使用Python脚本实现Catalyst 9000交换机的自动化

目录

简介

本文档介绍如何使用Python脚本扩展EEM，以在Catalyst 9000交换机上自动执行配置和数据收集。

先决条件

要求

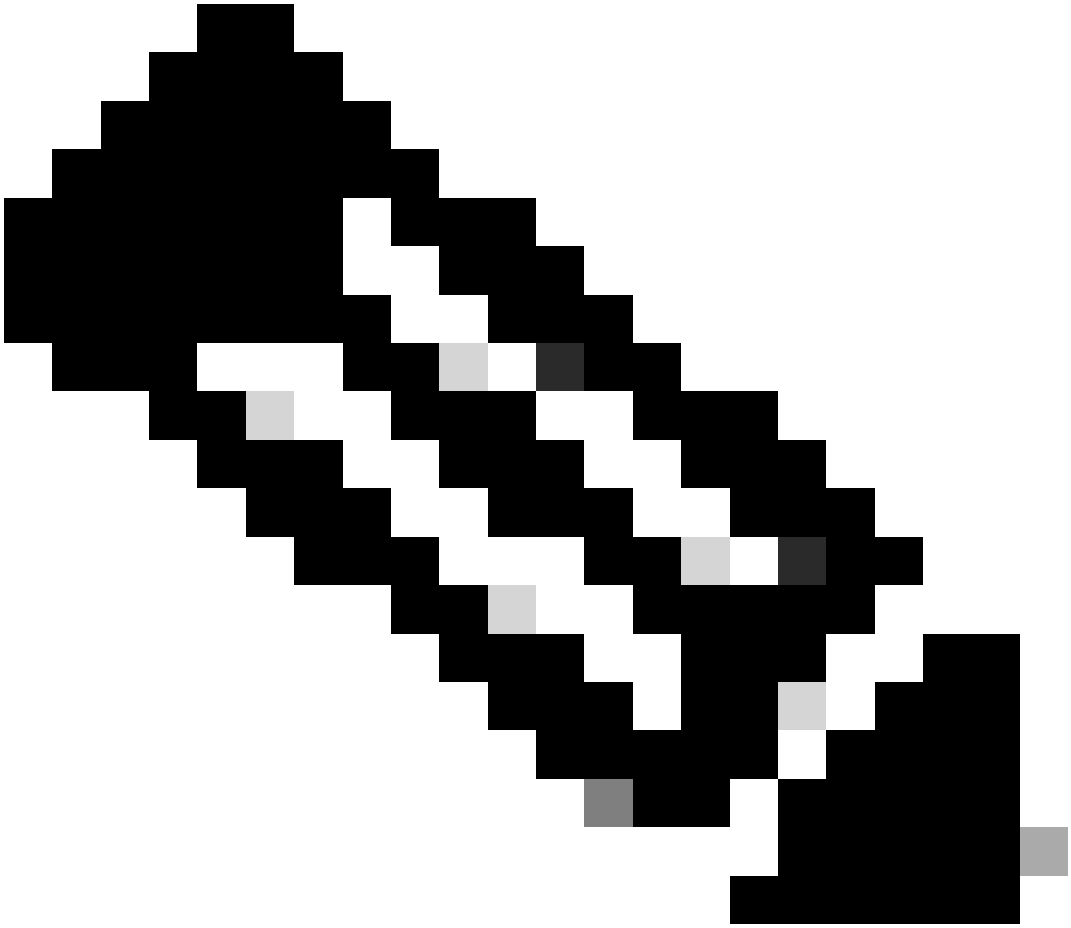
思科建议您了解并熟悉以下主题：

- Cisco IOS®和Cisco IOS® XE EEM
- 应用托管和访客外壳
- Python 脚本
- Linux命令

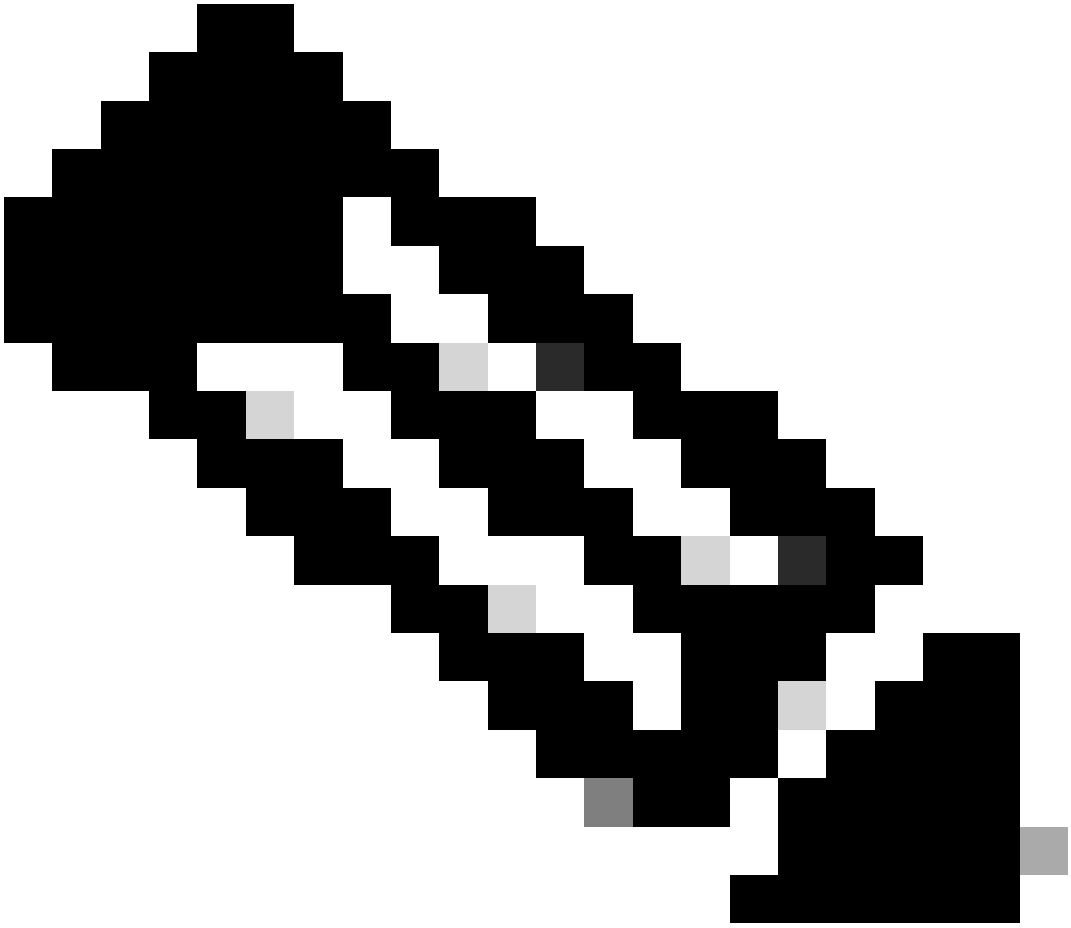
使用的组件

本文档中的信息基于以下软件和硬件版本：

