

Cisco Network Plug and Play Agent

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Prerequisites for Cisco Network Plug and Play Agent

- Cisco Network Plug and Play (PnP) deployment method depends on the type of discovery process as required by the customer.
- Deploy the discovery mechanism, either a DHCP server discovery process or a Domain Name Server (DNS) discovery process, before launching the PnP.
- Configure the DHCP server or the DNS server before deploying the PnP.
- Ensure that the PnP server talks to the PnP agent.
- Ensue that the Cisco Network PnP Agent has connectivity with the PnP Server. The Cisco Network PnP Agent should be able to PING server.
- The PnP agent enforces the PnP server to send user credentials for every request. Cisco recommends the usage of HTTP secure (HTTPS) protocol.

Note

- The terms Cisco Network Plug and Play, PnP are interchangeably used in this guide and all mean the same.
- The terms PnP agent, agent, and deployment agent are interchangeably used in this guide and all mean the same.
- The terms PnP server, server, and deployment server are interchangeably used in this guide and all mean the same.

Restrictions for Cisco Network Plug and Play Agent

- Cisco Network Plug and Play (PnP) agent facilitates HTTP and HTTP secure (HTTPS) transport based communication with the server.
- HTTPS cannot be used on platforms where crypto-enabled images are not supported (also, do not use Secure Sockets Layer [SSL] or Transport Layer Security [TLS] protocols if crypto-enabled images are used).
- Non-VLAN 1 configuration-Cisco Network Plug and Play supports devices using VLAN 1 by default. To use a VLAN other than 1, adjacent upstream devices must use supported releases and configure the following global CLI command on the upstream device to push this CLI to the upcoming Plug and Play device: **pnp startup-vlan x**. When you execute this command on an adjacent upstream device, the VLAN membership change does not happen on that device. However, all the active interfaces on the upcoming Plug and Play device are changed to the specified VLAN. This guideline applies to both routers and switches.

Note When performing a firmware upgrade during the PNP process, it is best to remove any old images on the router to prevent an incorrect image from loading.

Further details are available by viewing CSCwd68868.

Information About Cisco Network Plug and Play Agent

Cisco Network Plug and Play Deployment Solution

The Cisco Network PnP Agent is a part of Cisco Network Plug and Play solution. The Cisco initiated Network Plug and Play (PnP) deployment solution supports the concept of redirection and includes a PnP agent, a PnP server, and other components. Simplified deployment process of any Cisco device automates the following deployment related operational tasks:

- Establishing initial network connectivity for the device
- Delivering device configuration

- Delivering software and firmware images
- Delivering licenses
- Delivering deployment script files
- Provisioning local credentials
- Notifying other management systems about deployment related events

Simplified deployment reduces the cost and complexity and increases the speed and security of deployments.

Cisco Network Plug and Play (PnP) agent is a software application that is running on a Cisco IOS or IOS-XE device. The PnP agent together with the PnP deployment server provides effortless deployment services. When a device is powered on for the first time, the PnP agent process wakes up in the absence of the startup config, user input on the device's console, and attempts to discover the address of the PnP server. The PnP agent uses methods like 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 lived, bidirectional layer 3 connection with the server and waits for a message from the server. The PnP server application sends messages to the agent requesting for information and services to be performed on the device.

The PnP agent converges existing solutions into a unified agent and adds functionality to enhance the current solutions. The main objectives of PnP agent are:

- Provide consistent day 1 deployment solution for all the deployment scenarios.
- Add new features to improve existing solutions.
- Provide day 2 management framework mainly in the context of configuration and image upgrades.

Cisco Network Plug and Play Features

Some of the features that the Cisco Network Plug and Play agent provides:

- Day 0 boot strapping—Configuration, image, licenses, and other files
- Day 2 management—Configuration and image upgrades and on-going monitoring of Simple Network Management Protocol (SNMP) and syslog messages.
- Open communication protocol—Enables customers and partners to write applications
- XML based payload over HTTP between the server and the agent.
- Security—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)
- Unified solution across Cisco platforms (including IOS classic)
- Support for various deployment scenarios and use cases
- Zero-touch when possible, low-touch when needed

Cisco Network Plug and Play Agent Services and Capabilities

The services and capabilities of the Cisco Network Plug and Play agent are as follows:

1. Backoff
2. CLI execution
3. Configuration upgrade
4. Device information
5. File transfer
6. Image install
7. License install
8. PnP tagging
9. Script execution
10. Topology information



Note The PnP server provides an optional checksum tag to be used in the image installation and config upgrade service requests by the PnP agent. When the checksum is provided in the 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 same, then the new image will be copied to the local file system, and checksum will again be calculated and compared against the checksum provided in the request. If same, the process will continue to install the new image or upgrade the device to new image. If now, the checksums are not same, the process will exit with error.

Backoff

A Cisco IOS device that supports PnP protocol (that uses HTTP transport), requires the PnP agent to send the work request to the PnP server continuously. In case the PnP server does not have any scheduled or outstanding PnP service for the PnP agent to execute, the continuous no operation work requests exhausts both network bandwidth and device resource. This PnP backoff service allows the PnP server to inform the PnP agent to rest for the specified time and call back later.

CLI Execution

Cisco IOS supports two modes of command execution—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 modes allow user to make changes to the running configuration. If you save the configuration, these commands are saved when a device reboots.



Note For **show** command request and response details and for all PnP configuration commands, see *Cisco Network Plug and Play Agent Command Reference*.

Configuration Upgrade

There are two types of configuration upgrades that can happen in a Cisco device—copying a new configuration files to startup configuration and copying new configuration files to running configuration.

Copying a new configuration files to startup configuration— The new configuration file is copied from the file server to the device through **copy** command and file check is performed to check the validity of the file. If the file is valid, then the file is copied to startup configuration. Backing up the previous configuration file will be done if there is enough disk space available. The new configuration is seen when the device reloads again.

Copying new configuration files to running configuration— The new configuration file is copied from the file server to the device through **copy** command or **configure replace** command. Configuration file replace and rollback may leave the system in an unstable state if rollback is performed efficiently. So configuration upgrade by copying the files is preferred.

Device Information

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

1. all—returns complete inventory information, which includes unique device identifier (UDI), image, hardware and file system inventory data.
2. 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.
3. 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, midplane revision, and location.
4. 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 variable.
5. UDI— returns device UDI.

File Transfer

The PnP file server hosts files that can be copied over by the deploying devices in the network. The file server can be a dedicated server hosting files or a part of the device hosting the PnP server. The PnP agent uses standard file transfer protocols to copy files from the remote file server to the device. If the device is running a crypto image then secured file transfer protocols such as SFTP, SCP, HTTPS are supported. For devices running non-crypto images, the PnP agent supports unsecured copy protocols such as FTP, TFTP, HTTP.

Image Install

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

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. The PnP agent populates the data structure defined by the ImageInstall service and passes it to the ImageInstall service.

The Image Install service then performs the following operations to successfully load the device with the new image:

1. Copies the image from the file server to a local disk (the file server information is provided by the PnP server in the request).
2. Configures the device to load the new image on next reload by executing the **boot system** command.
3. Reloads the device and sends a message to the PnP server.

PnP Tagging

Cisco IOS provides capability to assign tags to the devices for better grouping and tracking of all Cisco devices. The PnP agent provides XML service for configuring the tag information on the device and for propagating the tag information within the network using Cisco Discovery Protocol (CDP). The purpose of this service is for the PnP agents to get to know their tag information and to pass on this information to the PnP server upon request.

Topology Information

By default, every Cisco device on the network runs Cisco Discovery Protocol (CDP). Through CDP, devices in the network discover their immediate neighbors and populate their databases with the attributes learnt or derived through the protocol. This neighbor information is stored in the database and is available on demand by the device to the PNP server. Typical neighbor information comprises neighboring device ID, software version, hardware platform, interface ip, and the port on which CDP messages are sent or received.

Software Maintenance Upgrade

The software maintenance upgrade (SMU) is a package that contains fixes for a specific defect or security resolution to a released image. SMUs are created to respond to immediate issues and do not include new features. SMUs do not have a large impact on router operations. SMU versions are synchronized to the package major, minor, and maintenance versions they upgrade.

To install and activate a software maintenance upgrade package:

Procedure

Step 1 Use the **install add** <*filename*> command to unpack the package software file and copy it to the boot device (usually disk0). If the file is on a remote source, use the tftp/ftp option to copy the file to the device.

After the file is copied to the device, information within the package is used to verify compatibility with the target cards and with the other active software. Actual activation is performed only after the package compatibility and application program interface (API) compatibility checks are passed.

Step 2 To activate a package, use the **install activate** <*filename*> command. The activate operation will run the compatibility checks and install the software maintenance upgrade package. If it is a reload software maintenance upgrade, it will automatically initiate a reload.

Step 3 Use the **install commit** command to commit the changes

Step 4 To deactivate the package, use the **install deactivate** <*filename*> command.

Step 5 If you find that you prefer a previous package set over the currently active package set, you can use the **install rollback to committed** command to make a previously active package set active again

Step 6 To remove the installed version, use the **install remove** <*filename*> command.

