.

Once registered, you receive a service contract in the mail containing the customer service phone number and your Service Agreement Identifier (SAID). You need the SAID when you phone for technical support.

To obtain full technical support prior to receiving the service contract in the mail, please call Technical Support with the proof of purchase of the Care Pack.

### 12.4.2 Obtaining software updates

The software for the HP VAN SDN Controller and HP SDN applications can be downloaded for free from the HP Networking support lookup tool:

http://www8.hp.com/us/en/support.html

This website also provides links for manuals, electronic case submission, and other support functions.

### 12.4.3 Warranty

For the software end user license agreement and warranty information for HP Networking products, see http://www8.hp.com/us/en/drivers.html

## 12.5 Related information

#### Documentation

- HP SDN information library
  http://www.hp.com/go/sdn/infolib

#### Product websites

- HP Software-Defined Networking website:
  - Primary website:
    http://www.hp.com/go/sdn
  - Development center:
    http://www.sdndevcenter.hp.com
  - User community forum:
    http://www.hp.com/networking/sdnforum
- HP Open Source Download Site:
  http://www.hp.com/software/opensource
- HP Networking services website:
  http://www.hp.com/networking/services

# 13 Documentation feedback

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# A cURL commands

The HP VAN SDN Controller provides a restful web service API. There are several tools available for accessing restful web service APIs, one of which is cURL. This sppendix shows examples of accessing the HP VAN SDN Controller's restful web service API with cURL. For details on installing the curl application, see http://curl.haxx.se/download.html.

The cURL application has many options, which are described in detail in the cURL manual (run "curl --manual") and at http://curl.haxx.se/docs/manpage.html. The examples in this appendix use minimal options and assume a non-scripted, command line mode of execution and no conflicts with a web proxy. Additional options can be used to customize your experience for your environment.

**CAUTION:** Credential information (user name, password, domain, and authentication tokens) used in cURL commands may be saved in the command history. For security reasons, HP recommends that you disable command history prior to executing commands containing credential information.

**NOTE:** The '-k' option should only be used when issuing the request against an HP VAN SDN Controller with a self-signed certificate, which is installed by default. If a CA signed certificate is installed, the '-k' option should not be used. See http://curl.haxx.se/docs/sslcerts.html for further details.

**NOTE:** Examples of cURL commands in this guide use the "--noproxy" option, which is appropriate where execution of cURL commands does not need a proxy to access controllers. If your network is set up such that a proxy is needed to access controllers, use the "--proxy" option. For details on cURL proxy options, visit http://curl.haxx.se/docs/manpage.html.

## A.1 Export audit log data as a CSV file

To export the audit log use the following command:

```
curl [options] -H "X-Auth-Token: <token>"\
      -H "Accept-Type: application/zip" \
         https://<controller_ip>:8443/sdn/v2.0/auditlog \
        -o <zip-file-name>
```

To acquire the token for the command, see “Installing, activating, uninstalling, or transferring licenses” (page 34).

For example, to export the current content in the controller audit log in a file named `auditlogExport.CSV` inside a zip file:

```
curl -ksS -H "X-Auth-Token:3d61f0d3e61349359e6dbd82ec02c113" \
                  -H "Accept-Type: application/zip" \
                  https://10.0.1.42:8443/sdn/v2.0/auditlog \
                  -o auditlogExport.zip
```

## A.2 Licensing actions

### A.2.1 Obtaining an install ID

To acquire the token for the command, see “Installing, activating, uninstalling, or transferring licenses” (page 34).

To obtain an Install ID:

1. Use the following command to obtain the SDN controller-assigned `install_id` value.

   curl [options] -H "X-Auth-Token:" \
   https://<controller_ip>:8443/sdn/v2.0/licenses/installid

   - Replace `<token>`with the token created in step 2.
   - Replace `<controller_ip>` with your controller IP address.

   **NOTE:** If you are installing a High Availability license, enter the IP address of the lead controller.

   A numerical `install_id` appears. For example: `1249679`
2. Record your `install_id` for use in the next part of the license registration process.

## A.2.2 Activating a license on the controller

Using your license key, you must now activate a license on the controller, completing the license registration and activation process.

To activate a license on the controller:

1. If your previous cURL session has closed or timed out, re–enter the authentication command to obtain a new token. See Section "Authentication manager" (page 27).
2. Use this command to activate the license on the controller.

   curl [options] -H "X-Auth-Token:<token>" \
   -d <license_key> \
   https://<controller_ip>:8443/sdn/v2.0/licenses

   - Replace `<token>` with the token you obtained using the authentication command.
   - Replace `<license_key>` with the key obtained in "Registering your license and obtaining a license key". You can view the key by logging on to the **My Network** portal and selecting **My Licenses**, as shown in Figure 33.
   - Replacec`<controller_id>` with your controller IP address.

   **NOTE:** If you are installing a High Availability license, enter the IP address of the lead controller.

The installed license information appears in JSON format, as shown below.

**Example 2 Installed license output**

```
{
  "license" : {
    "install_id" : 1249679,
    "serial_no" : 13,
    "license_metric" : "HA Controller",
    "product" : "HP VAN SDN Ctrl Base",
    "metric_qty" : 500,
    "license_type" : "PRODUCTION",
    "base_license" : false,
    "creation_date" : "2013-09-06T00:26:52.248+0000",
    "activated_date" : "2013-09-06T00:26:52.248+0000",
    "expiry_date" : "2014-01-14T00:26:52.248+0000",
    "license_status" : "ACTIVE"
  }
}
```

## A.2.3 Uninstalling licenses to prepare for transfer

To uninstall licenses, see "Installing, activating, uninstalling, or transferring licenses" (page 34).

1. Use the following command to obtain information about all installed licenses on your controller.

   curl [options] -H "X-Auth-Token:<token>" \
   https://<controller_ip>:8443/sdn/v2.0/licenses

   - Replace `<token>` with the token created in step 1.
   - Replace `controller_ip` with your controller IP address.

     **NOTE:** If you are uninstalling a High Availability license, enter the IP address of the lead controller.

   The installed license information appears in JSON format, as shown below.

