Network Plug and Play

This chapter provides information about the Network Plug and Play (PnP) feature in the Cisco Nexus 7000 Series Switches, and contains the following sections:

- Finding Feature Information, on page 1
- Feature History for Network Plug and Play, on page 2
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- Configuring the Upstream Switch to Broadcast PnP, on page 11
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Finding Feature Information

Your software release might not support all the features documented in this module. For the latest caveats and feature information, see the Bug Search Tool at https://tools.cisco.com/bugsearch/ and the release notes for your software release. To find information about the features documented in this module, and to see a list of the releases in which each feature is supported, see the “New and Changed Information” section or the "Feature History" table.

Feature History for Network Plug and Play

This table lists the release history for this feature.

Table 1: Feature History for Network Plug and Play

Feature Name	Releases	Feature Information	
Network Plug and Play	8.2(1)	This feature was introduced. Network Plug and Play (PnP) is a software application that runs on a Cisco Nexus 7000 Series Switch. The PnP feature provides a simple, secure, unified, and integrated offering to make a new branch or campus rollouts much easier, or for provisioning updates to an existing or a new network. This feature provides a unified approach to provision networks comprising multiple devices with a near-zero-touch deployment experience.	

Information About Network Plug and Play

Network Plug and Play (PnP) is a software application that runs on a Cisco Nexus 7000 Series Switch. The PnP feature provides a simple, secure, unified, and integrated offering to make a new branch or campus rollouts much easier, or for provisioning updates to an existing or a new network. This feature provides a unified approach to provision networks comprising multiple devices with a near-zero-touch deployment experience.

Simplified deployment reduces the cost and complexity and increases the speed and security of the deployments. The PnP feature helps simplify the deployment of any Cisco device by automating the following deployment-related operational tasks:

- Establishing initial network connectivity for a device.
- Delivering device configuration to the controller.
- Delivering software and firmware images to the controller.
- Delivering licenses to the controller.
- Delivering deployment script files to the controller.
- Provisioning local credentials of a switch.
- Notifying other management systems about deployment-related events.

The PnP is a client-server based model. The client (agent) runs on a Cisco Nexus 7000 Series Switch and the server (controller) runs on the Cisco DNA Controller.

PnP uses a secure connection to communicate between the agent and the controller. This communication is encrypted.

The PnP agent converge solutions that exist in a network into a unified agent and adds additional functionality to enhance the current solutions. The main objectives of the PnP agent are:

- Provide consistent Day 0 deployment solution for all the deployment scenarios.
- Add new or required features to improve existing solutions.
- Provide Day 2 management framework mainly in the context of configuration and image upgrades.

Features Provided by the Network Plug and Play (PnP) Agent

Some of the features that the PnP agent provides are:

- Day 0 bootstrapping. This includes the configuration, image, licenses, and other files.
- Day 2 management. This includes the configuration and image upgrades and ongoing monitoring of Simple Network Management Protocol (SNMP) and syslog messages.
- Open communication protocol. This enables customers and partners to write applications.
- XML-based payload over HTTP.
- Security. This includes authentication and encrypted communication channel between the management app and the agent.
- Deployment and management of devices behind firewall and Network Address Translation (NAT).
- Support for one-to-one and one-to-many communication.
- Support for policy-based deployment (product ID or location of the device).
- Deployment based on unique ID (Unique Device Identifier [UDI] or MAC).
- Support for various deployment scenarios and use cases.
- Zero-touch deployment is performed whenever possible. Low-touch deployment is performed based on the need.

When a device is powered on for the first time, the PnP discovery process, which is embedded in the device, gets enabled in the absence of a startup configuration file and attempts to discover the address of the PnP controller or server. The PnP agent uses methods such as DHCP, Domain Name System (DNS), and others to acquire the desired IP address of the PnP server.

When the PnP agent successfully acquires the IP address, it initiates a long-term, bidirectional Layer 3 connection with the server and waits for a message from the server. The PnP server application sends messages to the corresponding agent, requesting for information about the devices and the services to be performed on the device.

The agent running on the Cisco Nexus 7000 Series switch then configures the IP address on receiving the DHCP acknowledgment and establishes a secure channel with the controller to provision the configurations. The switch then upgrades the image and applies the configurations.

