Smart Install Overview

Introduction

Smart Install is a plug-and-play configuration and image-management feature that provides zero-touch deployment for new switches. You can ship a switch to a location, place it in the network and power it on with no configuration required on the device.

A network using Smart Install includes a group of networking devices, known as clients, that are served by a common Layer 3 switch or router that acts as a director. In a Smart Install network, you can use the Zero-Touch Installation process to install new access layer switches into the network without any assistance from the network administrator. The director provides a single management point for images and configuration of client switches. When a client switch is first installed into the network, the director automatically detects the new switch, and identifies the correct Cisco IOS image and the configuration file for downloading. It can allocate an IP address and host name to a client. If a standalone switch in the network is replaced by another switch of the same SKU (a switch with the same product ID), it automatically gets the same configuration and image as the previous one. The director can also perform on-demand configuration and software image updates of a switch or a group of switches in the network.

Zero-touch updates also take place on preconfigured switches after you have entered the **write erase** and **reload** privileged EXEC commands to clear the configuration.

Caution If you touch the console keyboard during a zero-touch update and attempt to enter a command or a return on the switch, the auto install and Smart Install processes stop. To recover and restart the process, at the system prompt, enter the **write erase** and **reload** commands on the client and restart the process.

The director can act as a DHCP and TFTP server and can store the configuration and image files. These files can also be stored on a third-party TFTP server for the director to use. The client can download the image and configuration files from the director TFTP server or from a remote server.

Note Switches running releases earlier than 12.2(52)SE are not Smart Install capable, but they can be Smart Install clients if they support the **archive download-sw** privileged EXEC command. Smart Install clients can be Layer 2 or Layer 3 switches. Switches running Cisco IOS Releases 3.2(0)SE and later, and 15.0(2)SE and later, 3.6.(0)E, and 15.2.(2)E support Smart Install.

See Appendix A, "Supported Devices for Smart Install" for a list of supported routers and switches, the roles they can play (client or director), and the required software releases.

In a typical Smart Install network, a client switch uses DHCP to get an IP address and the director snoops DHCP messages. For a client to participate in Smart Install zero-touch update, it must use DHCP, and all DHCP communication must pass through the director so that it can snoop all DHCP packets from clients. The most automatic operation is when all switches in the Smart Install network use DHCP and are Smart Install capable. However, any client switch that supports the **archive download-sw** privileged EXEC command to download a software image can be used in a zero-touch Smart Install network. Cisco IOS Release 3.2(0)SE and later, support software install.

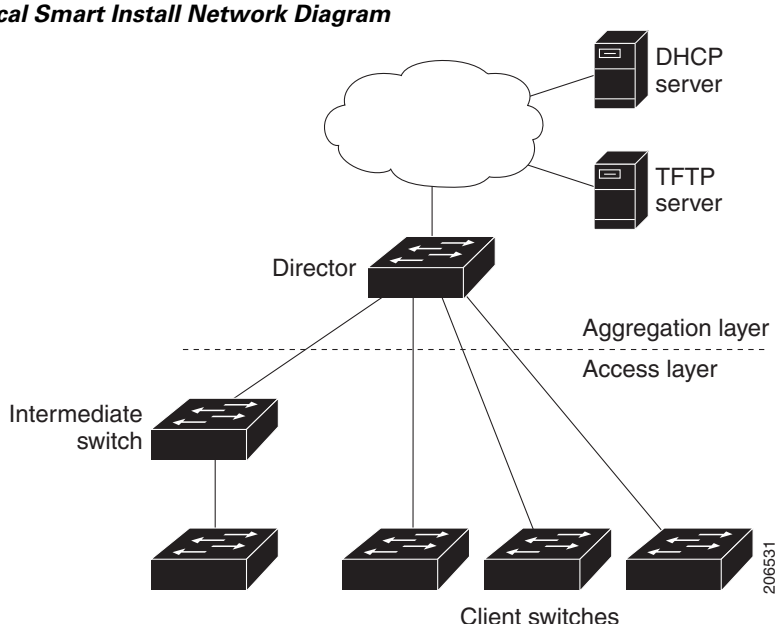
Note A Smart Install network can have only one director.

A client switch can participate in Smart Install even if it is not directly connected to the director. The Smart Install network supports up to seven hops. Intermediate switches or clients connected to the director through an intermediate switch in a multihop environment can be, but are not necessarily Smart Install-capable, provided the management VLAN is set to default VLAN1.

If you use a VLAN other than vlan 1 for management, then the intermediate switch must be Smart Install capable switch.

Figure 1-1 shows a Smart Install network with external DHCP and TFTP servers. There can be only one director amongst TFTP servers in any Smart Install network. The director can also serve as the DHCP and TFTP server.

Figure 1-1 Typical Smart Install Network Diagram



A Smart Install network can be:

- A network where all client switches are of the same product ID (PID), for example, WS-2960S-48FPS-L. In this case, you can identify a default image and a seed or basic configuration to use on all client switches.
- A network that includes switches with different PIDs. In these networks, you can configure switch groups and specify that the same images and seed configuration files are applied to all switches in the group. A group can be based on a predefined PID, or you can create groups based on product ID, MAC address, switch stack number, MAC address, or client switch connectivity to a specific upstream neighbor. When switches in a group are replaced by another switch with the same product ID, the replacement switch receives the same configuration and image.

After a switch has an image and basic configuration, you can configure specific features on individual switches and save the configuration to the startup configuration file.