This example shows how to install and remove the software maintenance upgrade package on a device.

```
install add <filename>
install activate <filename>
install commit
install rollback to committed
install remove <filename>
```

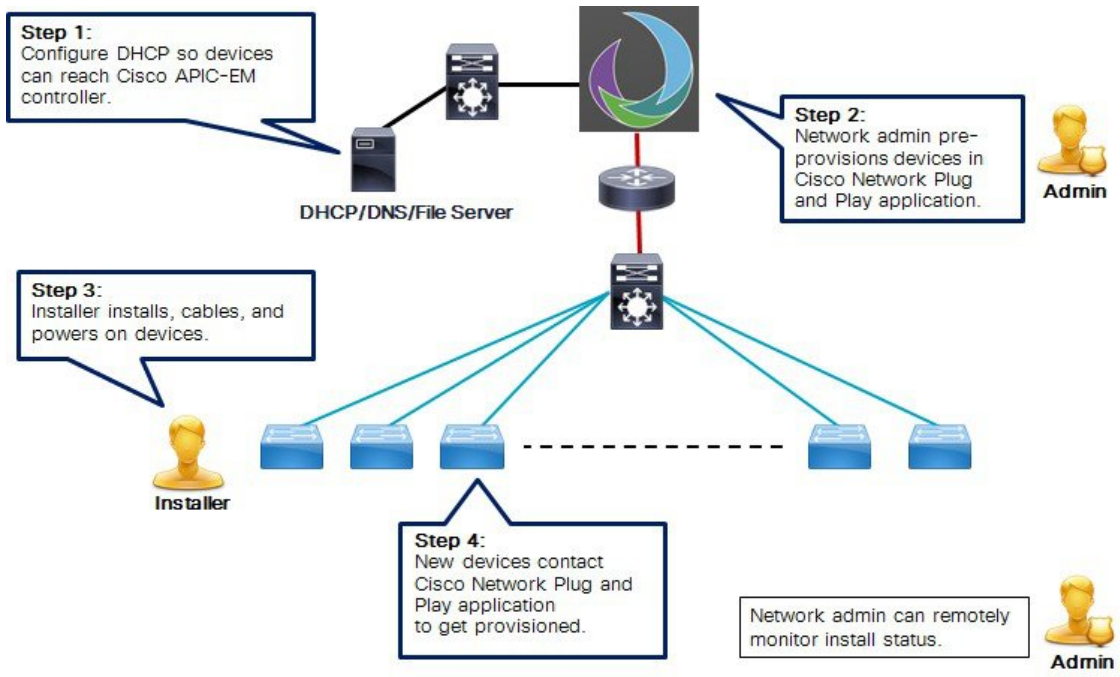
Cisco Network Plug and Play Agent

The Cisco Network Plug and Play 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. Once a server is found and connection established, the agent performs deployment related activities like configuration, image, license, and file updates by communicating with the server. It also notifies the server of all interesting deployment related events like out-of-band configuration changes and a new device connection on an interface.

Cisco Network Plug and Play Server

The Cisco Network Plug and Play 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 1: Simplified Deployment Server



The PnP server also communicates with proxy servers like 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 like VPN gateways.

The PnP server can redirect the 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's 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 like Authentication, Authorizing, and Accounting (AAA) systems, provisioning systems, and other management applications.

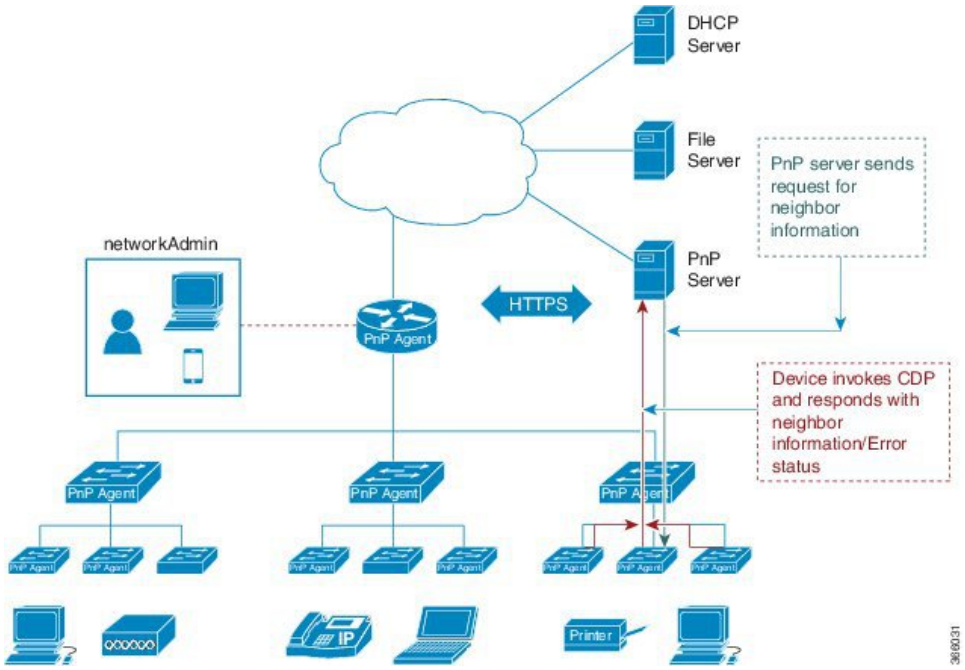
Cisco Network Plug and Play Agent Deployment

The following steps indicate the Cisco Network Plug and Play agent deployment on Cisco devices:

1. The Cisco device, having PnP agent contacts the PnP server requesting for a task, that is, the PnP Agent sends its unique device identifier (UDI) along with a request for work.
2. The PnP server if it has any task for the device, sends a work request. For example, image install, config upgrade, and so on.
3. When the PnP agent receives the work request, executes the task and sends back a reply to the PnP server about the task status, whether it is a success or error, and the corresponding information requested.

Cisco Network Plug and Play Agent Network Topology

Figure 2: Network Topology of Cisco Network Plug and Play Agent Deployment



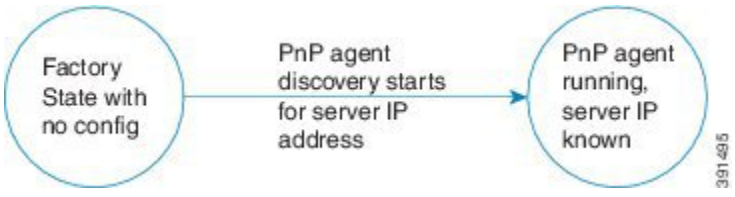
Cisco Network Plug and Play Agent Initialization

The Cisco Network Plug and Play agent software is currently available on all Cisco IOS XE platforms, and is enabled by default. The PnP agent can be initiated on a device by the following ways:

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 and the user input file on the device, it will automatically trigger the Cisco Network Plug and Play agent to discover the PnP server IP address.

Figure 3: State Diagram for PnP Trigger with no Startup Configuration



CLI Configuration for Open Plug-n-Play Agent

Network administrators may use CLI configuration mode to initiate the Open Plug-n-Play (PnP) agent process at any time. By configuring a PnP profile through CLI, a network administrator can start and stop the PnP agent on a device. When the PnP profile is configured with CLI, the device starts the PnP agent process which, in turn, initiates a connection with the PnP server using the IP address in the PnP profile.

Figure 4: State Diagram for PnP Trigger with CLI Configured PnP Profile



Cisco Network Plug and Play Agent Deployment Solutions

This section discusses the functionality of the Cisco Network Plug and Play agent, exposed to the PnP server, for device deployment and management. The PnP agent deployment solution comprises the discovery process initiated by the agent, communication between the device, agent, and the server, and the PnP agent services. The PnP solution is described in detail in the following sections:

Cisco Network Plug and Play Agent Discovery Process

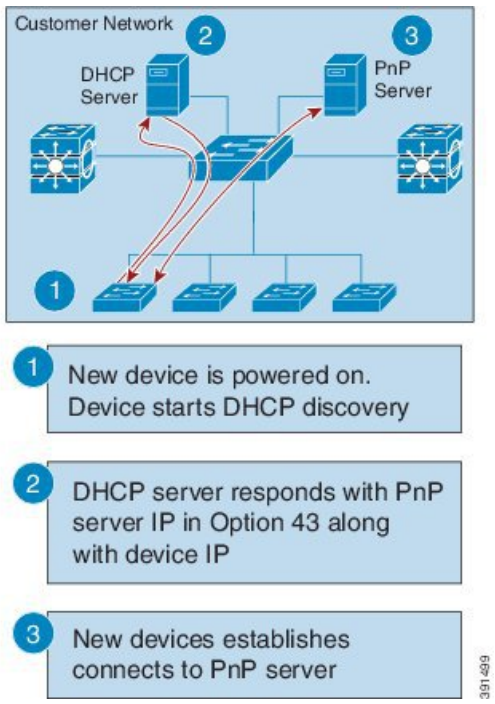
When the device boots up, the absence of any startup config on the NVRAM triggers the PnP discovery agent to acquire the IP address of the PnP server. In order to acquire the IP address of the PnP server, the PnP agent goes through one of the following discovery mechanisms:

1. PnP discovery through DHCP server
2. PnP discovery through DHCP snooping
3. PnP discovery through DNS lookup
4. PnP proxy for layer 2 and layer 3 devices
5. PnP deployment application

Cisco Network Plug and Play Discovery through DHCP Server

Device with no startup configuration in the NVRAM triggers the Cisco Network Plug and Play agent to initiate a DHCP discovery process which acquires the IPv4 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 IPv4 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. PnP agent then uses this IPv4 address or hostname to communicate with the PnP server.