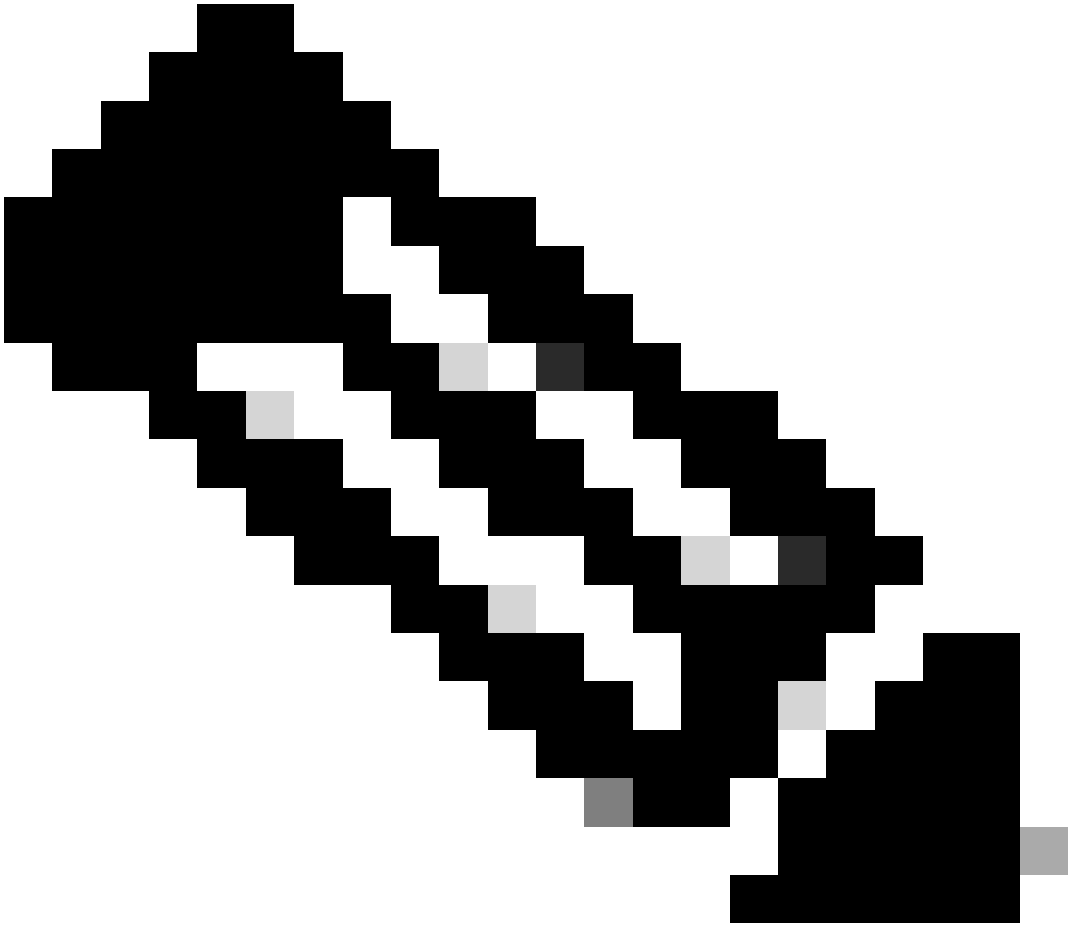
- Catalyst 9200
- Catalyst 9300
- Catalyst 9400
- Catalyst 9500
- Catalyst 9600
- Cisco IOS XE 17.9.1及更高版本



注意：有关在其他思科平台上启用这些功能所使用的命令，请参阅相应的配置指南。



注意：Catalyst 9200L交换机不支持Guest Shell。



注意：思科TAC不支持这些脚本，这些脚本按原样提供，用于教学目的。

本文档中的信息都是基于特定实验室环境中的设备编写的。本文档中使用的所有设备最初均采用原始（默认）配置。如果您的网络处于活动状态，请确保您了解所有命令的潜在影响。

规则

有关文档规则的信息，请参阅 Cisco 技术提示规则。

背景信息

访客Shell和Python脚本

Cisco Catalyst 9000系列交换机上的应用托管为合作伙伴和开发人员带来了创新机会，因为网络设备可以与应用运行时环境合并。

它支持容器化应用，与主操作系统和思科IOS XE内核完全隔离。这种分离可确保托管应用的资源分

配与核心路由和交换功能不同。

Cisco IOS XE设备的应用托管基础设施称为IOx(Cisco IOS + Linux)，便于在网络设备上托管由思科、合作伙伴和第三方开发人员开发的应用和服务，确保跨各种硬件平台无缝集成。