Switches participating in Smart Install zero-touch updates must use DHCP to obtain their IP addresses. DHCP options are used to send:

- Image filename and location
- TFTP server IP address
- Hostname
- Configuration filename
- Director IP address to the other switches

When a director is configured and a client joins the Smart Install network, Smart Install is automatically enabled on these devices. Beginning with Cisco IOS Release 12.2(58)SE, XE 3.4SG, 15.1(2)SG, 15.1(1)SY, 15.0(2)SE, 3.2(0)SE and later, 3.6.(0)E, or 15.2.(2)E, you can disable Smart Install on a device and also shut down its Smart Install TCP ports by entering the **no vstack** global configuration command on the client or director. When Smart Install is disabled on a device, any Smart Install configuration on it remains in the running configuration but does not take effect while Smart Install is disabled. To reenable Smart Install on the device, enter the **vstack** global configuration command.

These sections include more detailed information on Smart Install components:

- Smart Install Director, page 1-3
- Smart Install Clients, page 1-6
- Smart Install Groups, page 1-9

Smart Install Director

The director in a Smart Install network must be a Layer 3 switch running Cisco IOS Release 12.2(52)SE or later, XE 3.4SG, 15.1(2)SG, 15.0(2)SE or later, 15.1(1)SY or later, 3.2(0)SE or later, or a router running Cisco IOS Release 15.1(3)T or later. See Appendix A, “Supported Devices for Smart Install” for a list of routers and switches that can perform the role of Smart Install director.

Note IE2000 IE3000, and IE3010 support Director with Cisco IOS Release 15.2(2)E.

To configure a device as director, enter the IP address of one of its Layer 3 interfaces in the **vstack director** *ip_ address* global configuration command and enable it as director by entering the **vstack basic** command.

Note If you have entered the **no vstack** global configuration command to disable Smart Install on a device, the **vstack director** *ip_ address* and **vstack basic** global configuration commands are not allowed on the device. To reenable Smart Install on a device, enter the **vstack** global configuration command.

When a device is configured as director, The VLAN on which the DHCP snooping is automatically enabled becomes VLAN 1 by default. The director begins building the director database in VLAN 1. To specify another VLAN for Smart Install management, you can use the **vstack startup-vlan** global configuration command. Depending on the VLAN that is specified in the command, DHCP snooping is enabled on that VLAN so that the director can identify new switches that are connected to the network, known as non-VLAN 1 switches.

The database lists the client devices in the Smart Install network and includes this information:

- Type of switch (PID) for all switches, including switches in a stack
- MAC addresses for all switches, including switches in a stack
- IP address of the switch or stack
- Hostname
- Network topology including neighbors interfacing with the switch
- Serial number (only Smart Install capable switches)

Note When the director is a switch, DHCP snooping is enabled on VLAN 1 by default. It is also enabled on other Smart Install management VLANs that are configured by entering the **vstack vlan** *vlan-range* global configuration command. You can use the **vstack startup-vlan** global configuration command to specify another VLAN that should be used for Smart Install management. Cisco IOS Releases 15.1(1)SY, 15.0(2)SE or later, 15.1(2)SG, 3.6.(0)E, 15.2.(2)E, and Cisco IOS XE 3.4SG support non-VLAN1 management and provide the ability to discover the client switches available on non-VLAN1.

In a Smart Install network that uses DHCP to assign IP addresses, you only need to configure the director. Client switches do not require any configuration. Although you can enter command-line interface commands on clients, configuration commands do not take effect unless the switch assumes the role of director.

Note You can configure the **vstack** commands in client mode. but this is effective only when the switch is converted to a director.

There can be only one director for a set of clients and you cannot configure a backup director. If the director fails:

- Director database must be rebuilt.
- Any update being performed for a non-Smart Install-capable switch might fail.
- The accumulated download status is lost.
- A configuration backup might not occur before the director restarts.

The director can change status and become a client switch if:

- The director interface that has the director IP address shuts down.
- The director interface that has the director IP address is deleted.

- The director IP address is changed.

If the director becomes a client, DHCP snooping is disabled, and the director database is no longer used.

If the director IP address is provided by DHCP and you configure a different director IP address on a client switch, the client is longer part of the director's Smart Install network.

Smart Install relies on a TFTP server to store image and configuration files. The TFTP server can be an external device, or the director can act as a TFTP server. If the director is the TFTP server, the available flash file space on the director must be adequate to accommodate the client Cisco IOS image and configuration files. See the "Configuring the TFTP Server" section on page 2-8.

In a Smart Install network using DHCP, the DHCP server can be an external device or the director can act as the DHCP server. See the "Configuring the DHCP Server" section on page 2-5. The director snoops all DHCP packets that pass through it on VLANs that are configured as Smart Install management VLANs. All network DHCP packets from intermediate or client switches or from an external DHCP server must pass through the director. The director must be able to snoop all DHCP packets from clients.

Note Smart Install options in the DCHP offer are option 125, suboption 5 (the image list file), option 125 sub-option 16 (the director IP address), and option 67 (the configuration file).

The director builds a topology director database for the network by collecting information from the network Smart Install switches. The director uses the database:

- To assign a configuration file and image to a client.
- As a reference to obtain the PID, the image name, and the configuration file for an on-demand update of network switches.

The director periodically updates the director database based on CDP updates that it receives from neighbor switches and from Smart Install messages sent to the director by Smart Install capable clients. The updates contain information about the client neighbors.