Discovery Methods

A PnP agent discovers the PnP controller or server using one of the following methods:

- DHCP-based discovery
- DNS-based discovery
- PnP connect

After the discovery, the PnP agent writes the discovered information into a file, which is then used to handshake with the PnP server (DNA controller/APIC-EM).

The following tasks are carried out by the agent in the PnP discovery phase:

- Brings up all the interfaces.
- Sends a DHCP request in parallel for all the interfaces.
- On receiving a DHCP reply, configures the IP address and mask, default route, DNS server, domain name, and writes the PnP server IP in a lease-parsing file. Note that there is no DHCP client in Cisco Nexus Switches and static configuration is required.
- Brings down all the interfaces.

DHCP-Based Discovery

When the switch is powered on and if there is no startup configuration, the PnP starts with DHCP discovery. DHCP discovery obtains the PnP server connectivity details.

The PnP agent configures the following:

- IP address
- Netmask
- Default gateway
- DNS server
- Domain name

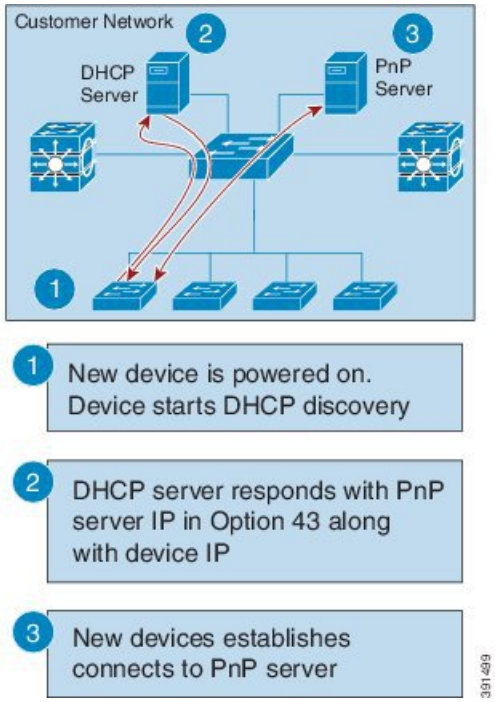
If the agent configuration fails, you should manually intervene and configure the switch.

DHCP discovery has the following flow:

- Power on the switch.
- Switch will boot up, the PnP process will be started, as there is no configuration present.
- Start DHCP discovery.
- DHCP Server replies with the PnP agent and the PnP server configuration.
- PnP agent handshakes with the PnP server.
- Download the image, install, and reload.
- Download and apply the configuration from the controller.
- Reload the switch.

A device with no startup configuration in the NV-RAM triggers the PnP agent to initiate a DHCP discovery process, which acquires the IP configuration from the DHCP server required for the device. The DHCP server can be configured to insert additional information using vendor-specific Option 43. Upon receiving Option 60 from the device with the string (cisco pnp), to pass on the IP address or hostname of the PnP server to the requesting device. When the DHCP response is received by the device, the PnP agent extracts the Option 43 from the response to get the IP address or the hostname of the PnP server. The PnP agent then uses this IP address or hostname to communicate with the PnP server.