Figure 5: DHCP Discovery Process for PnP server



Assumptions:

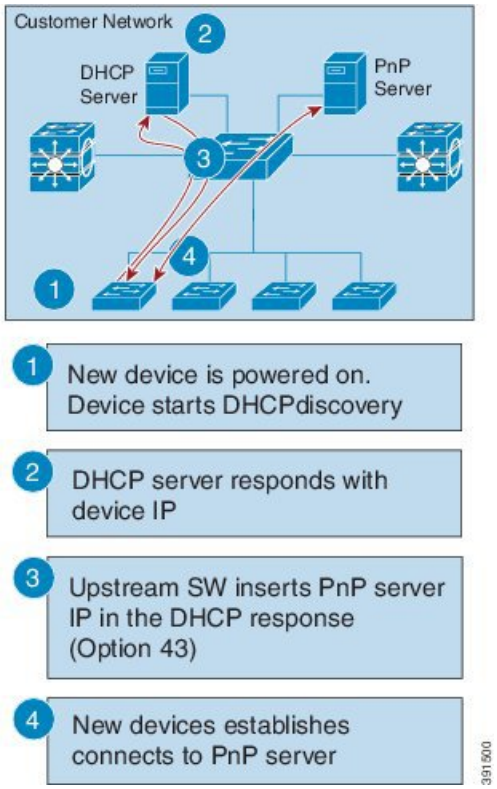
- New devices can reach DHCP server
- Customer is willing to configure DHCP server for network devices

Plug-n-Play Discovery through DHCP Snooping

If a third party DHCP server cannot be configured to insert any vendor specific options, an existing Cisco Open Plug-n-Play (PnP) enabled device can be configured to snoop in to the DHCP response and insert PnP specific option 43 with the PnP server IP address.

Before inserting the option 43, the snooping agent verifies if the DHCP message is from a Cisco device in the network. The remaining DHCP discovery process is same as described in the previous section.

Figure 6: DHCP Snooping by PnP Server



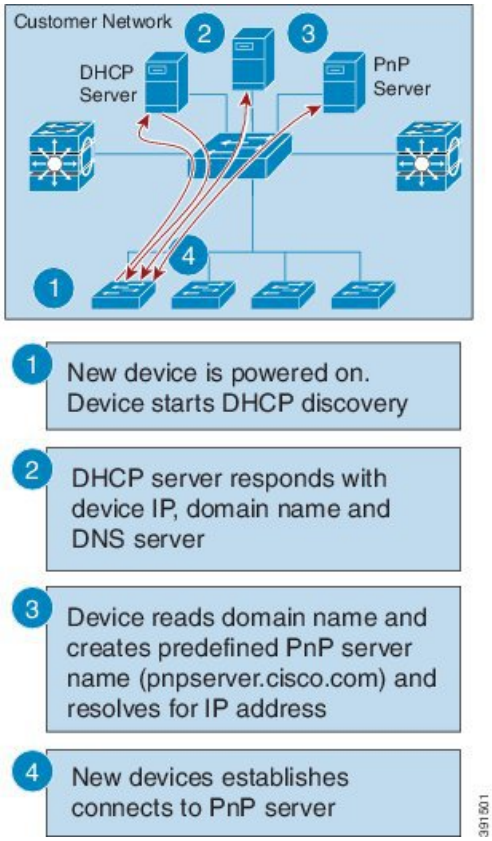
Assumptions:

- New devices can reach DHCP server
- New devices can reach DNS server
- Customer is not willing to configure DHCP server for network devices
- Upstream switch (SW) is configured to snoop DHCP and insert PnP server IP

Cisco Network Plug and Play Discovery through DNS Lookup

When the DHCP discovery fails to get the IP address of the Cisco Network Plug and Play server, the agent falls back on Domain Name System (DNS) lookup method. PnP agent then uses a preset deployment server 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, *deployment.customer.com*. The agent then looks up the local name server and tries to resolve the IP address for the above FQDN.

Figure 7: DNS Lookup for deployment.customer.com



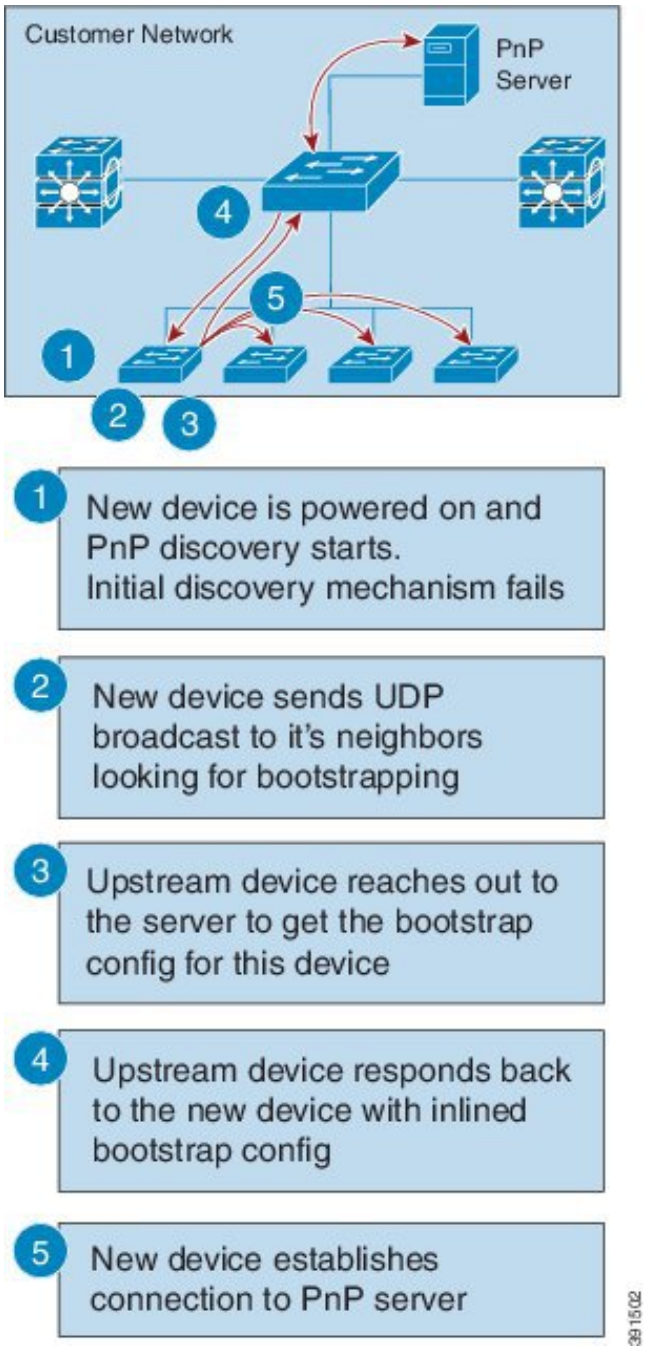
Assumptions:

- New devices can reach DHCP server
- Customer deployed PnP server in the network with the name “pnpserver”

Cisco Network Plug and Play Proxy Server for Layer 3 and Layer 2 Devices

This device listens to a specific port for any incoming PnP messages. The Cisco device which is trying to come up as a PnP device sends a UDP broadcast message to its network every 30 min for ten times. Hence, if the device does not receive a response, the broadcasts stop after 300 min.

Figure 8: DNS Lookup for Layer 3 and Layer 2 Devices



When the device hosting the proxy server process receives the incoming broadcasts, it verifies the version field in the request and forwards the request to the PnP server if version validation is successful. The proxy server process also caches the unique device identifier (UDI) of the requesting client coming in via incoming datagram before forwarding the request to PnP server.

Upon receiving the configlet datagram from PnP server, the proxy server validates UDI in the incoming datagram with the entries in the UDI cache. If validation is successful, proxy server process broadcasts the datagram to a specific port number reserved for the proxy client processes to receive datagrams.

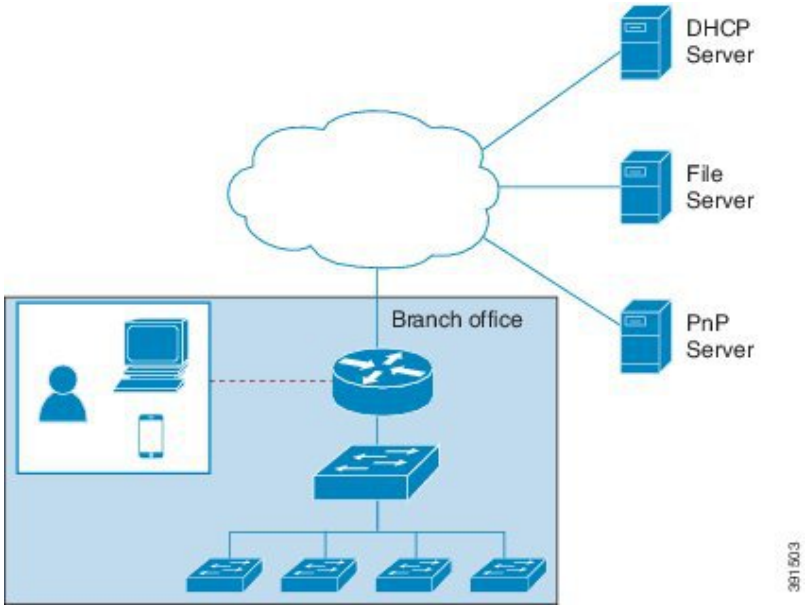
Upon receiving the datagrams, devices running proxy client processes, parse the incoming datagram for the target UDI. If the target UDI in the datagram matches the UDI of the device, proxy client process proceeds with framing, error control and configuring the configlet.

If the target UDI in the datagram fails to match UDI of the device, the packet is dropped.

Plug-n-Play Agent Deployment Application

A Cisco device can alternatively be manually configured by the network administrator using a deployment application running on their PC or on a smart phone. The PC or the smart phone can be connected to the device using an USB or an Ethernet cable.