Image List File

An image list identifies the images to be loaded on the client. The image list file is the file that contains the correct image name for the client. When the director is the TFTP server, this file is stored in flash memory. Otherwise, it is stored in a remote, third-party TFTP server.

- When the file is stored in the director, the prefix for the image list is **flash://**, **usbflash0://**, **bootflash://**, **bootdisk://**, or **disk0://** based on the appropriate file systems available on the switch.
- When the file is stored in a remote TFTP server, the prefix is **tftp://***ip_address*/*image*.**tar**.

Note In Catalyst Switches 3850 and 3650, the image is a bundled with **.bin** extension.

Images must be stored either on the director or on the third-party TFTP server.

For a standalone switch, the image list file contains a single image. For a stack, the image list contains images for all members of the stack, which could be the same image or different images. For a switch stack, the director creates the image list file after the user specifies the tar file for each switch in the stack.

Starting with Cisco IOS Release 12.2(55)SE or later,15.1(1)SY, 15.0(2)SE and later, 3.2(0)SE and later, XE 3.4SG, 15.1(2)SG, 3.6.(0)E, and 15.2.(2)E, when the user specifies the tar file for each switch, the director automatically creates the imagelist file.

When an external TFTP server is used, the director writes the image list file to the TFTP server. It is recommended that the TFTP server permit the director to write the image list files to the TFTP Server. If the director does not have permission to write to the file system of the TFTP server, the director logs the failure in the system log. You can create the image list files and put them on the TFTP server manually if the director fails to do so automatically; you cannot fix the issue that prevents the director from writing to the TFTP server.

Note The upgrade process is initialized even when the imagelist file is copied manually, but the director tries to copy the image list file to the TFTP server and the failure system log is displayed periodically.

Configuration Files

The director manages these configuration files:

- Startup configuration—The configuration that a client uses when it boots.
- Seed configuration—A configuration on the director that is the basis for the client startup configuration.
- Backup configuration—An exact copy of a client startup configuration stored in the director.

Smart Install Clients

Client switches have a direct or indirect connection to the director so that they can receive image and configuration downloads from it. A switch becomes a Smart Install client when either director or when the director IP address is configured on the switch manually. Client switches use the director database for image and configuration downloads and receive the image and configuration files from the Smart Install TFTP server.

A client switch can be an intermediate switch connected to another client switch. A client can be a standalone switch or a switch stack.

- Director can download images and configuration of clients that are not Smart Install. However, such clients are entered into the director database only if they are connected to a Smart Install capable switch. The director can telnet to the client switch and use the **archive download-sw** privileged EXEC command to download software to the switch. The director must know the client switch password to perform the download.
- Smart Install capable switches can communicate directly with the director to update switch information, can have images and configuration downloaded, and can be managed by the director. A Smart Install capable client with the director IP address and connectivity to the director sends switch and neighbor information to the director by using the Smart Install protocol.

Note Switches running Cisco IOS XE Releases 3.2(0)SE and later, 3.6.(0)E, and 15.2.(2)E support software install.

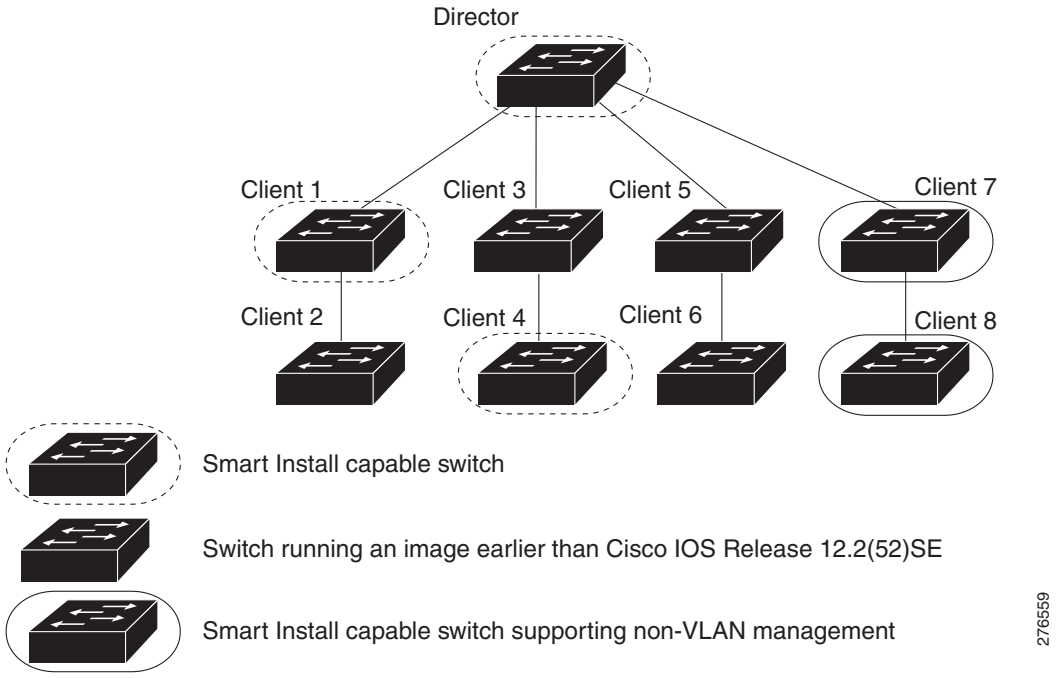
All switches in the network with “network” connectivity to the director can be clients, whether or not they are Smart Install capable. A client switch needs an IP address for management communication and the director must be able to communicate with that IP address. Client switch IP addresses are assigned by DHCP or statically configured.