Guest Shell是一种专用容器部署，它是对系统部署有帮助的应用示例。

Guest Shell提供基于Linux的虚拟化环境，旨在运行自定义Linux应用（包括Python），以实现思科设备的自动化控制和管理。Guest Shell容器允许用户在系统中运行脚本和应用。具体来说，在Intel x86平台上，Guest Shell容器是一个Linux容器(LXC)，其中包含CentOS 8.0最小根文件系统。在Cisco IOS XE Amsterdam 17.3.1及更高版本中，仅支持Python V3.6。可以在运行时使用CentOS 8.0中的Yum实用程序安装其他Python库。也可以使用Pip安装包(PIP)安装或更新Python包。

Guest Shell包含Python应用编程接口(API)，允许使用Python CLI模块运行Cisco IOS XE命令。这样，Python脚本增强了自动化功能，为网络工程师提供了一款通用工具，用于开发用于自动化配置和数据收集任务的脚本。虽然这些脚本可以通过CLI手动运行，但是也可以与EEM脚本一起用于响应特定事件，例如系统日志消息、接口事件或命令运行。实际上，任何能够触发EEM脚本的事件也可用于触发Python脚本，从而扩大Cisco Catalyst 9000交换机内部的自动化潜力。

安装Guest Shell后，将在闪存文件系统中自动创建访客共享目录。这是可以通过Python脚本和访客外壳访问的文件系统。为确保使用堆叠时正确同步，请将此文件夹保持在50 MB以下。

将Python与EEM脚本配合使用的优势

- Python允许在Python脚本中处理复杂的逻辑（如正则表达式、循环和匹配），从而扩展了EEM脚本的自动化功能。此功能提供了创建更强大的EEM脚本的机会。
- 作为一种著名的编程语言，Python可降低希望自动化Cisco IOS XE设备的网络工程师的进入障碍。此外，它还提供可维护性和可读性。
- Python还提供错误处理功能以及强大的标准库。

将Python与EEM脚本配合使用的注意事项

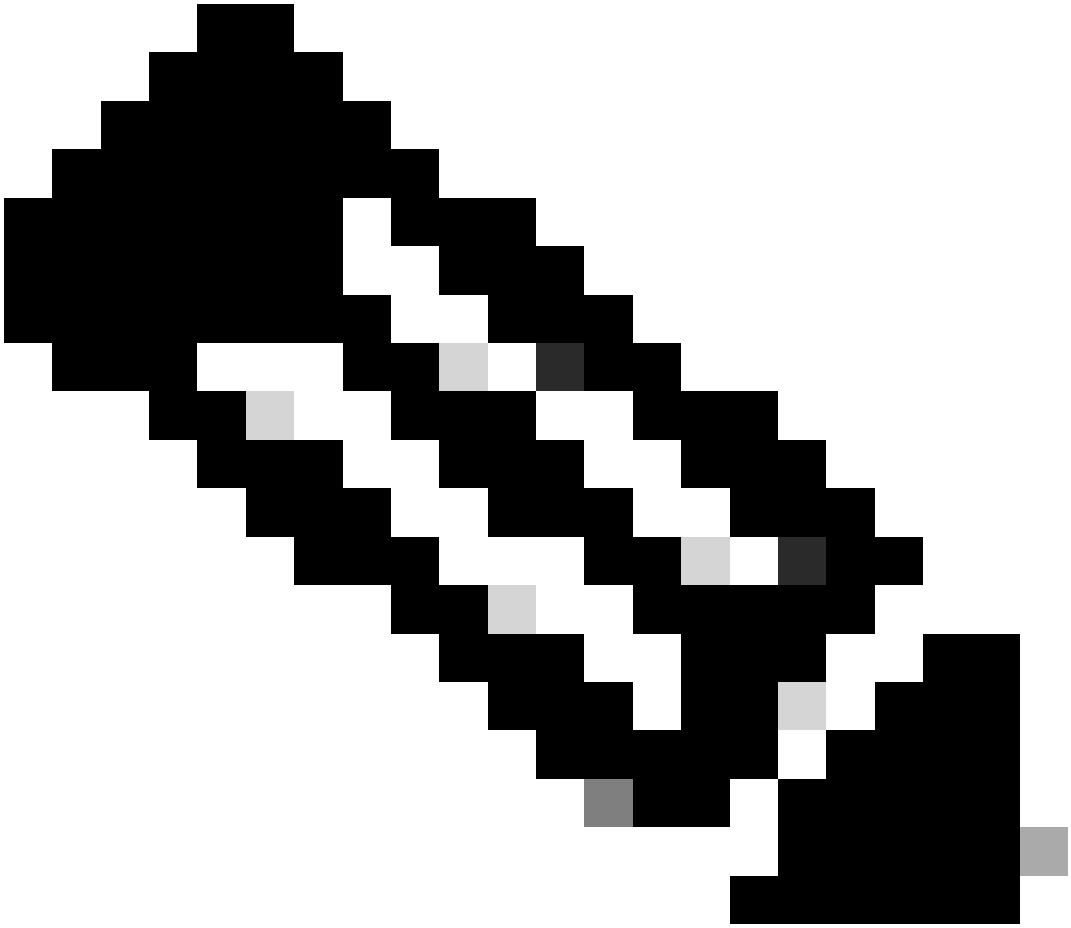
- 默认情况下，Guest Shell未启用，因此需要先启用它，然后才能运行Python脚本。
- 无法直接在CLI中创建Python脚本；它们需要首先在开发环境中开发，然后复制到交换机的闪存中。