   **Example 3 All installed licenses output**

```
{
  "licenses" : [{
    "install_id" : 12491640,
    "serial_no" : 12,
    "license_metric" : "Controller Node",
    "product" : "HP VAN SDN Ctrl Base",
    "metric_qty" : 52,
    "license_type" : "PRODUCTION",
    "base_license" : true,
    "creation_date" : "2013-09-06T00:26:52.248+0000",
    "activated_date" : "2013-09-06T00:26:52.248+0000",
    "expiry_date" : "2014-01-14T00:26:52.248+0000",
    "license_status" : "ACTIVE"
  },{
}
 "licenses" : {
    "install_id" : 12491640,
    "serial_no" : 13,
    "license_metric" : "HA Controller",
    "product" : "HP VAN SDN Ctrl Base",
    "metric_qty" : 500,
    "license_type" : "PRODUCTION",
    "base_license" : false,
    "creation_date" : "2013-09-06T00:26:52.248+0000",
    "activated_date" : "2013-09-06T00:26:52.248+0000",
    "expiry_date" : "2014-01-14T00:26:52.248+0000",
    "license_status" : "ACTIVE"
  }]
}
```

2. Record each `serial_no` value.
3. Use the following command to uninstall, or deactivate, each active license on your controller:

   curl [options] -H "X-Auth-Token:" \
   -d deactivate \
   https://<controller_ip>:8443/sdn/v2.0/licenses/<serial_number>/action

   - Replace `<token>` with the token you obtained using the authentication command.
   - Replace `<controller_ip>` with your controller IP address.

     **NOTE:** If you are installing a High Availability license, enter the IP address of the lead controller.

   - Replace `<serial_number` with the serial number of the license you want to deactivate. You can view the key by logging on to the **My Network** portal and selecting **My Licenses**, as shown in Figure 33.

The license uninstall key appears in JSON format, as shown below.

**Example 4 License uninstall key output**

```
{
  "license" : {
    "install_id" : 1249679,
    "serial_no" : 13,
    "license_metric" : "HA Controller",
    "product" : "HP VAN SDN Ctrl Base",
    "metric_qty" : 500,
    "license_type" : "PRODUCTION",
    "base_license" : false,
    "creation_date" : "2013-09-06T00:26:52.248+0000",
    "activated_date" : "2013-09-06T00:26:52.248+0000",
    "expiry_date" : "2014-01-14T00:26:52.248+0000",
  "license_uninstall_key" : "MYOCD9JMCRRRM-IRTEQ2QUNBYCB-6Q6CJIEIJFKIQ-VAI2QUJBYC433"
    "license_status" : "INACTIVE"
  }
}
```

4. Record your `license_uninstall_key`. For example:

**Example 5 Security token obtained from output**

The `license_uninstall_key` obtained from the example in the previous step is:

`MYOCD9JMCRRRM-IRTEQ2QUNBYCB-6Q6CJIEIJFKIQ-VAI2QUJBYC433`

# A.3 Application manager actions

## A.3.1 Listing applications

### Form

```
curl [options] -H "X-Auth-Token:<token>" \
      https://<controller_ip>:8443/sdn/v2.0/apps
```

### Example of listing applications

```
curl -ksS -H "X-Auth-Token:3d61f0d3e61349359e6dbd82ec02c113" \
      https://10.0.1.42:8443/sdn/v2.0/apps
```

### Example output:


```
{
    "apps": [
      {
      "action": "NONE",
       "catalog_id": "",
      "deployed": "2014-06-18T19:22:49.536Z",
      "desc": "Path Diagnostic Utility",
       "download_url": "",
      "name": "Path Diagnostics",
      "product_id": "",
      "sku": "",
      "state": "ACTIVE",
      "uid": "com.hp.sdn.ctl.diag",
      "vendor": "Hewlett-Packard",
      "version": "2.3.5.6370"
     },
     {
      "action": "NONE",
```

```
    "catalog_id": "",
    "deployed": "2014-06-18T19:22:50.890Z",
    "desc": "Link Management",
    "download_url": "",
    "name": "Link Manager",
    "product_id": "",
    "sku": "",
    "state": "ACTIVE",
    "uid": "com.hp.sdn.ctl.linkdisco",
    "vendor": "Hewlett-Packard",
    "version": "2.3.5.6370"
   }
  ]
 }
```


## A.3.2 Listing information about an application

### Form

```
curl [options] -H "X-Auth-Token:<token>" \
      https://<controller_ip>:8443/sdn/v2.0/apps/<app_id>
```

### Example

```
curl -ksS -H "X-Auth-Token:3d61f0d3e61349359e6dbd82ec02c113" \
      https://10.0.1.42:8443/sdn/v2.0/apps/com.hp.sdn.ctl.diag
```

### Example output


```
{
    "app": {
     "action": "NONE",
     "catalog_id": "",
     "deployed": "2014-06-18T19:22:49.536Z",
     "desc": "Path Diagnostic Utility",
     "download_url": "",
     "name": "Path Diagnostics",
     "product_id": "",
     "sku": "",
     "state": "ACTIVE",
     "uid": "com.hp.sdn.ctl.diag",
     "vendor": "Hewlett-Packard",
     "version": "2.3.5.6370"
    }
   }
```


## A.3.3 Getting application health status

The HEAD command on health status returns only the response code rather than the entire message for management-type clients that want to poll for health status. Returns HTTP status as follows:

200 for healthy
290 for unhealthy
295 for critical

### Form

```
curl [options] -H "X-Auth-Token:" -w %{http_code} \
      -X HEAD https://<controller_ip>:8443/sdn/v2.0/apps/<app_id>/health
```

### Example

```
curl -ksS -H "X-Auth-Token:3d61f0d3e61349359e6dbd82ec02c113" -w %{http_code} \
      -X HEAD https://10.0.1.42:8443/sdn/v2.0/apps/com.hp.sdn.ctl.diag/health
```

### Example output

```
200
```

## A.3.4 Uploading an application (new or upgrade)

### Form

```
curl [options] -H "X-Auth-Token:<token>" \
      -X POST https://<controller_ip>:8443/sdn/v2.0/apps/ \
      --data-binary @<full_path_to_app_zip>
```

### Example

```
curl -ksS -H "X-Auth-Token:3d61f0d3e61349359e6dbd82ec02c113" \
      -X POST https://10.0.1.42:8443/sdn/v2.0/apps/ \
      --data-binary @/home/hummer/dev/flare/dist/testApps/geewiz-apps-1.0.0.zip
```