Figure 1: DHCP Discovery Process for PnP Server



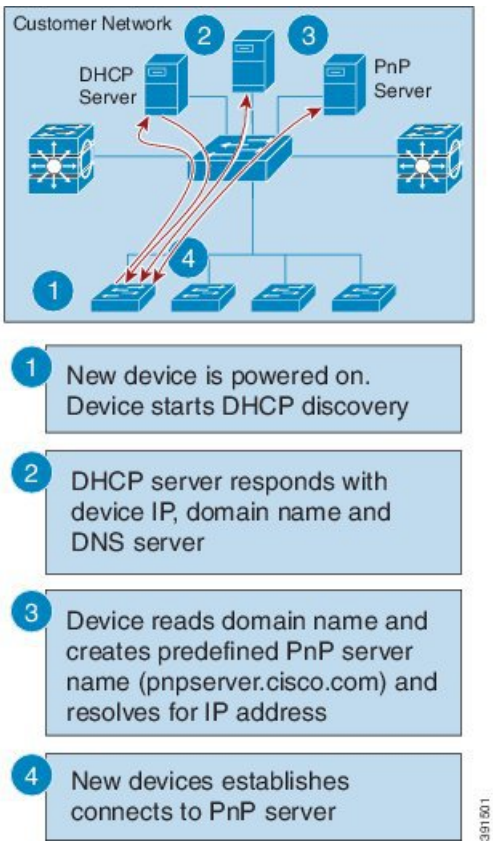
DNS-Based Discovery

When the DHCP discovery fails to get the PnP server, the agent falls back to DNS-based discovery. To start the DNS-based discovery, the following information is required from DHCP:

- IP address and netmask
- Default gateway
- DNS server IP
- Domain name

The agent obtains the domain name of the customer network from the DHCP response and constructs the fully qualified domain name (FQDN). The following FQDN is constructed by the PnP agent using a preset deployment server name and the domain name information for the DHCP response. The agent then looks up the local name server and tries to resolve the IP address for the above FQDN.

Figure 2: DNS Lookup for pnpserver.[domainname].com



Note The device reads domain name and creates predefined PnP server name as pnpserver.[domain name].com, for example; pnpserver.cisco.com.

Plug and Play Connect

When the DHCP and the DNS discovery fail, the PnP agent discovers and communicates with Cisco Cloud-based deployment service for initial deployment. The PnP agent directly opens an HTTPS channel using the Python library, which internally invokes OpenSSL to talk with cloud for configuration.

Cisco Power On Auto Provisioning

Cisco Power On Auto Provisioning (PoAP) communicates with the DHCP and TFTP servers to download the image and configurations. With the introduction of the PnP feature, PnP and PoAP coexist together in a Cisco Nexus 7000 switch. PoAP and PnP interworking has the following processes:

- PoAP starts first no configuration is present in the system.
- PnP starts later if PoAP does not get provisioned.
- PoAP and PnP discover the controller alternatively.
- The controller discovery process continues until a controller or until the admin aborts auto provision.
- The process (POAP or PnP) that finds the controller continues provisioning and the other process that does not find the controller is notified and eventually terminated.

Services and Capabilities of the Network Plug and Play Agent

The PnP agent performs the following tasks:

- Backoff
- Capability
- CLI execution
- Configuration upgrade
- Device information
- Certificate install
- Image install
- Redirection

Note The PnP controller or server provides an optional checksum tag to be used in the image installation and configuration upgrade service requests by the PnP agent. When the checksum is provided in a request, the image install process compares the checksum against the current running image checksum.

If the checksums are same, the image being installed or upgraded is the same as the current image running on the device. The image install process will not perform any other operation in this scenario.

If the checksums are not the same, the new image will be copied to the local file system, and the checksum will be calculated again and compared with the checksum provided in the request. If they are the same, the image install process continues to install the new image or upgrade the device to the new image. If the checksums are not the same, the process exits with an error.

Backoff

A Cisco NX-OS device that supports PnP protocol, which uses HTTP transport, requires the PnP agent to send the work request to the PnP server continuously. If the PnP server does not have any scheduled or outstanding PnP service for the PnP agent to execute, the continuous no-operation work requests exhaust both the network bandwidth and the device resources. This PnP backoff service allows the PnP server to inform the PnP agent to rest for the specified time and call back later.

Capability

Capability service request is sent by the PnP server to the PnP agent on a device to query the supported services by the agent. The server then sends an inventory service request to query the device's inventory information; and then sends an image installation request to download an image and install it. After getting the response from the agent, the list of supported PnP services and features are enlisted and returned back to the Server.

CLI Execution

Cisco NX-OS supports two modes of command execution, privileged EXEC mode and global configuration mode. Most of the EXEC commands are one-time commands, such as **show** commands, which show the current configuration status, and clear commands, which clear counters or interfaces. The EXEC commands are not saved when a device reboots. Configuration mode commands allow user to make changes to the running configuration. If you save the configuration, these commands are saved when a device reboots.

Configuration Upgrade

Two types of configuration upgrades takes place in a Cisco device—copying new configuration files to the startup configuration and copying new configuration files to the running configuration.