Figure 9: Manually Configured PnP Agent



Plug-n-Play Agent Deployment Protocol

Deployment can be run over different transports. These transports include Ethernet and IP with Transport Layer Security (TLS). Layer 2 transport is typically used between a deployment agent and a proxy deployment server like a deployment application or as a deployment agent acting as a proxy. Transport between an agent and a server is over an IP connection with TLS for security. Transport between a proxy deployment server and a deployment server is also over IP with TLS.

Plug-n-Play Agent Application Protocol

The Cisco Open Plug-n-Play (PnP) agent application protocol is an XML-based protocol that defines a mechanism that allows network devices to be monitored and controlled by a remote application. The PnP agent is a software module running on a Cisco device. The PnP server is an application running as the network manager that remotely manages the network devices. The main features of the PnP protocol are as follows:

1. Supports HTTP protocols

2. Supports Transport Level Security (TLS) based encryption for HTTP
3. Uses HTTP secure (HTTPS) certificate for TLS handshake

Plug-n-Play Transport over Ethernet

Cisco Open Plug-n-Play (PnP) agent uses the Ethernet based transport in the following two scenarios:

- **Deployment agent communicating with a deployment application on a PC**: In this case, the PC is connected to the device being deployed using an Ethernet cable. The deployment application advertises itself as a deployment server supporting Ethernet transport.
- **Deployment agent communicating with an already deployed device acting as a proxy deployment server**: In this case, the new device being deployed has an Ethernet connection to an already deployed device. The deployment agent on the deployed device responds to the discovery requests and acts as a proxy deployment server for the new device.

Once discovery is complete, the deployment agent starts an unsecured XML stream with the deployment server over Ethernet. This protocol reserves an Ethertype (0xXX TBD) for this purpose. The deployment agent and the server then negotiate to use Extensible Authentication Protocol–Transport Layer Security (EAP-TLS) to protect the communication and complete the EAP-TLS session establishment. The deployment server then authenticates the device with the HTTP secure (HTTPS) certificate or some other supported mechanism.

Plug-n-Play Transport over IP

In Cisco Network Plug-n-Play (PnP) agent, the deployment agent opens TCP connection to the deployment server and starts an XML stream of messages. The server can request the use of Transport Layer Security (TLS) at this time. The agent closes the existing XML stream, initiates a TLS connection to the server, and then restarts the XML stream. The server can request agent authentication over the TLS connection.

Plug-n-Play Agent Security

Security to all Cisco Open Plug-n-Play (PnP) devices is provided at both transport level as well as the application level. The following sections describe the security mechanisms in detail:

Plug-n-Play Transport Layer 3 Security

For non-crypto or non-crypto-enabled images, TLS security choice is not possible. One alternative minimum security is to have the PnP agent initiate the connection to the specified trusted PnP server on port 5222.

Authentication and Authorization between Plug-n-Play Agent and Server

Once the Cisco Open Plug-n-Play (PnP) deployment agent discovers the PnP server, the agent engages the server in a Transport Layer Security (TLS) handshake. In order to authenticate itself to the server, the agent presents its HTTP secure (HTTPS) certificate. The administrator for the PnP server sets device authentication mechanisms which are acceptable for a particular deployment.

The deployment server presents its certificate to the deployment agent so that the agent can authenticate the server. Irrespective of whether the agent is able to verify the server certificate, the agent engages the deployment server in a post-TLS authorization exchange. In this exchange the agent requests the server to present its server authorization token. In response to this request the server presents the authorization token it had obtained from Cisco. The agent verifies the signature on the authorization token. If the authorization token is specific to a Unique Device Identifier (UDI), the agent also ensures its UDI is listed in the authorization-token. At the

end of this step, a secure communication channel is established between the deployment agent and the server. This secure communication channel is leveraged by the server to send deployment information to the agent.

Security Methods for the PnP Discovery Process

This section describes the methods that are used to secure the PnP agent-server communication in various scenarios. The security options are used by the PnP agent during the zero-touch PnP server discovery.

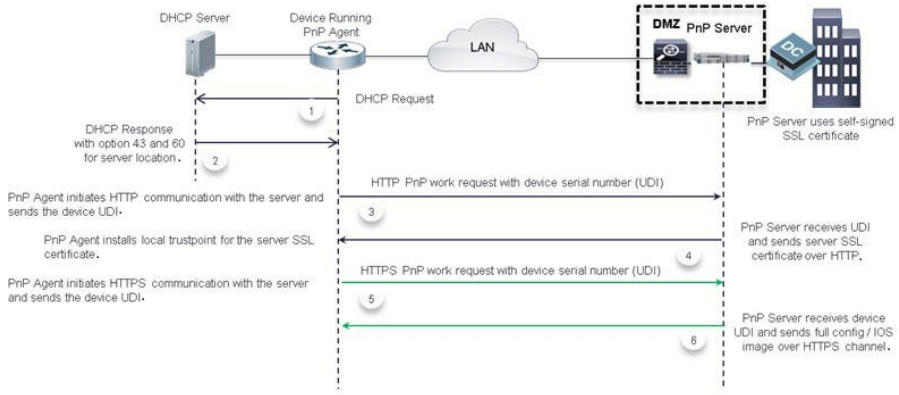
Self-Signed Certificate Based Authentication

The PnP server has an option to use a self-signed SSL certificate for server side authentication. When the PnP server uses a self-signed certificate, the PnP discovery cannot be used for automatically initiating secured communication from the agent to the server. The device goes through usual PnP discovery mechanisms and when it finds the server, the agent sends a work-request over HTTP. The server should use the PnP certificate-install service to instruct the agent to install the server self-signed certificate, and then automatically reconnect back to the server over HTTPs.

To keep the solution secured, it is recommended that you use the unsecured port 80 of server to deliver the one-time certificate installation to the devices. All other services should be sent over the secured port.

The following figure shows the end-to-end secured PnP workflow using a self-signed server SSL certificate.

Figure 10: PnP Deployment with Self-Signed Certificate

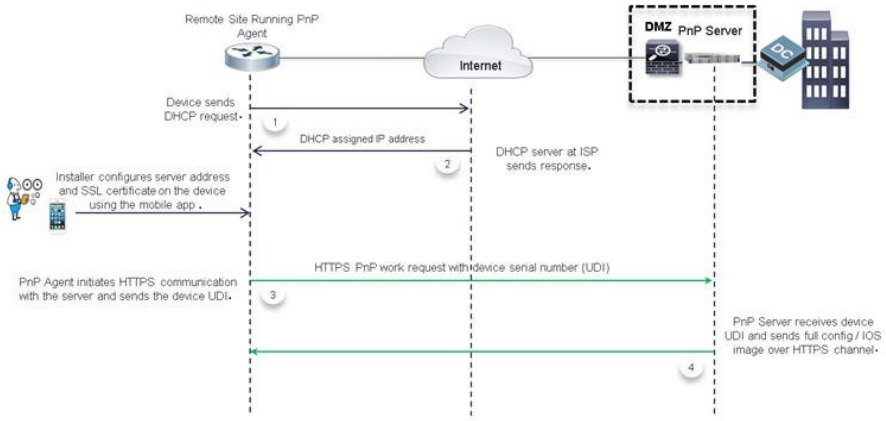


Mobile Device Based Secured Installation

As part of this solution, an application for mobile devices is available to configure the bootstrap on the devices. The mobile application can be used to install the server certificate directly on each device along with other bootstrap configuration and then allow the PnP agent initiate secured communication with the server. In this method, the server does not open up any unsecured port for certificate-install.

The following figure shows the end-to-end secured PnP workflow using the application on the mobile devices.

Figure 11: Secured PnP Deployment with the Mobile Application



CA-Signed Certificate based Authentication

Cisco distributes certificates signed by a signing authorities in a tar file format and signs the bundle with Cisco Certificate Authority (CA) signature. This certificate bundle is provided by Cisco infoSec for public downloads on cisco.com.

The certificates from this bundle can be installed on the Cisco IOS device for server side validation during SSL handshake. It is assumed that the server uses a certificate, which is signed by one of the CA that is available in the bundle.

The PnP agent uses the built-in PKI capability to validate the certificate bundle. As the bundle is signed by Cisco CA, the agent is capable of identifying the bundle that is tampered before installing the certificates on the device. After the integrity of the bundle is ensured by the agent, the agent installs the certificates on the device. After the certificates are installed on the device, the PnP agent initiates an HTTPs connection to the server without any additional steps from the server. The following mechanisms helps the PnP agent to initiate a zero-touch secured communication.

DHCP Option based Discovery over an IPv4 Network

The DHCP option 43 and option 60 is a vendor specific identifier which is used by the PnP agent to locate and connect to the PnP server. To support multiple vendors, the PnP agent in Cisco device sends out a case-sensitive “ciscopnp” as the option 60 string during the DHCP discovery. The DHCP server can be configured with multiple classes matching with a different option 60 string that comes from each network device. After the option 60 string matches, the DHCP server sends out the corresponding option 43 string back to the device. The following is the format for defining the option 43 for PnP deployments:

*option 43 ascii "5A;K5;B2;I10.30.30.10;J443;**Ttftp://10.30.30.10/ ios.p7b**;Z10.30.30.1*

The field ‘T’ in the PnP string provides an option for the network administrator to specify the location of the certificate bundle, which can be hosted on a local or remote file server.

If the certificate bundle is available at the specified location, then the agent:

1. Downloads the bundle from the file server to the device.
2. Checks the signature of the downloaded bundle to ensure it has a genuine Cisco signature.
3. Installs the certificates on the device.