### Example output (new)


```
{
      "app": {
        "action": "NONE",
        "catalog_id": "",
        "deployed": "1970-01-01T00:00:00.000Z",
        "desc": "Gee Wiz event production",
        "download_url": "",
        "name": "GeeWiz",
        "product_id": "",
        "sku": "",
        "state": "STAGED",
        "uid": "com.geewiz",
        "vendor": "Gee Wiz, Inc.",
        "version": "1.0.0"
      }
     }
```


### Example output (upgrade)


```
{
      "app": {
        "action": "NONE",
        "catalog_id": "",
        "deployed": "2014-06-18T23:04:25.955Z",
        "desc": "Gee Wiz event production",
        "download_url": "",
        "name": "GeeWiz",
        "product_id": "",
        "sku": "",
        "state": "UPGRADE_STAGED",
        "uid": "com.geewiz",
        "vendor": "Gee Wiz, Inc.",
        "version": "2.0.0"
      }
    }
```

## A.3.5 Installing a new application

### Form

```
curl [options] -H "X-Auth-Token:" \
      -X POST https://<controller_ip:8443/sdn/v2.0/apps/<app_id>/action \
       -d install
```

### Example

```
curl -ksS -H "X-Auth-Token:3d61f0d3e61349359e6dbd82ec02c113" \
      -X POST https://10.0.1.42:8443/sdn/v2.0/apps/com.geewiz/action \
      -d install
```

### Example output


```
{
    "app": {
      "action": "NONE",
      "catalog_id": "",
      "deployed": "2014-06-18T21:46:39.845Z",
      "desc": "Gee Wiz event production",
      "download_url": "",
      "name": "GeeWiz",
      "product_id": "",
      "sku": "",
      "state": "ACTIVE",
      "uid": "com.geewiz",
      "vendor": "Gee Wiz, Inc.",
      "version": "1.0.0"
       }
    }
```


## A.3.6 Upgrading an application

### Form

```
curl [options] -H "X-Auth-Token:<token>" \
      -X POST https://<controller_ip>:8443/sdn/v2.0/apps/<app_id>/action \
      -d upgrade
```

### Example

```
curl -ksS -H "X-Auth-Token:3d61f0d3e61349359e6dbd82ec02c113" \
      -X POST https://10.0.1.42:8443/sdn/v2.0/apps/com.geewiz/action \
       -d upgrade
```

### Example output


```
{
     "app": {
       "action": "NONE",
       "catalog_id": "",
       "deployed": "2014-06-18T23:04:25.955Z",
       "desc": "Gee Wiz event production",
       "download_url": "",
       "name": "GeeWiz",
       "product_id": "",
       "sku": "",
       "state": "ACTIVE",
       "uid": "com.geewiz",
       "vendor": "Gee Wiz, Inc.",
```

```
    "version": "2.0.0"
   }
  }
```


## A.3.7 Disabling an application

### Form

```
curl [options] -H "X-Auth-Token:<token>" \
     -X POST https://<controller_ip>:8443/sdn/v2.0/apps/<app_id>/action \
     -d disable
```

### Example

```
curl -ksS -H "X-Auth-Token:3d61f0d3e61349359e6dbd82ec02c113" \
     -X POST https://10.0.1.42:8443/sdn/v2.0/apps/com.geewiz/action \
     -d disable
```

### Example output


```
{
     "app": {
       "action": "NONE",
       "catalog_id": "",
       "deployed": "2014-06-18T23:04:25.955Z",
       "desc": "Gee Wiz event production",
       "download_url": "",
       "name": "GeeWiz",
       "product_id": "",
       "sku": "",
       "state": "DISABLED",
       "uid": "com.geewiz",
       "vendor": "Gee Wiz, Inc.",
       "version": "2.0.0"
     }
   }
```


## A.3.8 Enabling an application

### Form

```
curl [options] -H "X-Auth-Token:<token>" \
     -X POST https://<controller_ip>:8443/sdn/v2.0/apps/<app_id>/action \
     -d enable
```

### Example

```
curl -ksS -H "X-Auth-Token:3d61f0d3e61349359e6dbd82ec02c113" \
     -X POST https://10.0.1.42:8443/sdn/v2.0/apps/com.geewiz/action \
     -d enable
```

### Example output


```
{
     "app": {
       "action": "NONE",
       "catalog_id": "",
       "deployed": "2014-06-18T23:04:25.955Z",
       "desc": "Gee Wiz event production",
       "download_url": "",
       "name": "GeeWiz",
       "product_id": "",
```

```
    "sku": "",
    "state": "ACTIVE",
    "uid": "com.geewiz",
     "vendor": "Gee Wiz, Inc.",
    "version": "2.0.0"
  }
}
```

## A.3.9 Removing a staged application

This curl request is used to remove a newly uploaded application before it is installed or upgraded. It has no output.

### Form

```
curl [options] -H "X-Auth-Token:<token>" \
     -X POST https://<controller_ip>:8443/dn/v2.0/apps/<app_id>/action \
    -d cancel
```

### Example

```
curl -ksS -H "X-Auth-Token:3d61f0d3e61349359e6dbd82ec02c113" \
     -X POST https://10.0.1.42:8443/sdn/v2.0/apps/com.geewiz/action \
     -d cancel
```

## A.3.10 Deleting an application

This curl request is used to shutdown and completely remove all application versions. It has no output.

### Form

```
curl [options] -H "X-Auth-Token:<token>" \
     -X DELETE https://<controller_ip>:8443/sdn/v2.0/apps/<app_id>
```

### Example

```
curl -ksS -H "X-Auth-Token:3d61f0d3e61349359e6dbd82ec02c113" \
     -X DELETE https://10.0.1.42:8443/sdn/v2.0/apps/com.geewiz
```

# B Scripts

## B.1 Configuring a controller team

This script configures a team composed of three controllers.