Smart Install capable clients send switch and neighbor information to the connected director for the director database. Client switches that are not Smart Install capable or that are not connected to a Smart Install capable switch are not entered into the director database. In a multihop topology, for the director to get the complete topology overview, any client switch upstream of a group of clients must be Smart Install capable. Clients not in the director database can get an on-demand update, but they cannot get a zero-touch or group update.

Figure 1-2 shows some possible ways that clients can be interconnected in a network. Table 1-1 and Table 1-2 shows the director database knowledge of each client and the type of update that is supported.

Note The topology shown in Figure 1-2 does not represent a typical Smart Install topology but is used to demonstrate possible types of client interconnections.

Figure 1-2 Possible Interconnections of Smart Install Clients



Note The Cisco IOS releases12.2(52)SE or later, XE 3.4SG, 15.1(2)SG, 15.1(1)SY and later, 15.0(2)SE and later, and 3.2(0)SE and later, support the director role. The Cisco IOS releases 15.0(2)SE, 15.1(1)SY, 15.1(2)SG, XE 3.4SG, 15.0(2)EX, 15.0(2)EX1, 3.6.(0)E, and 15.2.(2)E are Smart Install capable switches, supporting non-VLAN 1 management and providing the ability to discover the client switches available on non-VLAN 1.

Table 1-1 shows the switches that are in the director database and how the director obtained the information. When a client is a single hop from the director, the client uses CDP to send the director information about itself. When a client is a Smart Install capable switch, it sends information to the director about itself and its neighbors.

Table 1-1 Director Database Contents of Client Switches

Client Switch	In Director Database?	Source of Database Information
Client 1	Yes	Learned from CDP and from Smart Install. The client also sends information about its neighbor (Client 2).
Client 2	Yes	Information received from Client 1.
Client 3	Yes	Learned from CDP.
Client 4	No	No information available. The client is not an immediate neighbor of the director or another Smart Install switch.
Client 5	Yes	Learned from CDP.
Client 6	No	No information available. The client is not an immediate neighbor of the director or another Smart Install switch.
Client 7	Yes	Learned from CDP and from Smart Install. The client also sends information about its neighbor Client 8. Client 7 is a non-VLAN 1 switch.
Client 8	Yes	The information to Client 8 will be sent by Client 7 via non-VLAN1. Client 8 is a non-VLAN 1 switch.

Table 1-2 shows the director database knowledge of each client and the type of update that is supported in various software versions. For information about Smart Install supported switches, routers, and minimum software releases for directors and clients, see Supported Devices for Smart Install.

Table 1-2 Types of Updates Supported by Each Client

Device	Software Version	Zero-Touch Update	On-Demand Update of Client	On-Demand Update of Group
Client 1	12.2(52)SE or later	Yes	Yes	Yes
Client 2	Earlier than 12.2(52)SE	Yes	Yes	Yes
Client 3	Earlier than 12.2(52)SE	Yes	Yes	Yes
Client 4	12.2(52)SE or later	Yes	Yes	Yes
Client 5	Earlier than 12.2(52)SE	Yes	Yes	Yes
Client 6	Earlier than 12.2(52)SE	Yes	Yes	No. Switch not in director database.
Client 7	15.0(2)SE, 15.1(1)SY, 15.1(2)SG, XE 3.4SG, 15.0(2)EX, 15.0(2)EX1, 3.6.(0)E, and 15.2.(2)E	Yes	Yes	Yes
Client 8	15.0(2)SE,15.1(1)SY, 15.1(2)SG, XE 3.4SG, 15.0(2)EX, 15.0(2)EX1, 3.6.(0)E, and 15.2.(2)E	Yes	Yes	Yes

To see the types of Smart Install clients in a network, enter the **show vstack status** privileged EXEC command.

```
Director# show vstack status
SmartInstall:  ENABLED
Status: Device_type Health_status Join-window_status Upgrade_status
Device_type:  S - Smart install N - Non smart install P - Pending
Health_status:  A - Active I - Inactive
Join-window_Status:  a - Allowed  h - On-hold   d - Denied
Image Upgrade:   i - in progress     I - done           X - failed
Config Upgrade:  c - in progress     C - done           x - failed
Director Database:
DevNo  MAC Address     Product-ID          IP_addr          Hostname    Status
=====  ==============  ==================  ===============  ==========  =========
0      0018.7363.4200  WS-C3750-24TS       172.20.249.54    IBD-MXD-ST  Director
1      0016.4779.b780  WS-C3750G-24TS      172.20.249.54    IBD-MXD-ST  Director
2      d0d0.fd37.5a80  WS-C3750X-48P       172.20.249.54    IBD-MXD-ST  Director
3      0026.5285.7380  WS-C3750E-24TD      172.20.249.54    IBD-MXD-ST  Director
4      0024.13c6.b580  WS-C3750E-24TD      172.20.249.115   DEV-c6.b5c  S A a
5      0021.a1ab.9b80  WS-C2960-48TC-S     172.20.249.249   DEV-ab.9bc  S A a I C
6      0024.5111.0900  WS-C3750E-24TD      172.20.249.222   DEV-11.094  S A a I C
7      001d.45f3.f600  WS-C3750G-24TS      172.20.249.87    DEV-90.f64  S A a
8      0016.c890.f600  WS-C3750G-24TS      172.20.249.87    DEV-90.f64  S A a
9      001f.2604.8980  WS-C2960-48TC-S     172.20.249.89    DEV-04.89c  S A a I C
10     001b.d576.2500  WS-C3750E-24PD      172.20.249.91    DEV-a6.1cc  S A a I C
```