Cisco IOS XE中的SELinux

从Cisco IOS XE 17.8.1开始，引入了对安全增强型Linux(SELinux)的支持，以通过管理进程、用户和文件相互交互方式的策略实施安全性。SELinux策略定义允许进程或用户访问哪些操作和资源。当用户或进程尝试执行策略不允许的操作（例如，访问资源或运行命令）时，可能会发生违规。SELinux可以在两种不同的模式下运行：

1. 许可模式：SELinux不会实施任何策略。但是，它仍会记录任何违规行为，好像这些行为被拒绝一样。

2. 实施：SELinux会在系统上主动实施安全策略。如果操作违反SELinux策略，则拒绝并记录操作。



注意：在Cisco IOS XE 17.8.1中引入默认模式时，默认模式被设置为允许模式。但是，从版本17.14.1开始，SELinux将在实施模式下启用。

使用Guest Shell时，在使用实施模式时，可能会拒绝访问某些资源。如果尝试使用Guest Shell或Python脚本执行操作时导致权限被拒绝错误，则与此日志类似：

```
*Jan 21 13:22:01: %SELINUX-1-VIOLATION: Chassis 1 R0/0: audispd: type=AVC msg=audit(1738074795.448:198)
```

要验证SELinux是否拒绝脚本，请使用命令show platform software audit summary检查拒绝计数是否增加。此外show platform software audit all，还会显示SELinux阻止的操作的日志。访问矢量缓存(AVC)是在SELinux中记录访问控制决策的机制，因此使用此命令时，请查找以type=AVC开头的日志。

如果脚本被拒绝和阻塞，可以使用命令将SELinux设置为允许模式set platform software selinux permissive。此更改不会存储在运行配置或启动配置中，因此重新加载后，模式将恢复为实施。因此，每次重新加载交换机时，都需要重新应用此更改。可使用验证更改show platform software selinux。

配置

要使用EEM和Python脚本自动执行交换机上的任务，请执行以下步骤：

1. 启用Guest Shell。
2. 将Python脚本复制到/flash/guest-share/目录。您可以使用Cisco IOS XE中可用的任何复制机制，例如SCP、FTP或WebUI中的FIle Manager。Python脚本在闪存中后，可以使用命令运行该脚本guestshell run python3 /flash/guest-share/cat9k_script.py。
3. 配置运行Python脚本的EEM脚本。此设置允许使用EEM脚本提供的任意多个事件检测器（例如系统日志消息、CLI模式和Cron调度程序）触发Python脚本。

本节介绍步骤1。下一部分提供了演示如何实施步骤2和步骤3的示例。

使用静态IP地址启用Guest Shell

按照以下过程启用Guest Shell:

1. 启用IOx。

<#root>

```
Switch#conf t
Switch(config)#iox
Switch(config)#
*Feb 17 18:13:24.440: %UICFGEXP-6-SERVER_NOTIFIED_START: Switch 1 R0/0: psd: Server iox has been r
*Feb 17 18:13:28.797: %IOX-3-IOX_RESTARTABITLITY: Switch 1 R0/0: run_ioxn_caf: Stack is in N+1 mod

*Feb 17 18:13:36.069: %IM-6-IOX_ENABLEMENT: Switch 1 R0/0: ioxman: IOX is ready.
```

2. 为Guest Shell配置Application Hosting Network。本示例使用AppGigabitEthernet接口提供网络访问；但是，也可以使用管理接口(Gi0/0)。

```
Switch(config)#int appgig1/0/1
Switch(config-if)#switchport mode trunk
Switch(config-if)#switchport trunk allowed vlan 20

Switch(config)#app-hosting appid guestshell
Switch(config-app-hosting)#app-vnic appGigabitEthernet trunk
Switch(config-config-app-hosting-trunk)#vlan 20 guest-interface 0
Switch(config-config-app-hosting-vlan-access-ip)#guest-ipaddress 10.20.1.2 netmask 255.255.255.0
Switch(config-config-app-hosting-vlan-access-ip)#exit
Switch(config-config-app-hosting-trunk)#exit
Switch(config-app-hosting)#app-default-gateway 10.20.1.1 guest-interface 0
```

```
Switch(config-app-hosting)#name-server0 10.31.104.74
Switch(config-app-hosting)#end
```

3. 启用Guest Shell。

<#root>

```
Switch#guestshell enable
Interface will be selected if configured in app-hosting
Please wait for completion
guestshell installed successfully
Current state is: DEPLOYED
guestshell activated successfully
Current state is: ACTIVATED
guestshell started successfully
Current state is: RUNNING
```

Guestshell enabled successfully

4. 验证Guest Shell。此示例验证默认网关和cisco.com均可访问。此外，验证Python 3是否可以从访客外壳运行。

<#root>

```
! Validate that the Guest Shell is running.
Switch#
```

show app-hosting list

```
App id                                   State
------------------------------------------------------------
```

guestshell

RUNNING

```
Switch#
```

guestshell run bash

```
[guestshell@guestshell ~]$
```

```
! Validate that the IP address of the Guest Shell is configured correctly.
[guestshell@guestshell ~]$
```

sudo ifconfig

```
eth0: flags=4163<UP,BROADCAST,RUNNING,MULTICAST>  mtu 1500
```

inet 10.20.1.2 netmask 255.255.255.0

```
  broadcast 10.20.1.255
```

```
        inet6 fe80::5054:ddff:fe61:24c7  prefixlen 64  scopeid 0x20
        ether 52:54:dd:61:24:c7  txqueuelen 1000  (Ethernet)
        RX packets 23  bytes 1524 (1.4 KiB)
        RX errors 0  dropped 0  overruns 0  frame 0
        TX packets 9  bytes 726 (726.0 B)
        TX errors 0  dropped 0 overruns 0  carrier 0  collisions 0

lo: flags=73<UP,LOOPBACK,RUNNING>  mtu 65536
        inet 127.0.0.1  netmask 255.0.0.0
        inet6 ::1  prefixlen 128  scopeid 0x10
        loop  txqueuelen 1000  (Local Loopback)
        RX packets 177  bytes 34754 (33.9 KiB)
        RX errors 0  dropped 0  overruns 0  frame 0
        TX packets 177  bytes 34754 (33.9 KiB)
        TX errors 0  dropped 0 overruns 0  carrier 0  collisions 0

! Validate reachability to the default gateway and ensure that DNS is resolving correctly.
[guestshell@guestshell ~]$
```