**NOTE:** Because the scripts in this appendix cross page boundaries, be careful to avoid including the page number when copying a script. Copying a script one page at a time can prevent inclusion of page numbers.

```
========== ===== ====================================================
#!/bin/bash
#-------------------------------------------------------------------------------
# Copyright 2013 Hewlett Packard Co., All Rights Reserved.
#-------------------------------------------------------------------------------
#
# Script to configuring a team (ie, create a team).
#
#
#
#-------------------------------------------------------------------------------
tok="/tmp/tok.txt"
token="$([ -f $tok ] && cat $tok)"
#echo $token
url="https://127.0.0.1:8443/sdn/v2.0/team"
#echo $url
createTeam="{
\"team\":
{
   \"ip\": \"10.143.0.100\",
   \"members\":[
    {
      \"ip\": \"10.143.0.10\"
    },
    {
      \"ip\": \"10.143.0.11\"
      },
      {
        \"ip\": \"10.143.0.12\"
       }
      ]
     }
    }"
#echo $createTeam
# Attempt to create team
postResp=`curl --noproxy ${SCA:-localhost} --header "X-Auth-Token:$token" \
--fail -ksSfL --request POST --url "$url" \
-H "Content-Type: application/json" --data-binary "$createTeam
" ` errorCode=$?
echo $errorCode
echo $postResp
echo "exiting script"
exit 0
```