Copying new configuration files to the startup configuration—A new configuration file is copied from the file server to the device using the **copy** command, and the file check task is performed to check the validity

of the file. If the file is valid, the file is copied to the startup configuration. The previous configuration file is backed up if enough disk space is available. The new configuration comes into effect when the device reloads again.

Copying new configuration files to the running configuration—A new configuration file is copied from the file server to the device using the **copy** command or **configure replace** command. Replace and rollback of configuration files may leave the system in an unstable state if rollback is performed inefficiently. Therefore, configuration upgrade by copying the files is preferred.

Device Information

The PnP agent provides the capability to extract device inventory and other important information to the PnP server on request. The following device-profile request types are supported:

- all—Returns complete inventory information, which includes unique device identifier (UDI), image, hardware, and file system inventory data.
- filesystem—Returns file system inventory information, which includes file system name and type, local size (in bytes), free size (in bytes), read flag, and write flag.
- hardware—Returns hardware inventory information, which includes hostname, vendor string, platform name, processor type, hardware revision, main memory size, I/O memory size, board ID, board rework ID, processor revision, mid-plane revision, and location.
- image—Returns image inventory information, which includes version string, image name, boot variable, return to ROMMON reason, bootloader variable, configuration register, configuration register on next boot, and configuration variables.
- UDI—Returns the device UDI.

Certificate Install

Certificate install is a security service through which a PnP server requests the PnP agent on a device for trust pool or trust point certificate installation or uninstallation. This service also specifies the agent about the primary and backup servers for reconnection. The following prerequisites are required for a successful certificate installation:

- The server from which the certificate or trust pool bundle needs to be downloaded should be reachable.
- There should not be any permission issues to download the certificate or the bundle.
- The PKI API should be available and accessible for the PnP agent so that the agent could call to download and install the certificate or the bundle.
- There is enough memory on the device to save the downloaded certificate or bundle.

Image Install

The image install service enables a PnP-enabled device to perform image upgrade on receiving a request from the PnP server.

An Image Install request can be made for the following types of devices:

- Standalone devices
- High-availability devices
- Stackable devices
- Cisco Nexus 7000 Series devices

Standalone Devices

When the PnP agent on a standalone device receives a request from the PnP server, the agent parses the XML payload and identifies the request as an Image Upgrade request. The agent then creates an ImageInstall process, which identifies the request as a standalone image install request.

High-Availability Devices

When the PnP agent is installed on a high-availability device, and the ImageInstall service gets the data structure, the agent determines if the request is for a high-availability device. The active route processor (RP) that is running the PnP agent performs all the tasks required to install the image on both the active and standby devices.

Redirection

The Redirection service is used to redirect a device to another controller.

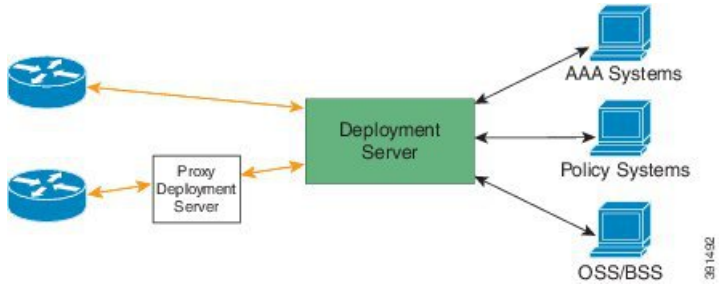
PnP Agent

The PnP agent is an embedded software component that is present in all Cisco network devices that support simplified deployment architecture. The PnP agent understands and interacts only with a PnP server. The PnP agent first tries to discover a PnP server, with which it can communicate. After a server is found and connection established, the agent performs deployment-related activities such as configuration, image, license, and file updates by communicating with the server. It also notifies the server of all interesting deployment-related events such as out-of-band configuration changes and new device connections on an interface.

PnP Server

The PnP server is a central server that encodes the logic of managing and distributing deployment information (images, configurations, files, and licenses) for the devices being deployed. The server communicates with the agent on the device that supports the simplified deployment process using a specific deployment protocol.