ping 10.20.1.1

```
PING 10.20.1.1 (10.20.1.1) 56(84) bytes of data.
64 bytes from 10.20.1.1: icmp_seq=2 ttl=254 time=0.537 ms
64 bytes from 10.20.1.1: icmp_seq=3 ttl=254 time=0.537 ms
64 bytes from 10.20.1.1: icmp_seq=4 ttl=254 time=0.532 ms
64 bytes from 10.20.1.1: icmp_seq=5 ttl=254 time=0.574 ms
64 bytes from 10.20.1.1: icmp_seq=6 ttl=254 time=0.590 ms
^C
--- 10.20.1.1 ping statistics ---
6 packets transmitted, 5 received, 16.6667% packet loss, time 5129ms
rtt min/avg/max/mdev = 0.532/0.554/0.590/0.023 ms

[guestshell@guestshell ~]$
```

ping cisco.com

```
PING cisco.com (X.X.X.X) 56(84) bytes of data.
64 bytes from www1.cisco.com (X.X.X.X): icmp_seq=1 ttl=237 time=125 ms
64 bytes from www1.cisco.com (X.X.X.X): icmp_seq=2 ttl=237 time=125 ms
^C
--- cisco.com ping statistics ---
2 packets transmitted, 2 received, 0% packet loss, time 1002ms
rtt min/avg/max/mdev = 124.937/125.141/125.345/0.204 ms

! Validate the Python version.
[guestshell@guestshell ~]$
```

python3 --version

Python 3.6.8

```
! Run Python commands within the Guest Shell.
[guestshell@guestshell ~]$
```

python3

```
Python 3.6.8 (default, Dec 22 2020, 19:04:08)
[GCC 8.4.1 20200928 (Red Hat 8.4.1-1)] on linux
Type "help", "copyright", "credits" or "license" for more information.
>>>
```

print("Cisco")
Cisco

```
>>> exit()
[guestshell@guestshell ~]$

[guestshell@guestshell ~]$ exit
exit

Switch#
```

使用DHCP IP地址启用Guest Shell

通常，Guest Shell配置有静态IP地址，因为Guest Shell容器默认情况下没有DHCP客户端服务。如果访客外壳需要动态请求IP地址，则需要安装DHCP客户端服务。遵循以下流程：

1. 按照以下步骤使用静态IP地址启用Guest Shell。但是，这次不要在步骤2中分配应用托管配置中的IP地址。请改用以下配置：

```
Switch(config)#int appgig1/0/1
Switch(config-if)#switchport mode trunk
Switch(config-if)#switchport trunk allowed vlan 20

Switch(config)#app-hosting appid guestshell
Switch(config-app-hosting)#app-vnic appGigabitEthernet trunk
Switch(config-config-app-hosting-trunk)#vlan 20 guest-interface 0
Switch(config-app-hosting)#end
```

2. DHCP客户端可以使用带有命令的Yum实用程序进行安装sudo yum install dhcp-client。但是，CentOS Stream 8的存储库已停用。要解决此问题，可以手动下载和安装DHCP客户端软件包。在PC上，从CentOS Stream 8存储区下载这些软件包，并将其打包为tar文件。

   - bind-export-libs-9.11.36-13.el8.x86_64.rpm
   - dhcp-client-4.3.6-50.el8.x86_64.rpm
   - dhcp-common-4.3.6-50.el8.noarch.rpm
   - dhcp-libs-4.3.6-50.el8.x86_64.rpm

```
[cisco@CISCO-PC guestshell-packages] % tar -cf dhcp-client.tar bind-export-libs-9.11.36-13.el8.x86
```