## B.2 Backing up a controller team

**NOTE:** Because the scripts in this appendix cross page boundaries, be careful to avoid including the page number when copying a script. Copying a script one page at a time can prevent inclusion of page numbers.

```
#!/bin/bash
#-------------------------------------------------------------------------------
# Copyright 2013 Hewlett Packard Co., All Rights Reserved.
#-------------------------------------------------------------------------------
#
# Backup a Team
```

```
#-------------------------------------------------------------------------------
export BACKUP_DIR="/opt/sdn/backup"
export BACKUP_TEAM_DIR="/opt/sdn/team_backup"
export TEAM_BACKUP_STATUS_FILE="$BACKUP_TEAM_DIR/teamBackup_status"
export TEAM_BACKUP_LOGFILE="$BACKUP_TEAM_DIR/teamBackup_log.log"
export BACKUP_WAIT_COUNT=200 # this * 10 = seconds to wait for backup to finish
export B_PID=$$
trap "exit 1" TERM
#===============================================================================
# F U N C T I O N S
#===============================================================================
#-------------------------------------------------------------------------------
# Function validateTeamLead ( )
# Validates configured node IP against the team leader IP.
#-------------------------------------------------------------------------------
function validateTeamLead {
leaderIp=`ifconfig|grep -o $leaderIp`
if [ "$leaderIp" == "" ]; then
teamBackup_log "Run this script from the team lead node."
exitBackup 1
fi
teamBackup_log "Leader node IP $leaderIp is correctly configured."
}
#-------------------------------------------------------------------------------
# Function validateTeamBackupStatus ( )
# Checks if a new backup can be started.
#-------------------------------------------------------------------------------
function validateTeamBackupStatus {
TEAM_BACKUP_ON="backup_in_progress=true"
# Check if any backup is going on now.
if [ -e "$TEAM_BACKUP_STATUS_FILE" ]; then
teamBackup_log "Backup status file $TEAM_BACKUP_STATUS_FILE exists."
backupStatus=`cat $TEAM_BACKUP_STATUS_FILE`
if [ "$backupStatus" == "$TEAM_BACKUP_ON" ]; then
teamBackup_log "Backup already in progress, aborting new backup..."

exitBackup 1
fi
fi
rm -rf $BACKUP_TEAM_DIR
mkdir $BACKUP_TEAM_DIR
chmod 777 $BACKUP_TEAM_DIR
echo $TEAM_BACKUP_ON>$TEAM_BACKUP_STATUS_FILE
teamBackup_log "No backup is currently in progress. A new backup can start."
}
#-------------------------------------------------------------------------------
# Function backupNode ( <nodeIndex> )
# Backs up a node.
#-------------------------------------------------------------------------------
function backupNode {
local nodeIndex=$1
local backupToken=${nodeAuth[$nodeIndex]}
local backupIp=${ipArr[$nodeIndex]}
local backupUUID=${nodeUUID[$nodeIndex]}
backupURL="https://$backupIp:8443/sdn/v2.0/backup
post $backupIp $backupToken "$backupURL"
if [ $errorCode -ne 0 ]; then
teamBackup_log "Failed to start backup for $backupIp."
exitBackup 1
fi
if [ "$sessionID" == "" ]; then
teamBackup_log "Failed to start backup on $backupIp."
exitBackup 1
fi
echo $sessionID
}
#-------------------------------------------------------------------------------
# Function downloadBackupSet ( <nodeIndex> )
# Downloads the backup file from each node to the team leader node, verifying the checkum.
#-------------------------------------------------------------------------------
function downloadBackupSet {
local nodeIndex=$1
local backupAuth=${nodeAuth[$nodeIndex]}
local backupIp=${ipArr[$nodeIndex]}
local backupUUID=${nodeUUID[$nodeIndex]}
local fileName=""
if [ "$backupIp" == "$leaderIp" ]; then
fileName="$BACKUP_TEAM_DIR/sdn_controller_backup_$backupIp.Leader.zip"
else
fileName="$BACKUP_TEAM_DIR/sdn_controller_backup_$backupIp.zip"
fi
```

```
backupUrl="https://$backupIp:8443/sdn/v2.0/backup"
`get $backupIp $backupAuth $backupUrl > $fileName`
expected=`get $nodeIP "v2.0/backup/checksum"`
actual=$(sha256sum "$fileName" | cut -d ' ' -f1)
if [ "$expected" != "$actual" ]; then
echo "Checksum failure: expected $expected but got $actual."
exitBackup 1
fi
teamBackup_log "Successfully copied backup MD5 file from $backupIp."
}
}
#-------------------------------------------------------------------------------
# Function verifyBackupStatus ( <nodeIndex> )
# Verifies the success of the backup.
#-------------------------------------------------------------------------------
function verifyBackupStatus {
local nodeIndex=$1
local backupIP=${ipArr[$nodeIndex]}
local backupUrl="https://$backupIP:8443/sdn/v2.0/backup/status"
backupStatus[$nodeIndex]=`get $backupIP ${nodeAuth[$nodeIndex]} $backupUrl`
if [ "${backupStatus[$nodeIndex]}" == "SUCCESS" ]; then
teamBackup_log "Backup completed successfully on $backupIP."
let "backup_complete = $backup_complete - 1"
return
fi
}

#-------------------------------------------------------------------------------
# Function teamBackupZip ( )
# Creates a single zip for all the team backup data.
#-------------------------------------------------------------------------------
function teamBackupZip {
teamZip=`date|tr ' ' '_'|tr ':' '_'`
teamZip="$BACKUP_TEAM_DIR/sdn_team_backup_$teamZip.zip"
rm -rf $BACKUP_TEAM_DIR/sdn_team_backup* $TEAM_BACKUP_STATUS_FILE
zip -r $teamZip $BACKUP_TEAM_DIR/
rm -rf $BACKUP_TEAM_DIR/sdn_controller_backup*
}
#-------------------------------------------------------------------------------
# Function remoteBackupFileCopy ( )
# Copies the team backup zip to the specified remote location.
#-------------------------------------------------------------------------------
function remoteBackupFileCopy {
if [ "$remotePath" == "" ]; then
teamBackup_log "Team backup data was not copied to the remote location."
return
fi
teamBackup_log "Copying team backup to the remote location $remotePath..."
scp $BACKUP_TEAM_DIR/sdn_team_backup* $remotePath
}
#-------------------------------------------------------------------------------
# Function getSysInfo ( <authToken> )
# Gets the SysInformation for the running node.
#-------------------------------------------------------------------------------
function getSysInfo {
local leadAuth=$1
local sysUrl="https://localhost:8443/sdn/v2.0/systems"
for i in {1..5}; do
sysInfo=`get localhost $leadAuth "$sysUrl"`
if [ $errorCode -ne 0 ]; then
teamBackup_log "Failed to retrieve the system information."
exitBackup 1
fi
[ "$sysInfo" != "" ] && break
sleep 5
done
if [ "$sysInfo" == "" ]; then
teamBackup_log "Failed to retrieve the system information."
exitBackup 1
fi
}
#-------------------------------------------------------------------------------
# Function extractRole_NodeIP ( <systemInfo>)
# Extracts IP and role for all the nodes in a team.
#-------------------------------------------------------------------------------
function extractRole_NodeIP {
sysinfo=$1
ipArr=($(echo $sysinfo|tr -d '"'| tr -d '['|tr -d ']'| sed -e 's/\,/\n/g'| grep -w "ip"| cut -d ':' -f2-))
roleArr=($(echo $sysinfo|tr -d '"'| tr -d '['|tr -d ']'| sed -e 's/\,/\n/g'| grep -w "role"| cut -d ':' -f2-))
numNodes=${#ipArr[@]}
teamBackup_log "Number of nodes in the team is $numNodes."
for (( i=0; i<=$numNodes; i++ )); do
if [ "${roleArr[$i]}" == "leader" ]; then
leaderIp=${ipArr[$i]}
teamBackup_log "The team leader is $leaderIp."
break
```

```
fi
done
}
#-------------------------------------------------------------------------------