These fields were added in Cisco IOS Release 12.2(58)SE or 15.1(1)SY to provide more information about each client:

- Device type: S (Smart Install capable, running Cisco IOS Release 12.2(52)SE or later, 15.1(1)SY, 15.0(2)SE and later, 3.2(0)SE and later), 3.6.(0)E, or 15.2.(2)E, N (not a Smart Install device), or P (pending, unable to determine).
- Device health status: Active (the director is receiving periodic updates from the device) or Inactive (the device is disconnected or has not provided updates for three consecutive keepalive periods)
- Join window status: a (allowed), h (on hold), or d (denied). See the "Using a Join Window" section on page 1-15.
- Upgrade status: An image update is i (in progress), I (complete), or X (failed). A configuration upgrade is c (in progress), C (complete), or x (failed).

Smart Install Groups

When all switches in a Smart Install network have the same PID, they can run the same image and the same seed (basic) configuration file. In this case, you can assign a default image and configuration file for all clients. However, if there is more than one PID in the network or if you want a different configuration file to run on some switches, depending on their function in the network, you should configure Smart Install groups and assign an image and configuration file for each group.

- Custom groups take precedence over built-in groups and are based on:
  - Stack group—For switches in a stack, you can configure groups based on their number in the stack. Stack groups are used only for switch stack upgrades, and clients do not need to be in the director database. Starting with Cisco IOS Release 12.2(58)SE, 15.1(1)SY, 15.0(2)SE and later, 3.2(0)SE and later, 3.6.(0)E, and 15.2.(2)E if a stack is homogeneous (all one switch type), you do not need to identify each switch type.
  - MAC address—You can create a custom group of specific switches by using the MAC addresses of the switches to configure the group. You can include switches with the same or different product IDs, as long as they use the same image and configuration file. Enter the **show vstack neighbors all** privileged EXEC command to see the MAC addresses of switches in the Smart Install network.

  - Connectivity—You can configure a custom group based on network topology; that is, all switches that have the same upstream neighbor. Connectivity groups take precedence over groups with matching product IDs or stack numbers. Connectivity groups include only standalone switches (not switch stacks), and clients must be in the director database.
  - Product IDs (PIDs)—These product IDs are all supported models, including newer PIDs that were not shipping when the software was released and therefore are not in the CLI. PID groups include only standalone switches (not switch stacks), and clients do not need to be in the director database.

  The priority of custom groups from high to low is stack group, MAC address, connectivity, and product ID.

- Built-in groups are based on PIDs that you can select from the CLI. These represent the fixed Ethernet switching products that were shipping when the software was released, for example, 3750, 3560, 2975, 2960, 3850, and 3650.

Switches that belong to a group use the image and configuration file assigned to that group. If a client switch does not belong to a group in the director database, it is assigned the default image and configuration file.

Note If there is more than one switch PID in the network, we recommend configuring built-in or custom groups. The default image and configuration is used in networks with only one product ID.

An example of the use of custom groups is a network where all client switches are the same PID, but one requires a different configuration. For example, a retail store might have checkout counters and a pharmacy, and the pharmacy switch requires a different configuration. The checkout counters would use the default configuration, but you would create a custom group for the pharmacy.

Restrictions for Smart Install

The absence of an authorization or authentication mechanism in the Smart Install protocol between the client and the director can allow a client to process crafted Smart Install messages as if these messages were from the Smart Install Director. These include the following:

- Change the TFTP server address on Smart Install clients.
- Copy the startup configuration of client switches to the previously-changed and attacker-controlled TFTP server.
- Substitute the startup configuration of clients with a configuration created by the attacker, and forcing a reload of the clients after a configured time interval.
- Upgrade the IOS image on client switches to an image supplied by the attacker.
- Execute arbitrary commands on client switches (applicable to Cisco IOS Release 15.2(2)E and later releases and Cisco IOS XE Release 3.6.0E and later releases.)

While designing a Smart Install architecture, care should be taken such that the infrastructure IP address space is not accessible to untrusted parties. Design considerations are listed in the Security Best Practices section of this document.

Security Best Practices

Security best practices around the Cisco Smart Install feature depend on how the feature is used in a specific customer environment. We differentiate the following use cases:

- Customers not using the Smart Install feature.
- Customers leveraging the Smart Install feature only for zero-touch deployment.
- Customers leveraging the Smart Install feature for more than zero-touch deployment (configuration and image-management).

The following sections describe each scenario in detail:

Customers Not Using the Smart Install Feature

Customers who do not use the Cisco Smart Install feature, and are running a release of Cisco IOS and IOS XE Software where the command is available, should disable the Smart Install feature with the **no vstack** command.

Note The **vstack** command was introduced in Cisco IOS Release 12.2(55)SE03.

The following is sample output from the **show vstack** command on a Cisco Catalyst Switch with the Smart Install client feature disabled:

```
switch# show vstack config

Role: Client (SmartInstall disabled)
Vstack Director IP address: 0.0.0.0
```

Customers Leveraging the Smart Install Feature Only for Zero-Touch Deployment

Disable the Smart Install client functionality after the zero-touch installation is complete or use the **no vstack** command.