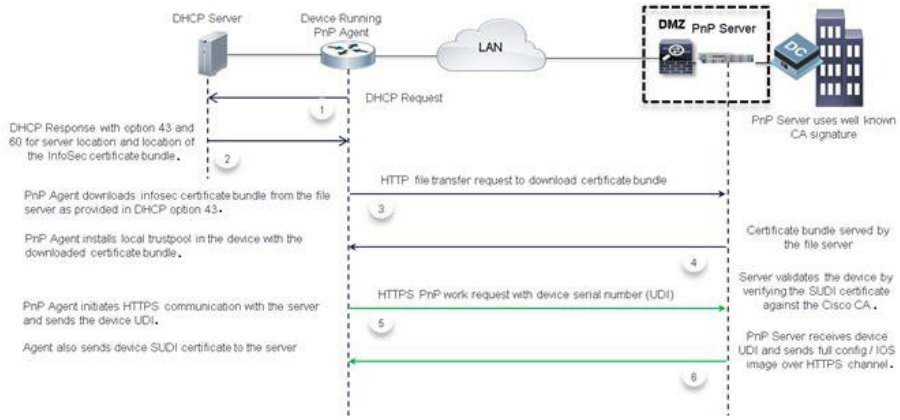
If the ‘T’ option is not specified and the transport mechanism is specified in the option 43 string as HTTPs, the PnP agent looks for the Cisco signed certificate bundle in the default folder of the same server *http://10.30.30.10:443/certificates/default/cert.p7b* .

If the certificates are available at the default location then the agent performs the steps mentioned above to install the certificates.

After the certificates are installed and the server discovery is complete, the agent initiates the HTTPs connection with the server without any additional configuration. During the HTTPs handshake, the device uses the certificates installed from the bundle to validate the server certificate.

The following figure shows the end-to-end secured PnP workflow using the CA bundle-based certificate.

Figure 12: Secured PnP Deployment with Trustpool



This flow works only if the server is using a certificate signed by one of the known signing authorities that is available in the bundle. If the server uses a certificate that is not a part of the bundle then the HTTPs handshake will fail. When you specify the option 43 string with HTTPs as a transport option and if the bundle download fails, the agent will not fall back to any of the unsecured communication protocol even if the server is reachable. If the transport option is specified as HTTP with a parameter 'T' pointing to a valid certificate bundle location, the agent overrides the transport option HTTP and changes it to HTTPs for secured communication. Generally, the agent will choose the most secured communication from the available options.

The path specified in the DHCP option 43 to locate the certificate bundle file can be an absolute URL or a relative URL. If you specify a relative URL, the agent forms a full URL with the server IP address or hostname as specified in the option 43 string and uses HTTP as the file transfer protocol.

Also, to install the certificates, the agent expects the device to have an updated system clock. Because, you configure the DHCP server first, you cannot specify the current time in the DHCP server. In such a scenario, an IP address or a URL can be specified as an alternative parameter in the option 43 with the prefix 'Z', which can point the device to a NTP server. The agent synchronizes the clock on the device with the NTP server and then installs the certificates.

DHCP Option based Discovery over an IPv6 Network

Cisco Network PnP uses the DHCP Option 16 and Option 17 for an IPv6 DHCP discovery process.The Option 16 and Option 17 are vendor specific identifiers. These are used by the Cisco Network PnP agent to locate and connect to the Cisco Network PnP server. The DHCP server can be configured to insert an additional information using the vendor specific Option 17. When the DHCP server receives an Option 16 from the device with the string *cisco pnp* , and if it matches the Option 17 string, the server passes the IP address or the hostname of the Cisco PnP server to the requesting device. When the device receives the DHCPv6 response,

the Cisco Network PnP agent extracts the option from the response and identifies the IPv6 address of the Cisco PnP server. Cisco PnP agent uses this IPv6 address to communicate with the Cisco PnP server. To obtain and install the certificate, use the same process explained in the DHCP Option based Discovery over an IPv4 Network section.

The following example shows how to configure a pool (DHCPv6-pool) with the vendor-specific options:

```
ipv6 dhcp pool dhcpv6-pool
 address prefix 2003::/64 lifetime infinite infinite
 vendor-specific 9
  suboption 16 ascii "ciscopnp"
  suboption 17 ascii "5A1D;K4;B3;IFE80::2E0:81FF:FE2D:3799;J6088"
```

DNS-based Discovery

In DNS-based discovery, a DHCP server receives the domain name of the customer network. The domain name is used to create a PnP-specific, fully qualified domain name (FQDN) such as *pnpserver.<domain_name>*. In this method, the customer network resolves this URL to a valid PnP server IP address. Because, there is no mechanism to specify the certificate location, the agent locates the server certificate to initiate the HTTPs connection without manual intervention.

During the system boot up, the device acquires IP network information from a DHCP server along with the domain name. With the customer specific domain name, the Cisco PnP agent creates the following URL *pnpserver.<domain_name>* and looks for the Cisco signed certificate bundle in a default folder of the server *<domain_name>/ca/trustpool/cabundle.p7b*.

If the certificate bundle is available at the specified location, then the agent:

1. Downloads the bundle from the file server to the device.
2. Checks the signature of the downloaded bundle to ensure it has genuine Cisco signature.
3. Installs the certificates on the device.

If the certificate bundle is not available at the specified location, the PnP agent use a predefined URL,*pnpcertserver.<domain_name>* and looks for the Cisco signed certificate bundle in the default folder of the server, *<domain_name>/ca/trustpool/cabundle.p7b*.

If the certificates are available at the specified location, then the agent performs the steps specified above to install the certificates.

After the certificates are installed and the server discovery is complete, the agent initiates the HTTPs connection with the server at the URL, *pnpserver.<domain_name >* without any additional configuration. During the HTTPs handshake, the device uses the certificates that are installed from the bundle to validate the server certificate.

Also, to install the certificates, the agent expects the device to have an updated system clock. Because, you configure the DHCP server first, you cannot specify the current time in the DHCP server. In such a scenario, the agent uses a predefined URL, *pnpntpserver.<domain_name>* which needs to be mapped to a NTP sever to synchronize the clock on the device, and then installs the certificates.

However, if the certificate is not present at either URL, the Cisco PnP agent will fall back and establish the HTTP connection to the server using the created FQDN pnpserver.<domain_name>. With this workflow, the agent expects the server to use the certificate-install service to install the self-signed certificates first and then start the provisioning steps.

DNS-based Discovery over an IPv6 Network

To enable DNS-based discovery over an IPv6 network:

Procedure

Step 1 Configure the DNS server with an IPv6 option. To enable the Cisco Network PnP DNS discovery, configure the DNS server as shown in this example:

```
ip host pnpntpserver.domain.com 2001::1
ip host pnptrustpool.domain.com 2001::2
ip host pnpserver.domain.com   2001::3
```

Step 2 DHCPv6 server is discovered through DHCP bootstrap process. The following example shows how to configure the DHCP server:

```
ipv6 unicast routing
ipv6 cef

ipv6 dhcp pool test
dns-server 2001::4
domain-name example.com
```

The device sends the DHCPv6 packets to the server over an IPv6 network. After receiving the DHCPv6 packets, the DNS server information and the domain-name are returned to the device as Option 23 and Option 24 respectively.

Step 3 Configure the NTP server. The following example shows how to configure the NTP server:

```
ntp master 1
```

Note
Similarly, the device NTP configuration should use the NTPv4 option.

Step 4 Host the trustpool server on an IPv6 network. Trustpool is supported only on DHCP Options T and Z. If the Option T is configured, specify the URL of the trustpool CA bundle. If the Option Z is configured, specify the NTP server IP address.

Note
When the Cisco Network PnP agent attempts to download the trustpool bundle over HTTP by using an IPv6 option, the trustpool server should support HTTP over an IPv6 network. Also, the clock must be syncronized before configuring the trustpool.

Step 5 Host the Cisco Network PnP server on an IPv6 network.

Cisco Cloud Redirection over an IPv4 and IPv6 Network

Cisco Cloud Redirection service supports Cisco Network PnP zero-touch discovery. It is supported on both IPv4 and IPv6 based Cisco Cloud discovery.



Note Some of the Cisco PnP devices may have root certificate embedded in the devices. These devices will communicate with the CCO server using HTTPS from the beginning. If the device does not have the embedded certificate then the legacy behavior is initiated.

When the device boots up without any start-up configuration or authentication certificates, and if the DHCP and DNS discovery fails, the device tries to contact the Cisco Cloud server at *devicehelper.cisco.com*.

If the *devicehelper.cisco.com* is reachable, the Cisco Network PnP agent downloads the trustpool bundle and establishes a secure HTTP connection with the Cisco Cloud Redirection service. When the device tries the Cisco cloud discovery for the first time, Cisco Network PnP agent downloads the trustpool from this location *devicehelper.cisco.com/ca/trustpool* and saves it to the local flash memory. This location is shared with a Public Key Infrastructure for a trustpool installation. If the Cisco cloud discovery fails, trustpool bundle is retained in the flash memory and Cisco Network PnP checks for a copy of the trustpool bundle in the local device flash memory. If the copy is not available in the local flash memory, it retries to download the trustpool bundle from this location *devicehelper.cisco.com/ca/trustpool download*.