# Function teamBackup_log ( <message> )
# Writes messages to the log for the team backup operation.
#-------------------------------------------------------------------------------
function teamBackup_log {
msg="$1"
echo "$msg" |tee -a $TEAM_BACKUP_LOGFILE
}
#-------------------------------------------------------------------------------
# Function exitBackup ( <exitStatus> )
# Exits the backup.
#-------------------------------------------------------------------------------
function exitBackup {
[ $1 -ne 0 ] && teamBackup_log "Stopping backup/restore with errors."
rm -rf $TEAM_BACKUP_STATUS_FILE
kill -s TERM $B_PID
exit $1
}
#-------------------------------------------------------------------------------
# Function get ( <ipAddr> <authToken> <url> )
# Performs a GET.
#-------------------------------------------------------------------------------
function get {
local getIP=$1
local getToken=$2
local getUrl=$3
local attempts=0
while [ $attempts -lt 5 ]; do
curl --noproxy $getIP --header "X-Auth-Token:$getToken" \
--fail -ksS -L -f --request GET --url "$getUrl"
errorCode=$?
let "attempts = $attempts + 1"
if [ 35 -eq $errorCode ]; then
teamBackup_log "SSL error on GET of $getUrl, retrying..."
continue;
fi
break;
done
}
#-------------------------------------------------------------------------------
# Function post ( <ipAddr> <authToken> <url> <data>)
# Performs a POST of the specified data.
#-------------------------------------------------------------------------------
function post {
local postIP=$1
local postToken=$2
local postUrl=$3
local postData=$4
local attempts=0
while [ $attempts -lt 5 ]; do
postRes=`curl --noproxy $postIP --header "X-Auth-Token:$postToken" \
--fail -ksS --request POST --url "$postUrl" --data-binary "$postData"`
errorCode=$?
let "attempts = $attempts + 1"
if [ 35 -eq $errorCode ]; then
teamBackup_log "SSL error on POST to $postUrl, retrying..."
continue;
fi

break;
done
echo $postRes
}
#-------------------------------------------------------------------------------
# Function put ( <ipAddr> <authToken> <url> <data> )
# Performs a PUT of the specified data.
#-------------------------------------------------------------------------------
function put {
local putIP=$1
local putToken=$2
local putUrl=$3
local putData=$4
local attempts=0
while [ $attempts -lt 5 ]; do
putRes=`curl --noproxy $putIP --header "X-Auth-Token:$putToken" \
--fail -ksS -L -f --request PUT "$putUrl" --data-binary "$putData"`
errorCode=$?
let "attempts = $attempts + 1"
if [ 35 -eq $errorCode ]; then
teamBackup_log "SSL error on POST to $putUrl, retrying"
continue;
fi
break;
done
echo $putRes
}
#-------------------------------------------------------------------------------
# Function extractJSONString ( <json> <fieldName> )
# Extracts the Json value corresponding to the field name.
#-------------------------------------------------------------------------------
```

```
function extractJSONString {
json=$1
field=$2
json=`echo $json|tr -d '"'| sed -e 's/\,\|{/\n/g'|grep -w "$field"| \
cut -d ':' -f2-`
echo $json
}
#-------------------------------------------------------------------------------
# Function getAuthToken ( <ipAddr> )
# Log-in and get the UID.
#-------------------------------------------------------------------------------
function getAuthToken {
local nodeIP=$1
url="https://$nodeIP:8443/sdn/v2.0/auth"
login="{
\"login\": {
\"domain\": \"$domain\",
\"user\": \"$user\",
\"password\": \"$pass\"
}
}"
# Attempt to authenticate and extract token if successful.
auth=$(curl --noproxy $nodeIP -X POST --fail -ksSfL --url "$url" \
-H "Content-Type: application/json" --data-binary "$login" 2>&1)
if [ $? -ne 0 ]; then
teamBackup_log "Unable to authenticate as user $user in $domain domain."
exitBackup 1
fi
authToken=`extractJSONString "$auth" "token" | sed '/^$/d'`
if [ $restore_mode -ne 1 ] && [ "$authToken" == "" ]; then
teamBackup_log "Failed to get the authentication token."
exitBackup 1
fi
echo $authToken
}
#===============================================================================
# M A I N
#===============================================================================
restore_mode=0
# Check for zip package.
command -v zip &> /dev/null
if [ $? -ne 0 ]; then
echo "The zip package must be installed to use this script."
exit 1
fi
# Check the user specified script parameters.
if [ $# -lt 2 ]; then
echo "Usage : backupTeam <user> <domain> [<user@ip:path>]"
echo " <user> - user name to access the controller"
echo " <domain> - domain of the controller"
echo " [<user@ip:path>] - remote location to store backup file"
echo " user - the login name for the system"
echo " ip - the ip address of the system"
echo " path - where to copy the file to on the remote system"
exit 1
fi
validateTeamBackupStatus
user="$1"
echo -n "Enter Controller Password: "
read -s pass
echo
domain="$2"
remotePath=$3
errorCode=0
# Get the authentication token for the local controller.
leaderAuth=`getAuthToken localhost`
# Get the system Information for the local controller.
getSysInfo $leaderAuth
# Get the set of team IPs and their associated team roles.
extractRole_NodeIP $sysInfo
(validateTeamLead)
# Initiate a backup on each node.
for (( i=0; i<$numNodes; i++ )); do
nodeAuth[$i]=`getAuthToken ${ipArr[$i]}`
uuidURL="https://${ipArr[$i]}:8443/sdn/v2.0/systems"
nodeUUID[$i]=`get ${ipArr[$i]} ${nodeAuth[$i]} "$uuidURL?ip=${ipArr[$i]}"`
nodeUUID[$i]=`extractJSONString "${nodeUUID[$i]}" "uid" | sed '/^$/d'`
if [ "${ipArr[$i]}" == "$leaderIp" ]; then
# Skip the leader backup backup, since it will be done last.
leaderIndex=$i
continue
fi
backupNode $i
teamBackup_log "Started backup on ${ipArr[$i]}."
done
# Verify the status of the backup on each node.
backup_complete=$numNodes
waitTime=$(($BACKUP_WAIT_COUNT*10/60))
for (( k=0; k<$BACKUP_WAIT_COUNT; k++ )); do
if [ $backup_complete -le 1 ]; then
teamBackup_log "Backup on all member nodes completed successfully."
```

```
break
fi
sleep 10
for (( i=0; i<$numNodes; i++ )); do
# Skip the leader node check, since it will be done last.
[ "${ipArr[$i]}" == "$leaderIp" ] && continue
# Backup already completed for this node, so continue.
[ "${backupStatus[$i]}" == "SUCCESS" ] && continue
verifyBackupStatus $i
done
done
if [ $backup_complete -gt 1 ]; then
teamBackup_log "Backup of all member nodes took longer than $waitTime min. Aborting backup..."
teamBackup_log "To increase backup wait time, change BACKUP_WAIT_COUNT in the script."
exitBackup 1
fi
# Last, backup the leader node to avoid synchronization issues on a restore.
backupNode $leaderIndex
teamBackup_log "Started backup on leader ${ipArr[$leaderIndex]}."
backup_complete=1

# Verify the backup on the leader node.
for (( k=0; k<$BACKUP_WAIT_COUNT; k++ )); do
sleep 10
verifyBackupStatus $leaderIndex
if [ $backup_complete -le 0 ]; then
teamBackup_log "Backup on the leader node completed successfully."
break
fi
done
if [ $backup_complete -gt 0 ]; then
teamBackup_log "Backup of the leader node took longer than $waitTime min. Aborting backup..."
teamBackup_log "To increase backup wait time, change BACKUP_WAIT_COUNT in the script."
exitBackup 1
fi
# Copy all the backup files from each node in the team onto the leader node.
for (( i=0; i<$numNodes; i++ )); do
downloadBackupSet $i
done
# Create one zip for entire team and copy it to the specified remote location.
teamBackupZip
remoteBackupFileCopy
echo
teamBackup_log "The team was backed up successfully."
exitBackup 0
```