Figure 3: Simplified Deployment Server



The PnP server also communicates with proxy servers such as deployment applications on smart phones and PCs, or other PnP agents acting as Neighbor Assisted Provisioning Protocol (NAPP) servers, and other types of proxy deployment servers such as VPN gateways.

The PnP server can redirect the PnP agent to another deployment server. A common example of redirection is a PnP server redirecting a device to communicate with it directly after sending the bootstrap configuration through a NAPP server. A PnP server can be hosted by an enterprise. This solution allows for a cloud-based deployment service provided by Cisco. In this case, a device discovers and communicates with Cisco cloud-based deployment service for initial deployment. After that, it can be redirected to the customer's deployment server.

In addition to communicating with the devices, the server interfaces with a variety of external systems such as authentication, authorizing, and accounting (AAA) systems, provisioning systems, and other management applications.

PnP Agent Deployment

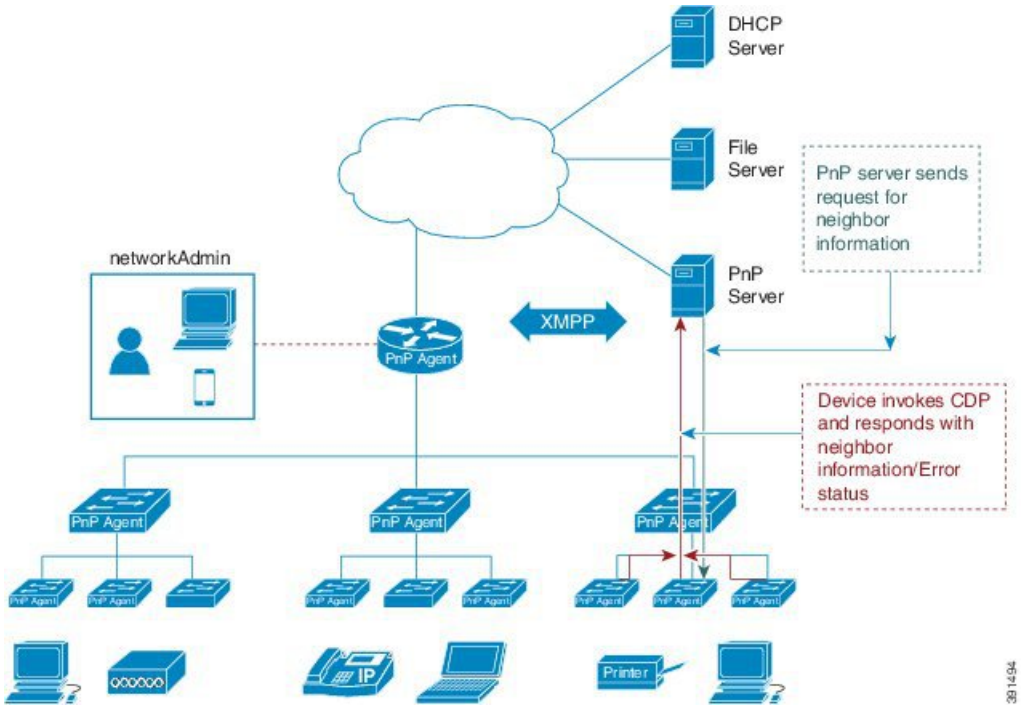
The following steps indicate the PnP agent deployment procedure on Cisco devices:

1. A Cisco device with a PnP agent contacts the PnP server, requesting for a task, that is, the PnP agent sends UDI along with a request for work.

2. If the PnP server has a task for the device, for example, image installation, configuration, upgrade, and so on, it sends a work request.
3. After the PnP agent receives the work request, it executes the task and sends back a reply to the PnP server about the task status, that is whether it is successful or if an error has occurred, and the corresponding information that is requested.

PnP Agent Network Topology

Figure 4: Network Topology of Cisco PnP Agent Deployment



PnP Agent Initialization

The PnP agent is enabled by default, but can be initiated on a device when the startup configuration is not available.

Absence of Startup Configuration

New Cisco devices are shipped to customers with no startup configuration file in the NVRAM of the devices. When a new device is connected to a network and powered on, the absence of a startup configuration file on the device automatically triggers the PnP agent to discover the PnP server IP address.