Cisco Network PnP agent sends a HTTPS hello message to the Cisco cloud. The Cisco Network PnP redirection service running at Cisco cloud server replies to the HTTP request. A Cisco cloud server PnP profile is created on the device as shown in this example.

```
pnp profile pnp_cco_profile
transport https host devicehelper.cisco.com port 443
```

After the Cisco cloud profile is created, the device sends a work-information message with its unique device identifier information to the Cisco cloud server. Cisco Cloud Redirection service sends a redirection non-backoff PnP request with the Cisco Network PnP server information. It can be an IPv4 address, IPv6 address, or a hostname. When the redirection is successful, the following redirection profile is configured on the device.

```
pnp profile pnp_redirection_profile
transport https ipv4 172.19.153.133 port 443
```

If the non-backoff PnP request is not received within default wait time, Cisco Network PnP discovery process continues with the next discovery mechanism.

Cisco Network PnP Discovery Over 4G Interface

Cisco Network PnP over 4G interface is available on platforms that have 4G NIMs and running Cisco IOS XE.When a device with an activated SIM card boots up, the 4G interface is activated and used for the Cisco Network PnP cloud discovery process. When a device without an activated SIM card boots up, the non-4G interfaces are preferred for the discovery process. Cisco Network PnP cloud discovery over 4G interfaces is attempted when the non-4G interfaces are not available or if the Cisco Network PnP discovery does not succeed on the non-4G interfaces. When the device has multiple 4G interfaces with active SIM cards, the Cisco Network PnP tries the cloud discovery on all the 4G interfaces one after the other until one of them succeeds.



Note To use the 4G interface for the Cisco Network PnP discovery, the 4G NIMs should have an activated SIM card on it.

Cisco Network PnP Cloud discovery over 4G interfaces works when all the 4G interfaces are activated during the device bootup by default. In the absence of a startup configuration, the device attempts to bring up the 4G inutrafec by default and attempts Cicso PnP over cloud. After the device is redirected, the device connects to the Cisco Network PnP server and downloads the appropriate image and configuration to the device.

Note The DNS server is available as part of the 4G network and the cloud portal should be programmed to redirect the calling device to an appropriate Cisco Network PnP server for provisioning the device. Currently, Cisco Network PnP support over 4G interface uses only the IPv4 network.

Ensure that the configuration pushed through the Cisco Network PnP server contains a route to Cisco Network PnP server over the 4G interface. This can be a default route and should retain the Cisco Network PnP agent and server communication to continue to work over the 4G interface, after the provisioning is completed.

Cisco Network PnP Discovery over a Management Interface

Cisco Network PnP Agent supports discovery and four-way handshake over a management interface with a default VPN Routing/Forwarding (VRF). To send and receive the DHCP traffic over an VRF interface, you have to configure the IOS DHCP server . This feature helps the new devices to access the Cisco Network PnP features when only the management interface is active.

When the device boots up, the management interface under the default VRF is assigned an IP address though DHCP. This interface establishes a connection to a Cisco Network PnP server and the Cisco Network PnP agent on the device records this information (VRF name and source interface). This information is used for future PnP communication with the Cisco Network PnP server. In this case, the Cisco PnP profile that is created on the device will have an extra keyword **VRF** attached to it.

Cisco PnP over an EtherChannel

When you deploy an access switch by using the Cisco Network Plug and Play, the existence of LACP EtherChannels on the provisioned switch (which acts as trunk) does not allow you to configure the device. When the access device tries to connect through the provisioned switch over an L2 EtherChannel using LACP, it breaks the connectivity. Since the configuration does not exists on the access device, the access device cannot bring up the EtherChannel with the switch. This results in keeping the EtherChannel ports in suspended state and breaks the L2 connectivity. Cisco Network PnP Agent detects the presence of EtherChannels and auto-configures the EtherChannel on the device to bring up the Layer 2 connectivity automatically for the day-zero configuration.

Security Methods for Post-PnP Discovery Process

This section explains the methods provided by the Cisco PnP agent which can be, used by the Cisco PnP server to secure the client-server communication after completing the discovery process. This section includes the following topic:

• Certificate Install Service, on page 23

Certificate Install Service

The Cisco PnP agent provides a mechanism to manage SSL certificates on the device by providing the certificate-install service to the Cisco PnP server. The certificate-install service provides a simple XML to install the server's self-signed certificates or certificates signed by standard CA certificates on the device, before initiating an HTTPs connection. The certificate-install service also provides an option to install the

client SSL certificate and instruct the device to use the same SSL certificate during the next device authentication process.

SUDI-based PnP Application Level Authentication

The SSL communication ensures encryption of the data packets exchanged between the server and the device, but does not provide a solution to authenticate the device.

To ensure that the server is talking to a genuine Cisco device, the agent uses the built-in Secure Unique Device Identifier (SUDI) certificate support on the device. SUDI is a X.509 compliant device certificate burnt into the device's secured chip (ACT2) during the manufacture time. The SUDI certificate contains the device's serial number, private-public keys, and the Cisco CA signature. The agent provides the following mechanisms that can be used by the server to authenticate the device as a genuine Cisco device:

- SUDI-based Client Certificate Validation, on page 24
- SUDI-based Serial Number, on page 24

SUDI-based Client Certificate Validation

Before the agent initiates an HTTPs connection with the server, the agent checks whether the device has a built-in SUDI certificate. If the device has a certificate, then the agent sends the SUDI certificate to the client during the SSL handshake for validating. Optionally, the HTTPs server may choose to validate the device using the SUDI certificate during the SSL handshake. After validating, the HTTPs server allows the device to connect to the server. To validate the device's SUDI certificate, the server should use Cisco CA to complete the validation.

SUDI-based Serial Number

If the device is loaded with SUDI certificate, the PnP agent reads the serial number from the SUDI certificate and presents the same information as an additional tag in the work-request body for all communication with the server. To achieve this, the following optional tag is added in the work-info message, which goes out from the device in every work-request. This field is optional and does not show up for devices that does not have SUDI certificate.

There is no change in the existing UDI mechanism that is read from the chassis inventory. The agent continues to be backwards compatible by sending the chassis UDI as the primary identifier. The server can use the additionally provided SUDI-based serial number to authenticate the device and then continue to use the primary UDI. For the devices without a SUDI certificate, the agent does not send this additional SUDI-based serial number. Therefore, the server should continue with the primary UDI for authentication and further communication.

There is no mechanism available to read the SUDI-based serial number from member hardware and there is no change in how UDI is read from other members on a stack or HA unit. The agent will continue to read the UDI from all the hardware units as it does presently.

SUDI-Based Device Authentication

In SUDI-based device authentication, the agent checks whether the device has a built-in SUDI certificate at the boot-up time. If the device is loaded with the SUDI certificate, the agent provides a new PnP service, which allows the server to help the device to identify itself. The availability of this new service depends on the presence of the SUDI certificate and is listed in the agent's capability service.

Along with the above change in the capability-service, the agent adds an additional field under the hardware-info section of the device-info response, to specify and check whether the SUDI certificate is built into the device.

After, the agent initiates an HTTPs connection with the server and sends a work-request, the server should be able to use the device authentication service for a challenge request-response. The device authentication service requires a minimum of one field to generated a string by the server. Optionally, the server can send a list of encryptions and hashing methods that it can support. The agent checks whether it has the capability to use any of the listed encryption methods specified by the server, uses the encryption method and sends a notification to the server. If the agent does not have the capability to use any of the methods specified by the server, then the agent responds with an error message.

When the server sends a device authentication service request to the agent, the agent does the following:

1. Uses one of the specified encryption and hashing methods.
2. If the agent does not have capability to use one of the specified encryption and hashing methods, the agent responds with an error message.
3. Encrypts the challenge string provided by the server using the private key using the PKI APIs.
4. Sends a response back with the following:
    a. Cipher text
    b. Methods used to cipher
    c. Certificate (SUDI or client installed certificate)

After, the server receives the above response from the device, the server does the following:

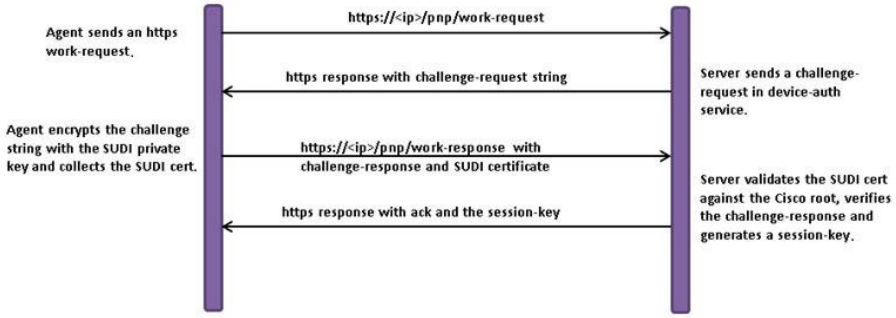
1. Verifies the SUDI or the client certificate against the Cisco or customer CA.
2. Decrypts the cipher-string using the public key that is available in the SUDI or client certificate.
3. Verifies whether the deciphered string matches the original version.
4. Generates a session key (string) and sends it back to the device as an acknowledgment.

After the agent receives the final acknowledgment from the server with the session-key, it associates the corresponding profile with the provided session-key and sends it to the server as an attribute in the root PnP section of all the subsequent messages that the agent sends.

The server validates the session-key before sending any message from the device. Optionally, the server maintains a timer for the session-keys and moves to invalid status when the timer expires. If the agent sends a message with an expired session-key, the server repeats the device authentication process and generate a new session-key before sending to the same device again. If the device sends a request without any session-key, then the server performs the device authentication process and generates a new session-key before sending to the same device.

The following figure displays the message sequence between the agent and the server to accomplish the device authentication using the SUDI certificate.