## B.3 Restoring a controller team

**NOTE:** Before running this script, re-install the controller. Otherwise an Error 404 condition results and the controller is not restored. See "Restoring a controller from a backup " (page 95).

Because the scripts in this appendix cross page boundaries, be careful to avoid including the page number when copying a script. Copying a script one page at a time can prevent inclusion of page numbers.

```
#!/bin/bash
#-------------------------------------------------------------------------------
# Copyright 2013 Hewlett Packard Co., All Rights Reserved.
#-------------------------------------------------------------------------------
#
# Restore a Team
#-------------------------------------------------------------------------------
export BACKUP_DIR="/opt/sdn/backup"
export BACKUP_TEAM_DIR="/opt/sdn/team_backup"
export RESTORE_TEAM_DIR="/opt/sdn/team_restore"
export TEAM_BACKUP_STATUS_FILE="$RESTORE_TEAM_DIR/teamRestore_status"
export TEAM_BACKUP_LOGFILE="$RESTORE_TEAM_DIR/teamRestore_log.log"
export RESTORE_BACKUP_FILESET="$RESTORE_TEAM_DIR/opt/sdn/team_backup"
export B_PID=$$
trap "exit 1" TERM
#===============================================================================
# F U N C T I O N S
#===============================================================================
#-------------------------------------------------------------------------------
# Function extract_zip_and_ip ( )
# Extracts the team backup zip and the backed up IP addresses.
#-------------------------------------------------------------------------------
function extract_zip_and_ip {
unzip -o "$RESTORE_TEAM_DIR/sdn_team_backup*" -d $RESTORE_TEAM_DIR
if [ $? -ne 0 ]; then
teamBackup_log "Failed to unzip the team backup file."
```

```
exitBackup 1
fi
teamBackup_log "Extracted the team backup file successfully."
rm -rf "$RESTORE_TEAM_DIR/sdn_team_backup*"
backupIp=($(ls $RESTORE_BACKUP_FILESET | grep "zip$" | sed "s/.zip//" | \
sed "s/.Leader//" | sed "s/sdn_controller_backup_//"))
numBackup=${#backupIp[@]}
teamBackup_log "Found $numBackup backup file sets in the team backup file."
}
#-------------------------------------------------------------------------------
# Function create_restoreDir ( )
# Creates the team restore directory.
#-------------------------------------------------------------------------------
function create_restoreDir {
rm -rf $RESTORE_TEAM_DIR
mkdir $RESTORE_TEAM_DIR
chmod 777 $RESTORE_TEAM_DIR
}
#-------------------------------------------------------------------------------
# Function validate_my_Ip ( )
# Validates the configured node IP against the backed up IP addresses.
#-------------------------------------------------------------------------------
function validate_my_Ip {
for (( v=0; v<numBackup; v++ )); do
myip=`ifconfig|grep -o "${backupIp[$v]}"`
if [ "$myip" != "" ]; then
teamBackup_log "IP $myip is a valid member of the team."
return
fi
done
teamBackup_log "IP $myip is not a valid member of the team, exiting."
exitBackup 1
}
#-------------------------------------------------------------------------------
# Function upload_backup_file ( <systemIp> <systemUUID> <authToken> <zipFile> )
# Uploads backup file to the specific nodes of the team.
#-------------------------------------------------------------------------------
function upload_backup_file {
local sysIp=$1
local sysUUID=$2
local sysAuth=$3
local uploadUrl="https://$sysIp:8443/sdn/v2.0/restore/backup"
local zipFile=$4
if [ ! -f $zipFile ]; then
teamBackup_log "File $zipFile does not exist."
exitBackup 1
fi
curl --noproxy $sysIp -X POST --fail -ksSfL --url $uploadUrl \
-H "X-Auth-Token:$sysAuth"\
--data-binary @$zipFile
if [ $? -ne 0 ]; then
teamBackup_log "Failed to upload backup $zipFile to $sysIp."
exitBackup 1
fi
teamBackup_log "Backup $zipFile uploaded successfully to $sysIp."
}
#-------------------------------------------------------------------------------
# Function restore_node ( <systemIp> <systemUUID> <authToken> )
# Restores a particular node.
#-------------------------------------------------------------------------------
function restore_node {
local sysIp=$1
local sysUUID=$2
local sysAuth=$3
local restoreUrl="https://$sysIp:8443/sdn/v2.0/restore"
# Set the IP first. Ignore errors since this only works for standalone.
put $sysIp $sysAuth "https://$sysIp:8443/sdn/v2.0/systems/$sysUUID" \
"{\"system\":{\"ip\":\"$sysIp\"}}" > /dev/null 2>&1
restoreSession=`post $sysIp $sysAuth $restoreUrl `
if [ $errorCode -ne 0 ]; then
teamBackup_log "Failed to start restore on node $sysIp."
exitBackup 1
fi
teamBackup_log "Started restore on node $sysIp."
}
#-------------------------------------------------------------------------------
# Function validate_node_status ( )
# Validates node status after the restore.
#-------------------------------------------------------------------------------
function validate_node_status {
local sysIp=$1
# Wait for the restore to complete.
local sysUrl="https://$sysIp:8443/sdn/v2.0/systems"
for (( k=0; k<100; k++ )); do
sleep 30
authToken=`getAuthToken $sysIp`
[ "$authToken" == "" ] && continue
# Try to contact the system.
data=`get $sysIp $authToken "$sysUr?ip=$sysIp"`
[ "$data" == "" ] && continue
teamBackup_log "Node:$sysIp came up successfully." && return
done
teamBackup_log "Node:$sysIP failed to come up."
```

```
exitBackup 1
}
#-------------------------------------------------------------------------------
# Function restore_nodes ( <ipAddrArray> )
# Restores only the specified node(s).
#-------------------------------------------------------------------------------
function restore_nodes {
local leaderindex=-1
local restoreIpArr=("$@")
local numNodes=${#restoreIpArr[@]}
for (( i=0; i<$numNodes; i++ )); do
# Get the auth token for a specific node.
restoreAuth[$i]=`getAuthToken ${restoreIpArr[$i]}`
if [ "${restoreAuth[$i]}" == "" ]; then
teamBackup_log "Failed to get the auth Token for ${restoreIpArr[$i]}, can't start restore."
exitBackup 1
fi
uuidURL="https://${restoreIpArr[$i]}:8443/sdn/v2.0/systems"
restoreUUID[$i]=`get ${restoreIpArr[$i]} ${restoreAuth[$i]} "$uuidURL"`
if [ "${restoreUUID[$i]}" == "" ]; then
teamBackup_log "Failed to get the UUID for ${restoreIpArr[$i]}, can't start restore."
exitBackup 1
fi
restoreUUID[$i]=`extractJSONString "${restoreUUID[$i]}" "uid" | sed '/^$/d'`
teamBackup_log "UUID for ${restoreIpArr[$i]} is ${restoreUUID[$i]}"
# Upload the backup files to a specific node.
local ipFileName="sdn_controller_backup_${restoreIpArr[$i]}*.zip"
local zipFile=`ls $RESTORE_BACKUP_FILESET/$ipFileName`
upload_backup_file ${restoreIpArr[$i]} ${restoreUUID[$i]} \
${restoreAuth[$i]} $zipFile
# Check if this is the leader node from the backup set.
local leaderZip=`echo $zipFile|grep "Leader"`
[ "$leaderZip" != "" ] && leaderIndex=$I
done