To propagate the **no vstack** command into the network, use one of the following methods:

- Execute the **no vstack** command on all client switches either manually or using a script.
- Add the **no vstack** command as part of the IOS configuration that is pushed into each Smart Install client as part of the zero-touch installation.
- In the releases that do not support the **vstack** command (Cisco IOS Release 12.2(55)SE02 and prior releases), apply an access control list (ACL) on client switches to block the traffic on TCP port 4786.

To enable the Smart Install client functionality later, execute the **vstack** command on all client switches either manually or by using a script.

Note If the configuration changes in between the disabling and re-enabling of the Smart Install feature, to preserve these changes, execute the **write memory** command on client switches after re-enabling the feature. Configuring the command ensures a successful backup of the startup configuration of client switches.

Customers Leveraging the Smart Install Feature for More Than Zero-Touch Deployment

While designing a Smart Install architecture, care should be taken such that the infrastructure IP address space is not accessible to untrusted parties. In releases that do not support the **vstack** command, ensure that only the Smart Install director has TCP connectivity to all Smart Install clients on port 4786.

Administrators can use the following security best practices for Cisco Smart Install deployments on affected devices:

- Interface access control lists (ACLs)
- Control Plane Policing (CoPP). This feature is not available in all Cisco IOS Software releases.

The following example shows an interface ACL with the Smart Install director IP address as 10.10.10.1 and the Smart Install client IP address as 10.10.10.200:

```
ip access-list extended SMI_HARDENING_LIST
 permit tcp host 10.10.10.1 host 10.10.10.200 eq 4786
 deny tcp any any eq 4786
 permit ip any any
```

This ACL must be deployed on all IP interfaces on all clients. It can also be pushed via the director when switches are first deployed.

To further restrict access to all the clients within the infrastructure, administrators can use the following security best practices on other devices in the network:

- Infrastructure access control lists (iACLs)
- VLAN access control lists (VACLs)

Migration Plan

Customers who can not properly protect their Smart Install IP infrastructure address space, or need the added security of authorization and authentication between the director and clients can migrate to Cisco Plug-N-Play (PnP). For more information, see the *PnP Feature Guide*.

If your release does not support PnP, migrate to Smart Install Proxy (SMI Proxy). The SMI Proxy feature must be enabled on a network device that is configured as a PnP Agent. This device will bridge the communication between older devices running Smart Install and the PnP Server. The SMI Proxy device will contact the central PnP Server on behalf of the device running older versions, to retrieve the image and configuration information. For more information, see the *SMI Proxy* chapter.

SMI Proxy is available in Cisco IOS Release 15.2(2)E2 and later releases.

Note The security best practices must be followed for all devices on which the SMI Proxy feature is enabled, and also for all devices on which the Smart Install feature is enabled.

DHCP and Smart Install

DHCP is recommended in Smart Install networks and is required for zero-touch updates. On-demand updates do not require DHCP. In a DHCP network, DHCP snooping is automatically enabled on the director. The director snoops DHCP offers and requests to and from the client switches and uses DHCP snooping to insert the DHCP options used in the Smart Install operation.

However, because DHCP snooping is not supported on routed ports, you should not connect routed ports directly to the client or the director.

A DHCP server in a Smart Install network can be positioned in one of these ways:

- The Smart Install director can act as the DHCP server in the network. When the DHCP offer goes to the client switches, the director allocates the IP addresses and assigns configurations and images and the hostname as DHCP options in the DHCP offer and DHCP acknowledgment. DHCP snooping is automatically turned on for the director.
- The DHCP server can be another device (third-party server) in the Smart Install network. In this case, DHCP packets between the clients and DHCP server must pass through the director.

Note You can configure a join-window time period so that the director can only modify the DHCP offer and send the image and configuration files to the client during the configured window. The join window restricts Smart Install for a specified period of time and acts as a security precaution to control when a client can receive these files. See the "Using a Join Window" section on page 1-15.

- A third-party server and the director DHCP server can coexist in a network. In this case, the director is responsible only for the DHCP requests of the switches in the Smart Install network. The director maintains the Smart Install database and pool; other DHCP database functions are maintained by the third-party server.

See the "Configuring the DHCP Server" section on page 2-5 for configuration instructions.

If the Smart Install DHCP server is the director or another device running Cisco IOS and the network reloads, the server might assign new IP addresses to participating switches. If a switch IP address changes, it might no longer be reachable. If the director IP address changes, it is no longer the Smart Install director, which could break the director and client switch relationships. This is an unlikely but possible corner-case occurrence. To prevent this occurrence, you should enable *DHCP remembering* by entering the **ip dhcp remember** global configuration command or the **remember** DHCP-pool configuration command on the DHCP server,

Non-Cisco IOS third-party DHCP servers require an IP-address-to-MAC-address binding to ensure that the same IP address is given to a switch on a reload.

Note In Smart Install networks that do not use DHCP, you must manually configure the director IP address on each client switch by entering the **vstack director** *ip-address* global configuration command. Client switches require only the director IP address. Smart Install networks that do not use DHCP cannot support zero-touch updates but can support on-demand update.

Adding a Client Switch to the Network

When a switch arrives from the factory, it contains the factory default image. When it is plugged in and connected to the network and boots up, it tries to get its IP address from DHCP. When a device is added to the network, a notification is sent to the director that a new client has joined. If the switch is connected (directly or indirectly) to the Smart Install director, the director recognizes the new switch through DHCP offers and acknowledgments. The director searches its database to determine if the switch belongs to a configured group. If not, the director determines if the switch matches the Smart Install network default PID. If the director has a configuration for the type of client that was added and if the join window is open, the new client receives the image and configuration files.