CLI Configuration for the PnP Agent

PnP supports devices that are using VLAN 1 by default. To use a VLAN other than 1, adjacent upstream devices must configure the **pnp startup-vlan** *vlan-id* command on the upstream device.

This configuration on the upstream switch directs the VLAN that needs to be configured by the downstream switch for PnP provisioning. The VLAN value is exchanged with the downstream switch using Cisco Discovery Protocol (CDP) type, length, values (TLVs). All the inband ports of the downstream switch are configured as a trunk on receiving the **pnp startup vlan** from CDP TLV for Day 0 provisioning.

Guidelines for the PnP Deployment

- The PnP deployment method depends on the discovery process required for finding the PnP controller or server.
- The discovery mechanism should be deployed, either as a DHCP server discovery process or a Domain Name Server (DNS) discovery process, before launching PnP.
- The DHCP server or the DNS server should be configured before deploying PnP.
- The PnP server should communicate with the PnP agent.
- PnP connect does not require a DHCP or DNS configuration.
- PnP runs both the in-band and the management interfaces.
- IPv6 support for PnP is not available for Cisco Nexus 7000 Series devices.
- The kickstart and system images must be bundled into a tar file to update in APIC-EM.
- The bootflash should have enough space to download the image and configurations from APIC-EM.

Configuring the Upstream Switch to Broadcast PnP

Configure and Start the DPT capture

Procedure

Step 1 Enable the global configuration mode.

Example:

```
switch#configure terminal
```

Step 2 Configure the upstream switch to broadcast PnP VLAN over the Cisco Discovery Protocol (CDP):

Example:

```
switch(config)# pnp startup-vlan vlan ID
```

Note
To use a VLAN other than 1, adjacent upstream devices must configure the **pnp startup-vlan** *vlan-id* command on the upstream device. This configuration must be performed to push this command to the upcoming PnP device.

When you execute the **pnp startup-vlan** *vlan-id* command on an adjacent upstream device, the VLAN membership change does not happen on that device. However, all the active interfaces on the upcoming PnP device are changed to the specified VLAN.

Step 3 Exit global configuration mode and enter privileged EXEC mode:

Example:

```
switch(config)#end
```

Step 4 Verify the PnP status.

Example:

```
switch# show pnp status
```

Step 5 Display the PnP summary.

Example:

```
switch# show pnp summary
```

Step 6 Display the configured PnP profiles.

Example:

```
switch# show pnp profiles
```

Step 7 Troubleshoot PnP using these commands.

Example:

```
switch#show pnp internal info
switch#show pnp internal stats
switch#show logging log | grep -i pnp
switch#Show pnp internal trace
switch#show pnp internal msgs
switch# show tech-support pnp
```

Configuration Examples for Network Plug and Play

Example: Troubleshooting PnP

The following examples shows the PnP troubleshooting command outputs:

```
Switch# show pnp internal info

PnP Global Information
UDI:
VDC: switch
Platform: N77
Serial Number: FXS1820Q0MQ
Product ID: N77-C7706
 Software Version: 8.2(0)SK(1)
State:
PnP Phase: Init
FSM State: PNP_STATE_INIT
PnP Accelerated: No
Global Variable:
MTS Q FD: 11
```

```
Switch# show logging log | grep -i pnp

2017 Jan  3 13:01:42 switch %PNP-2-PNP_INFO: PnP Ignited
2017 Jan  3 13:01:59 switch %PNP-2-PNP_INFO: PnP Accelerated
2017 Jan  3 13:03:00 switch %PNP-2-PNP_INFO: PnP Starting DHCP Discovery
2017 Jan  3 13:03:01 switch %PNP-2-PNP_INFO: PnP Received Valid Offer, Saved.
2017 Jan  3 13:03:01 switch %PNP-2-PNP_INFO: PnP Received Best Offer, Saved.
2017 Jan  3 13:03:10 switch %PNP-2-PNP_INFO: Configuring IP Address from DHCP
```

```
Switch# show pnp internal stats

PnP Status
Invalid Argument : 0
No Memory : 0API Failed : 0
Net L2 Reg Failed : 0
Device Discovey Failed : 0
Pump Failed : 0
Create Event Faild : 0
Tx Failed : 0
Timer Faild : 0
```