# Start restore in the leader node first before all the other nodes.
if [ $leaderIndex -ne -1 ]; then
restore_node ${restoreIpArr[$leaderIndex]} ${restoreUUID[$leaderIndex]} \
${restoreAuth[$leaderIndex]}
fi
# Verify the leader node is up after the restore.
validate_node_status ${restoreIpArr[$leaderIndex]}
# Continue restore on the remaining nodes.
for (( i=0; i<$numNodes; i++ )); do
# Skip the leader node; it's already done.
[ $i -eq $leaderIndex ] && continue
# Restore the specified node.
restore_node ${restoreIpArr[$i]} ${restoreUUID[$i]} ${restoreAuth[$i]}
done
sleep 200
# Validate that the restored nodes are up.
for (( n=0; n<$numNodes; n++ )); do
# Skip the leader node; it's already done.
[ $n -eq $leaderIndex ] && continue
validate_node_status ${restoreIpArr[$n]}
done
}
#-------------------------------------------------------------------------------
# Function teamBackup_log ( <message> )
# Writes messages to the log for the team backup operation.
#-------------------------------------------------------------------------------
function teamBackup_log {
msg="$1"
echo "$msg" |tee -a $TEAM_BACKUP_LOGFILE
}
#-------------------------------------------------------------------------------
# Function exitBackup ( <exitStatus> )
# Exits the backup.
#-------------------------------------------------------------------------------
function exitBackup {
[ $1 -ne 0 ] && teamBackup_log "Stopping backup/restore with errors."
rm -rf $TEAM_BACKUP_STATUS_FILE
kill -s TERM $B_PID
exit $1
}
#-------------------------------------------------------------------------------
# Function get ( <ipAddr> <authToken> <url> )
# Performs a GET.
#-------------------------------------------------------------------------------
function get {
local getIP=$1
local getToken=$2
local getUrl=$3
local attempts=0
while [ $attempts -lt 5 ]; do
curl --noproxy $getIP --header "X-Auth-Token:$getToken" \
--fail -ksS -L -f --request GET --url "$getUrl"
errorCode=$
?
let "attempts = $attempts + 1"
if [ 35 -eq $errorCode ]; then
teamBackup_log "SSL error on GET of $getUrl, retrying..."
continue;
fi
```

```
break;
done
}
#-------------------------------------------------------------------------------
# Function post ( <ipAddr> <authToken> <url> <data>)
# Performs a POST of the specified data.
#-------------------------------------------------------------------------------
function post {
local postIP=$1
local postToken=$2
local postUrl=$3
local postData=$4
local attempts=0
while [ $attempts -lt 5 ]; do
postRes=`curl --noproxy $postIP --header "X-Auth-Token:$postToken" \
--fail -ksS --request POST --url "$postUrl" --data-binary "$postData"`
errorCode=$?
let "attempts = $attempts + 1"
if [ 35 -eq $errorCode ]; then
teamBackup_log "SSL error on POST to $postUrl, retrying..."
continue;
fi
break;
done
echo $postRes
}
#-------------------------------------------------------------------------------
# Function put ( <ipAddr> <authToken> <url> <data> )
# Performs a PUT of the specified data.
#-------------------------------------------------------------------------------
function put {
local putIP=$1
local putToken=$2
local putUrl=$3
local putData=$4
local attempts=0
while [ $attempts -lt 5 ]; do
putRes=`curl --noproxy $putIP --header "X-Auth-Token:$putToken" \
--fail -ksS -L -f --request PUT "$putUrl" --data-binary "$putData"`
errorCode=$?
let "attempts = $attempts + 1"
if [ 35 -eq $errorCode ]; then
teamBackup_log "SSL error on POST to $putUrl, retrying"
continue;
fi
break;
done
echo $putRes
}
#-------------------------------------------------------------------------------
# Function extractJSONString ( <json> <fieldName> )
# Extracts the Json value corresponding to the field name.
#-------------------------------------------------------------------------------
function extractJSONString {
json=$1
field=$2
json=`echo $json|tr -d '"'| sed -e 's/\,\|{/\n/g'|grep -w "$field"| \
cut -d ':' -f2-`
echo $json
}
#-------------------------------------------------------------------------------
# Function getAuthToken ( <ipAddr> )
# Log-in and get the UID.
#-------------------------------------------------------------------------------
function getAuthToken {
local nodeIP=$1
url="https://$nodeIP:8443/sdn/v2.0/auth"
login="{
\"login\": {
\"domain\": \"$domain\",
\"user\": \"$user\",
\"password\": \"$pass\"
}
}
}"
# Attempt to authenticate and extract token if successful.
auth=$(curl --noproxy $nodeIP -X POST --fail -ksSfL --url "$url" \
-H "Content-Type: application/json" --data-binary "$login" 2>&1)
if [ $? -ne 0 ]; then
teamBackup_log "Unable to authenticate as user $user in $domain domain."
exitBackup 1
fi
authToken=`extractJSONString "$auth" "token" | sed '/^$/d'`
if [ $restore_mode -ne 1 ] && [ "$authToken" == "" ]; then
teamBackup_log "Failed to get the authentication token."
exitBackup 1
fi
echo $authToken
}
#===============================================================================
# M A I N
#===============================================================================
restore_mode=1
```

```
selective_restore=0
# Check for unzip package.
command -v unzip &> /dev/null
if [ $? -ne 0 ]; then
echo "The unzip package must be installed to use this script."
exit 1
fi
# Check the user specified script parameters.
if [ $# -lt 3 ]; then
echo "Usage : restoreTeam <user> <domain> [<ip1> <ip2> ...] <user@IP:path>"
echo " <user> - user name to access the controller"
echo " <domain> - domain of the controller"
echo " [<ip1> <ip2> ...] - ip(s) of node(s) to be restored; if none are specified all nodes are restored"
echo " <user@IP:path> - remote location to retrieve backup file"
echo " user - the login name for the system"
echo " ip - the ip address of the system"
echo " path - where to copy the file from on the remote system"
exit 1
fi
create_restoreDir
user="$1"
echo -n "Enter Controller Password: "
read -s pass
echo
domain="$2"
file=""
if [ $# -eq 3 ]; then
teamBackup_log "Starting the team restore. This will restore all the nodes in a team."
file=$3
else
teamBackup_log "Starting selective restore on specified IPs. This restore will happen only on the specified
nodes."
count=0
selective_restore=1
for ip in "$@"; do
restoreIp[$count]=$ip
let "count = $count + 1"
done
fileIndex=$(($# - 1))
file=${restoreIp[$fileIndex]} && unset restoreIp[$fileIndex]
fi
# Upload the team backup file from the user specified location.
scp $file $RESTORE_TEAM_DIR
if [ $? -ne 0 ]; then
teamBackup_log "Failed to upload team backup file to the node."
exitBackup 1
fi
# Unzip the team backup file.
extract_zip_and_ip
# Validate the IP address of the node.
validate_my_Ip
# Restore the node(s).
if [ $selective_restore -eq 1 ]; then
restore_nodes ${restoreIp[@]}
else
restore_nodes ${backupIp[@]}
fi
echo
teamBackup_log "The team was restored successfully."
exitBackup 0
```

# Index