Note When clients in a Smart Install network consist of more than one PID, you should configure built-in groups or custom groups based on MAC address, connectivity, stack group, or product-ID, and define the image and configuration files for each group.

If the DHCP Server is external or internal (running on the director), the director inserts options into the DHCP response, informing the client where to download its IOS image and configuration file provided the join window is open.

Note If a join window has been configured, the Smart Install configuration and image files are sent to the client only during the configured time period. A client switch sends an error message if it cannot download an image or configuration file due to misconfiguration, if the image or configuration file is not available, or if a join window is configured and the DHCP acknowledgments occurs beyond the configured time frame. See the "Using a Join Window" section on page 1-15 for more information.

After a switch has been added to the Smart Install network, you can do an on-demand download of an image or configuration file to the client at any time if the switch meets these criteria:

- A switch that is not Smart Install capable must have an enable mode password and a valid IP interface.
- A switch running the Smart Install image must have a valid IP interface.

If a client switch in the Smart-Install network is running Cisco IOS Release 12.2(55)SE or later, or 3.2(0)SE and later, 15.0(2)EX, 15.0(2)EX1, 3.6.(0)E, and 15.2.(2)E is replaced with a switch with the same product ID, the new client receives the same image and configuration as the replaced client. Se the "Replacing a Client Switch" section on page 1-15.

See Chapter 2, "Configuring Cisco Smart Install Devices" for typical configurations.

Backing Up the Client Configuration

After a client boots up, it sends a copy of its startup configuration to the director. This file is the backup configuration for that client. Any time the user, directly or through the director, saves a client configuration, a backup configuration is created. The configuration is stored on the local repository on the director or on a remote repository on a server. The backup file is used to reconfigure a client during a zero-touch replacement.

Note Client backup is supported only when the director and client are running Cisco IOS Release 12.2(55)SE or later.

Client configuration backup is enabled by default. You can disable it by entering the **no vstack backup** global configuration command. You enable the file backup feature on the director by entering the **vstack backup** and you can configure a repository for the backup files. If you do not specify a repository, the files are stored in the director **flash:/vstack** directory.

A client configuration backup is triggered:

- When the **write memory** privileged EXEC command is entered on the client.
- When the director boots up, it requests configuration information from clients and backs up these configurations.

Replacing a Client Switch

You can use zero-touch replacement to exchange and install a like-type client in the Smart Install network. When a new switch is added to the network, a CDP database update is sent to the director, which determines if this is a new MAC address and therefore a new client. When a client needs to be replaced and is removed from the network, the CDP database lists the removed client as *inactive*. If another client MAC address with the same product-ID is detected on the same port, this client is considered a *replacement* client. The director gives it the same image and configuration that the previous client had.

The director removes the entry for the replaced client from the director database. If the replaced client is put elsewhere in the network, the director creates a new entry for it that includes the client's new information.

During a zero-touch replacement, the replacement client receives the last backed-up configuration file, which is stored in the director or a remote repository. Client configuration files are backed up by default, unless you disable this functionality on the director.

Only one Smart Install client can be replaced at a time on the same branch and only if there is one path to the director.

Note Zero-touch replacement is supported only when the director and the replaced client are running Cisco IOS Release 12.2(55)SE or later, 15.1(1)SY, 15.0(2)SE and later, 3.2(0)SE and later, 15.0(2)EX, 15.0(2)EX1, 3.6.(0)E, or 15.2.(2)E. When a client switch running an earlier release is replaced, the new switch receives a seed replacement.

When the replacement client and existing client do not have the same product ID, port connections, or interfaces, the replacement client is considered new to the Smart Install network. For example, a replacement client must be connected to the same ports on the director and on other client switches as was the original client. When a new device is added to the network, a notification is sent to the director that a new client has joined. If the director has a configuration for the type of client that was added and if the join window is open, the new client receives the image and configuration files.

Using a Join Window

A join window is a time window during which the client can update image or configuration files. The director can provide information about the image and configuration to the client only during this window. A client attempting to join the Smart Install network outside the join window is not allowed to do so and cannot update the image and configuration files.

Use the **vstack join-window mode auto** global configuration command to automatically update clients with the latest image and configuration files when they are added during a join window. Use the **no vstack join-window mode** global configuration command to put the client in a hold state.

Use the following commands to open or close a join window:

- Enter the **vstack join-window start** [*date*] *hh:mm* [*interval*] [*end date*] [**recurring**] global configuration command to configure a time window to control downloads of configuration and image files to client switches.
- Enter the **vstack join-window close** global configuration command to manually close a join window, enter the **no vstack join-window close** global configuration command to manually open a join window.

Note You cannot combine the **vstack join-window start** and **[no] vstack join-window** commands to close and open the join window.

If a join window *is* configured, a zero touch update is possible only during the configured window. If a switch connects to the director at any time other than during the join window, the Smart Install configuration and image files are not automatically downloaded. Instead, the new switch receives the default files from the DHCP server. This feature provides control of the files and prevents unauthorized switches from receiving the Smart Install configuration.

If a join window *is not* configured, a zero touch update can happen at any time because that is the default state.