Figure 13: Message Sequence



How to Configure Cisco Network Plug and Play Agent

Configuring Cisco Network Plug and Play Agent Profile

Perform the following task to create a Cisco Network Plug and Play agent profile:

Procedure

	Command or Action	Purpose
Step 1	**enable** **Example:** `Device> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Device# configure terminal`	Enters global configuration mode.
Step 3	**pnp profile** *profile-name* **Example:** `Device(config)# pnp profile test-profile-1`	Creates a PnP agent profile and enters the PnP profile initialization mode. • String of alphanumeric characters that specify a name for the PnP agent profile. Profile names cannot be duplicated.
Step 4	**end** **Example:** `Device(config-pnp-init)# end`	Exits the PnP profile initialization mode and returns to privileged EXEC mode.

Configuring Network Plug and Play Agent Device

Perform the following task to create a Cisco Network Plug and Play agent device:

Procedure

	Command or Action	Purpose
Step 1	**enable** **Example:** `Device> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Device# configure terminal`	Enters global configuration mode.
Step 3	**pnp profile** *profile-name* **Example:** `Device(config)# pnp profile test-profile-1`	Creates a PnP agent profile and enters the PnP profile initialization mode. • String of alphanumeric characters that specify a name for the PnP agent profile. Profile names cannot be duplicated.
Step 4	**device** {**username** *username* } {**password {0 | 7}** *password*} **Example:** `Device(config-pnp-init)# device username sjohn password 0 Tan123`	Configures the PnP agent on the device. • Establishes a username and password based authentication system. • *username*—User ID • *password*—Password that a user enters • **0**—Specifies that an unencrypted password or secret (depending on the configuration) follows. • **7**—Specifies that an encrypted (hidden) password follows.
Step 5	**end** **Example:** `Device(config-pnp-init)# end`	Exits the PnP profile initialization mode and returns to privileged EXEC mode.

Configuring Cisco Network Plug and Play Reconnect Factor

Perform the following task to configure the time to wait before attempting to reconnect a session in either fixed-interval-backoff, exponential-backoff, or random-exponential-backoff mode:

Procedure

	Command or Action	Purpose
Step 1	**enable** **Example:** `Device> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Device# configure terminal`	Enters global configuration mode.
Step 3	**pnp profile** *profile-name* **Example:** `Device(config)# pnp profile test-profile-1`	Creates a PnP agent profile and enters the PnP profile initialization mode. • String of alphanumeric characters that specify a name for the PnP agent profile. Profile names cannot be duplicated.
Step 4	**reconnect** [*pause-time* [*exponential-backoff-factor* [**random**]]] **Example:** `Device(config-pnp-init)# reconnect 100 2 random`	Specifies the time for the PnP agent initiator profile to wait before attempting to reconnect a session. • The pause-time value is the time to wait, in seconds, before attempting to reconnect after a connection is lost. The range is from 1 to 2000000. The default is 60. • Exponential backoff factor value is the value that triggers the reconnect attempt exponentially. The range is from 2 to 9.
Step 5	**end** **Example:** `Device(config-pnp-init)# end`	Exits the PnP profile initialization mode and returns to privileged EXEC mode.

Configuring Cisco Network Plug and Play HTTP Transport Profile

Perform the following task to create a HTTP transport profile of the Cisoc Plug and Play agent manually on a device.

Both IPv4 and IPv6 addresses can be used for PnP server IP configuration. Alternately, a hostname can also be used in the configuration to connect to the PnP server.

Every profile can have one primary server and a backup server configuration. The Cisco PnP agent attempts to initiate a connection with the primary server first and if it fails, it will try the backup server. If the backup server fails, the Cisco PnP agent will attempt to connect to the primary server again. This will continue until a connection is established with one of the servers.

Procedure

	Command or Action	Purpose
Step 1	**enable** **Example:** `Device> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Device# configure terminal`	Enters global configuration mode.
Step 3	**pnp profile** *profile-name* **Example:** `Device(config)# pnp profile test-profile-1`	Creates a PnP agent profile and enters the PnP profile initialization mode. • String of alphanumeric characters that specify a name for the PnP agent profile. Profile names cannot be duplicated.
Step 4	**transport http host** *host-name* [**port** *port-number*] [**source** *interface-type*] **Example:** `Device(config-pnp-init)# transport http host hostname-1 port 1 source gigabitEthernet 0/0/0`	Creates a HTTP transport configuration for the PnP agent profile based on the hostname of the server on which the PnP agent is deployed. • The value of the host specifies the host name, port, and source of the server. • The value of the port-number specifies the port that is used. • The value of the interface-type specifies the interface on which the agent is connected to the server.
Step 5	**transport http ipv4** *ipv4-address* [**port** *port-number*] [**source** *interface-type*] **Example:** `Device(config-pnp-init)# transport http ipv4 10.0.1.0 port 221 source gigabitEthernet 0/0/0`	Creates a HTTP transport configuration for the PnP agent profile based on the IPv4 address of the server on which the PnP agent is deployed.
Step 6	**transport http ipv6** *ipv6-address* [**port** *port-number*] [**source** *interface-type interface-number*] **Example:** `Device(config-pnp-init)# transport http ipv6 2001:DB8:1::1 port 331 source gigabitEthernet 0/0/1`	Creates a HTTP transport configuration for the PnP agent profile based on the IPv6 address of the server on which the PnP agent is deployed.
Step 7	**end** **Example:**	Exits the PnP profile initialization mode and returns to privileged EXEC mode.

	Command or Action	Purpose
	`Device(config-pnp-init)# end`	

Configuring Cisco Network Plug and Play HTTPS Transport Profile

Perform the following task to create a HTTP Secure (HTTPS) transport profile of the Cisco Network Plug and Play agent manually on a device.

Procedure

	Command or Action	Purpose
Step 1	**enable** **Example:** `Device> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Device# configure terminal`	Enters global configuration mode.
Step 3	**pnp profile** *profile-name* **Example:** `Device(config)# pnp profile test-profile-1`	Creates a PnP agent profile and enters the PnP profile initialization mode. • String of alphanumeric characters that specify a name for the PnP agent profile. Profile names cannot be duplicated.
Step 4	**transport https host** *host-name* [**port** *port-number*][**source** *interface-type*][**localcert** *trustpoint-name*][**remotecert** *trustpoint-name*] **Example:** `Device(config-pnp-init)# transport https host example.com port 231 source gigabitEthernet 0/0/0 localcert abc remotecert xyz`	Creates a HTTPS transport configuration for the PnP agent profile based on the hostname of the server on which the PnP agent is deployed. • The value of *localcert* specifies the trustpoint used for client-side authentication during the transport layer security (TLS) handshake. • The value of *remotecert* specifies the trustpoint used for server certificate validation. **Note** Configure the trustpoint-name using the **crypto pki trustpoint** command.
Step 5	**transport https ipv4** *ipv4-address* [**port** *port-number*][**source** *interface-type*][**localcert** *trustpoint-name*][**remotecert** *trustpoint-name*] **Example:**	Creates a HTTPS transport configuration for the PnP agent profile based on the IPv4 address of the server on which the PnP agent is deployed.

	Command or Action	Purpose
	`Device(config-pnp-init)# transport https ipv4 10.0.1.0 port 221 source gigabitEthernet 0/0/0 localcert abc remotecert xyz`	
Step 6	**transport https ipv6** *ipv6-address* [**port** *port-number*][**source** *interface-type interface-number*][**localcert** *trustpoint-name*][**remotecert** *trustpoint-name*] **Example:** `Device(config-pnp-init)# transport https ipv6 2001:DB8:1::1 port 331 source gigabitEthernet 0/0/1 localcert abc remotecert xyz`	Creates a HTTPS transport configuration for the PnP agent profile based on the IPv6 address of the server on which the PnP agent is deployed.
Step 7	**end** **Example:** `Device(config-pnp-init)# end`	Exits the PnP profile initialization mode and returns to privileged EXEC mode.

Configuring Backup Cisco Network Plug and Play Device

Perform the following task to create a backup profile and to enable or disable Cisco Network Plug and Play agent manually on a device:

Procedure

	Command or Action	Purpose
Step 1	**enable** **Example:** `Device> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Device# configure terminal`	Enters global configuration mode.
Step 3	**pnp profile** *profile-name* **Example:** `Device(config)# pnp profile test-profile-1`	Creates a PnP agent profile and enters the PnP profile initialization mode. • String of alphanumeric characters that specify a name for the PnP agent profile. Profile names cannot be duplicated.
Step 4	**backup device** {**username** *username* } {**password {0 | 7}** *password*} **Example:**	Configures the PnP agent backup profile on the device. • Establishes a username and password based authentication system.

	Command or Action	Purpose
	`Device(config-pnp-init)# backup device username sjohn password 0 Tan123`	• *username*-User ID • *password*-Password that a user enters • 0—Specifies that an unencrypted password or secret (depending on the configuration) follows. • 7—Specifies that a hidden password follows.
Step 5	**end** **Example:** `Device(config-pnp-init)# end`	Exits the PnP profile initialization mode and returns to privileged EXEC mode.

Configuring Backup Cisco Network Plug and Play Reconnect Factor

Perform the following task to configure backup reconnection of the Cisco Network Plug and Play (PnP) agent to the server in either fixed-interval-backoff, exponential-backoff, or random-exponential-backoff manner :

Procedure

	Command or Action	Purpose
Step 1	**enable** **Example:** `Device> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Device# configure terminal`	Enters global configuration mode.
Step 3	**pnp profile** *profile-name* **Example:** `Device(config)# pnp profile test-profile-1`	Creates a PnP agent profile and enters the PnP profile initialization mode. • String of alphanumeric characters that specify a name for the PnP agent profile. Profile names cannot be duplicated.
Step 4	**backup reconnect** [*pause-time* [*exponential-backoff-factor* [**random**]]] **Example:** `Device(config-pnp-init)# backup reconnect 100 2 random`	Specifies the time for the PnP agent initiator profile to wait before attempting to reconnect a session. • The pause-time value is the time to wait, in seconds, before attempting to reconnect after a connection is lost. The range is from 1 to 2000000. The default is 60.

	Command or Action	Purpose
		• Exponential backoff factor value is the value that triggers the reconnect attempt exponentially. The range is from 2 to 9.
Step 5	**end** **Example:** `Device(config-pnp-init)# end`	Exits the PnP profile initialization mode and returns to privileged EXEC mode.

Configuring Backup Cisco Network Plug and Play HTTP Transport Profile

Perform the following task to create a backup HTTP transport profile of the Cisco Network Plug and Play agent manually on a device.

Procedure

	Command or Action	Purpose
Step 1	**enable** **Example:** `Device> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Device# configure terminal`	Enters global configuration mode.
Step 3	**pnp profile** *profile-name* **Example:** `Device(config)# pnp profile test-profile-1`	Creates a PnP agent profile and enters the PnP profile initialization mode. • String of alphanumeric characters that specify a name for the PnP agent profile. Profile names cannot be duplicated.
Step 4	**backup transport http host** *host-name* [**port** *port-number*] [**source** *interface-type*] **Example:** `Device(config-pnp-init)# backup transport http host hostname-1 port 1 source gigabitEthernet 0/0/0`	Creates a backup HTTP transport configuration for the PnP agent profile based on the hostname of the server on which the PnP agent is deployed. • The value of the host specifies the host name, port, and source of the server. • The value of the port-number specifies the port that is used. • The value of the interface-type specifies the interface on which the agent is connected to the server.

	Command or Action	Purpose
Step 5	**backup transport http ipv4** *ipv4-address* [**port** *port-number*] [**source** *interface-type*] **Example:** `Device(config-pnp-init)# backup transport http ipv4 10.0.1.0 port 221 source gigabitEthernet 0/0/0`	Creates a backup HTTP transport configuration for the PnP agent profile based on the IPv4 address of the server on which the PnP agent is deployed.
Step 6	**backup transport http ipv6** *ipv6-address* [**port** *port-number*] [**source** *interface-type interface-number*] **Example:** `Device(config-pnp-init)# backup transport http ipv6 2001:DB8:1::1 port 331 source gigabitEthernet 0/0/1`	Creates a backup HTTP transport configuration for the PnP agent profile based on the IPv6 address of the server on which the PnP agent is deployed.
Step 7	**end** **Example:** `Device(config-pnp-init)# end`	Exits the PnP profile initialization mode and returns to privileged EXEC mode.

Configuring Backup Cisco Network Plug and Play HTTPS Transport Profile

Perform the following task to create a backup HTTPS transport profile of the Cisco Network Plug and Play agent manually on a device.

Procedure

	Command or Action	Purpose
Step 1	**enable** **Example:** `Device> enable`	Enables privileged EXEC mode. • Enter your password if prompted.
Step 2	**configure terminal** **Example:** `Device# configure terminal`	Enters global configuration mode.
Step 3	**pnp profile** *profile-name* **Example:** `Device(config)# pnp profile test-profile-1`	Creates a PnP agent profile and enters the PnP profile initialization mode. • String of alphanumeric characters that specify a name for the PnP agent profile. Profile names cannot be duplicated.

	Command or Action	Purpose
Step 4	**backup transport https host** *host-name* [**port** *port-number*][**source** *interface-type*][**localcert** *trustpoint-name*][**remotecert** *trustpoint-name*] **Example:** `Device(config-pnp-init)# backup transport https host example.com port 231 source gigabitEthernet 0/0/0 localcert abc remotecert xyz`	Creates a HTTPS backup transport configuration for the PnP agent profile based on the hostname of the server on which the PnP agent is deployed. • The value of *localcert* specifies the trustpoint used for client-side authentication during the transport layer security (TLS) handshake. • The value of *remotecert* specifies the trustpoint used for server certificate validation.
Step 5	**backup transport https ipv4** *ipv4-address* [**port** *port-number*][**source** *interface-type*][**localcert** *trustpoint-name*][**remotecert** *trustpoint-name*] **Example:** `Device(config-pnp-init)# backup transport https ipv4 10.0.1.0 port 221 source gigabitEthernet 0/0/0 localcert abc remotecert xyz`	Creates a HTTPS backup transport configuration for the PnP agent profile based on the IPv4 address of the server on which the PnP agent is deployed.
Step 6	**backup transport https ipv6** *ipv6-address* [**port** *port-number*][**source** *interface-type interface-number*][**localcert** *trustpoint-name*][**remotecert** *trustpoint-name*] **Example:** `Device(config-pnp-init)# backup transport https ipv6 2001:DB8:1::1 port 331 source gigabitEthernet 0/0/1 localcert abc remotecert xyz`	Creates a HTTPS backup transport configuration for the PnP agent profile based on the IPv6 address of the server on which the PnP agent is deployed.
Step 7	**end** **Example:** `Device(config-pnp-init)# end`	Exits the PnP profile initialization mode and returns to privileged EXEC mode.

Configuring Cisco Network Plug and Play Agent Tag

Perform the following task to create a Cisco Network Plug and Play agent tag information:

Procedure

	Command or Action	Purpose
Step 1	**enable** **Example:** `Device> enable`	Enables privileged EXEC mode. • Enter your password if prompted.

	Command or Action	Purpose
Step 2	**configure terminal** **Example:** `Device# configure terminal`	Enters global configuration mode.
Step 3	**pnp tag** *tag-name* **Example:** `Device(config)# pnp tag xyz`	Use the **pnp tag** command to configure the tag for the device. The neighboring Cisco devices will receive this tag information through Cisco Discovery Protocol (CDP). **Note** If there is an existing tag for the device, the tag name can be only changed when the xml schema is sent by the PnP server to change the tag name. The tag name cannot be overwritten. • String of alphanumeric characters that specify a name for the PnP agent tag.
Step 4	**end** **Example:** `Device(config)# end`	Exits the global configuration mode and returns to privileged EXEC mode.

Troubleshooting and Debugging

To run the debugging on the Cisco Network Plug and Play (server, start the server, configure the PnP profile and PnP transport. For example, start the service interaction between PnP agent and PnP server.

You can capture the debugs by executing the **debug pnp service** command. When you report a problem, collect all the pnp* files in the PnP agent flash" to the guide.

Note To collect Cisco Plug and Play server log, see the Cisco Application Policy Infrastructure Controller Enterprise Module Deployment Guide.

To troubleshoot the device, server and Cisco PnP Agent, use the following commands:

Table 1: Troubleshooting the Device, Server, and Cisco PnP Agent

Command	Description
dir nvram	Use this command to ensure tht the device does not have left over certificates.
ping vrf interface-name *<controller_ip>*	Use this command to ensure the the device can ping the controller.

Command	Description
show auto install trace	Use this command to view auto install trace log.
show boot	Use the show boot command to display the current value for the BOOTLDR variable.
show cdp neighbor	Use this command to display all CDP neighbors.
Show crypto pki trustpoint	Use this command to view the PKI trustpoint.
Show crypto pki trustful	Use this command to view the PKI trustful.
show ip interface brief	Use this command to view a summary of the router interfaces.
show ipv6 interface brief	Use this command to display the IPv6 interfaces.
show run | inc pnp	Uset this command to ensure that only one PnP profile installed
show pnp trace	Use this command to ensure that the device does not have start-up configuration.
show pnp tech	Use this command to view active connections for the Cisco Plug and Play IOS Agent.
show vlan	Use this command to view the VLAN information.
show ntp status	Use this command to view the NTP status.
show version	Use this command to ensure that the device is running the latest CCO image

Glossary

PnP Agent: An embedded agent on the device to automate deployment process

PnP Helper Applications: Applications on smart phones and personal computers that facilitate deployment. PnP helper applications are not specific to a customer or device and can be used in any deployment scenario. May be needed in limited scenarios

PnP Protocol: Protocol between the PnP agent and PnP server. This is an open protocol allowing third-party development of PnP servers

PnP Server: A central server that manages and distributes deployment information (images, configurations, files, and licenses) for the devices being deployed. Cisco Network Plug and Play server provides a north bound interface for management applications and communicates with the PnP agents on the devices using the PnP protocol.

Additional References for Open Plug-n-Play Agent

Related Documents

Related Topic	Document Title
Cisco IOS commands	Cisco IOS Master Command List, All Releases
PnP commands: Complete command syntax, command mode, command history, defaults, usage guidelines, and examples	Cisco IOS PnP Command Reference
Cisco Network Plug and Play solution	Solution Guide for Cisco Network Plug and Play.
How to use the Cisco Network Plug and Play in the APIC-EM to configure Cisco network devices.	Configuration Guide for Cisco Network Plug and Play on Cisco APIC-EM.
How to deploy the APIC-EM.	Cisco Application Policy Infrastructure Controller Enterprise Module Deployment Guide.
Getting started with the APIC-EM.	Cisco APIC-EM Quick Start Guide.

MIBs

MIB	MIBs Link
• CISCO-BULK-FILE-MIB • CISCO-DATA-COLLECTION-MIB • CISCO-PROCESS-MIB • Expression-MIB	To locate and download MIBs for selected platforms, Cisco software releases, and feature sets, use Cisco MIB Locator found at the following URL: http://www.cisco.com/go/mibs