When a join window is configured, and the DHCP acknowledgement occurs outside of the configured window, a client switch sends an error message that it cannot download an image or configuration file.

Configuring Join Window Mode

The join window mode includes a *hold* state that adds an extra level of security for the client. The hold state lets you control whether or not the client can receive a software upgrade, and how the upgrade is performed. The hold-state is either *on* or *off* when the join window is active.

You configure automatic join window mode with the **vstack join-window mode auto** global configuration command. In this mode, when a client joins the network, the director automatically upgrades it when the join window is open.

When you set the mode to manual by entering the **no vstack join-window mode** global configuration command, when a client joins the network during an open join window, the client is put on the hold list.

You can review clients on the hold list by entering the **show vstack status** user EXEC command. You can remove a client from the hold list by entering the **vstack on-hold-clients remove** global configuration command.

Note When a client has been removed from the hold state to allow that client to join the network, you must restart the client to again put it in the hold state (if the mode is manual) or to automatically upgrade if the mode is auto and the join window is open.

When a new client joins the network and the mode is set to auto, the join window state is active, whether or not the join window is open or closed. When the mode is set to manual and the join window is open, the client is put on the hold list. If the join window is closed, the client cannot join the network (denied).

Table 1-3 lists the join window states and the actions that are allowed or not allowed for each state.

Table 1-3 Join Window States and Functionality

Join Window State	Zero-Touch Updates	On-Demand Updates	Configuration Backup
Active	Allowed	Allowed	Allowed
Deny	Not allowed	Allowed	Allowed
Hold	Allowed with user intervention	Allowed	Not allowed

Starting with Cisco IOS Release 12.2(58)SE,15.1(1)SY, 15.0(2)SE and later, 3.2(0)SE and later, 3.6.(0)E, and 15.2.(2)E, you can manually change the join window state for a client or multiple clients from the denied state to the active or held state by using the **vstack join-window-status index** *client-id* {**allowed** | **held**} privileged EXEC command.

Updating Client Switches

Supported types of image and configuration updates:

- Zero-touch update—For a client with no configuration. This could be for the initial installation of an image and configuration on a new client, for image and configuration installation on a client after a **write erase** and **reload**, or, in case of a replacement switch, if **vstack backup** is enabled. The Smart Install network must run DHCP to perform zero-touch updates.

  On all clients, prior to Cisco IOS Release XE 3.5.0E and Cisco IOS 15.2(1)SG, only image+config zero-touch upgrades were supported. With Cisco IOS Release XE 3.6.0E and Cisco IOS Release 15.2(1)SG, image+config zero-touch upgrade are no longer mandatory; zero-touch config alone and zero-touch image alone upgrades are now supported on all clients.

- On-demand update—For clients that are already in the network and connected to the director. On-demand updates can be performed on single client or on all clients that belong to a built-in group. DHCP is not required for on-demand updates. The director needs the IP address of a client for a single-client update if the client is not in a built-in group. For an on-demand update of a client running an image earlier than 12.2(52)SE, the client must have an enable password and an IP interface configured.

You can do zero-touch or on-demand updates to any Smart Install client switches. You can also use the **vstack download-image** and **vstack download-config** privileged EXEC commands from the director to update the image or configuration of any switch as long as the director has a connection (directly or through another switch) to the switch. You can also telnet to a client switch and use the **archive download-sw** privileged EXEC command to update switch software. When you telnet to a client switch, you must know the switch enable passwords to do any configuration.

Beginning with Cisco IOS Release 12.2(58)SE, 15.1(1)SY, 15.0(2)SE, 3.2(0)SE and later, 3.6.(0)E, you can perform a simultaneous update of multiple clients that have the same product ID and password by entering the index numbers from the director database in the **vstack download-image** privileged EXEC command.

Zero-Touch Installation

A zero-touch installation is an update initiated by the director on a client switch that has no configuration. You can perform a zero-touch installation on Smart Install capable switches and non-Smart Install switches. The zero-touch installation occurs automatically with little or no intervention. A switch with no configuration can be a new, out-of-box switch or one on which you have entered the **write erase** and **reload** privileged EXEC commands.

During a zero-touch installation, do not touch the console keyboard or attempt to enter a command or auto return on the switch. Else, the auto install and Smart Install processes stop. To recover and restart the process, you need to return to the system prompt, enter **write erase** and **reload** commands, and restart the process.

During a zero-touch installation, the VLAN specified in the seed configuration for a particular client should be the same as the startup VLAN on the director. If it is not, the configuration backup process fails.

If the TFTP server is the director, the file is saved in the director root directory. If the server is another device, it is saved in the *tftproot directory*. This is the default directory in the TFTP server where the files to be sent using TFTP are stored. The imageclist file, the new configuration file, and the image are also stored in this directory.

See the "Configuring the TFTP Server" section on page 2-8.

Connecting to a Client Switch

To connect to the client switch command-line interface, enter the **vstack attach** {*client-index* | *client_ip_address*} privileged EXEC command. The client-index number represents active clients in the Smart Install network, displayed in the command-line help by entering a question mark (?) after the **vstack attach** command. The same client number is valid until the client reboots.

```
Director# vstack attach ?
  1        c3750-2042 @ IP 10.0.0.1 : MAC 0000.0040.4080
  2        c3750-2045 @ IP 10.0.0.2 : MAC 0000.000c.0d80
  A.B.C.D  IP address of remote node to attempt attaching to
```

To attach to a client, the client switch must be configured for telnet service and have a configured enable password.