3. 将文件复制到交换机的/flash/guest-share/目录dhcp-client.tar。

4. 输入Guest Shell bash session并运行Linux命令以安装DHCP客户端并请求IP地址。

```
<#root>

513E.D.02-C9300X-12Y-A-17#

guestshell run bash
```

```
[guestshell@guestshell ~]$

sudo ifconfig

lo: flags=73<UP,LOOPBACK,RUNNING>  mtu 65536

<--- no eth0 interface

        inet 127.0.0.1  netmask 255.0.0.0
        inet6 ::1  prefixlen 128  scopeid 0x10
        loop  txqueuelen 1000  (Local Loopback)
        RX packets 149  bytes 32462 (31.7 KiB)
        RX errors 0  dropped 0  overruns 0  frame 0
        TX packets 149  bytes 32462 (31.7 KiB)
        TX errors 0  dropped 0 overruns 0  carrier 0  collisions 0

! Unpack the packages needed for the DHCP client service.
[guestshell@guestshell ~]$

tar -xf /flash/guest-share/dhcp-client.tar

tar: Ignoring unknown extended header keyword 'LIBARCHIVE.xattr.com.apple.quarantine'
tar: Ignoring unknown extended header keyword 'LIBARCHIVE.xattr.com.apple.metadata:kMDItemWhereFro
tar: Ignoring unknown extended header keyword 'LIBARCHIVE.xattr.com.apple.macl'
tar: Ignoring unknown extended header keyword 'LIBARCHIVE.xattr.com.apple.quarantine'
tar: Ignoring unknown extended header keyword 'LIBARCHIVE.xattr.com.apple.metadata:kMDItemWhereFro
tar: Ignoring unknown extended header keyword 'LIBARCHIVE.xattr.com.apple.macl'
tar: Ignoring unknown extended header keyword 'LIBARCHIVE.xattr.com.apple.quarantine'
tar: Ignoring unknown extended header keyword 'LIBARCHIVE.xattr.com.apple.metadata:kMDItemWhereFro
tar: Ignoring unknown extended header keyword 'LIBARCHIVE.xattr.com.apple.macl'
tar: Ignoring unknown extended header keyword 'LIBARCHIVE.xattr.com.apple.quarantine'
tar: Ignoring unknown extended header keyword 'LIBARCHIVE.xattr.com.apple.metadata:kMDItemWhereFro
tar: Ignoring unknown extended header keyword 'LIBARCHIVE.xattr.com.apple.macl'

[guestshell@guestshell ~]$

ls

bind-export-libs-9.11.36-13.el8.x86_64.rpm  dhcp-common-4.3.6-50.el8.noarch.rpm
dhcp-client-4.3.6-50.el8.x86_64.rpm         dhcp-libs-4.3.6-50.el8.x86_64.rpm

! Install the packages using DNF.
[guestshell@guestshell ~]$

sudo dnf -y --disablerepo=* localinstall *.rpm

Warning: failed loading '/etc/yum.repos.d/CentOS-Base.repo', skipping.
Dependencies resolved.
==================================================================================================
 Package                   Architecture    Version                     Repository           Siz
==================================================================================================
Installing:
 bind-export-libs          x86_64          32:9.11.36-13.el8           @commandline         1.1
 dhcp-client               x86_64          12:4.3.6-50.el8             @commandline         319
 dhcp-common               noarch          12:4.3.6-50.el8             @commandline         208
 dhcp-libs                 x86_64          12:4.3.6-50.el8             @commandline         148

Transaction Summary
==================================================================================================
Install  4 Packages

Total size: 1.8 M
Installed size: 3.9 M
```

```
Downloading Packages:
Running transaction check
Transaction check succeeded.
Running transaction test
Transaction test succeeded.
Running transaction
  Preparing        :                                                                                                1/
  Installing       : dhcp-libs-12:4.3.6-50.el8.x86_64                                                               1/
  Installing       : dhcp-common-12:4.3.6-50.el8.noarch                                                             2/
  Installing       : bind-export-libs-32:9.11.36-13.el8.x86_64                                                      3/
  Running scriptlet: bind-export-libs-32:9.11.36-13.el8.x86_64                                                      3/
  Installing       : dhcp-client-12:4.3.6-50.el8.x86_64                                                             4/
  Running scriptlet: dhcp-client-12:4.3.6-50.el8.x86_64                                                             4/
  Verifying        : bind-export-libs-32:9.11.36-13.el8.x86_64                                                      1/
  Verifying        : dhcp-client-12:4.3.6-50.el8.x86_64                                                             2/
  Verifying        : dhcp-common-12:4.3.6-50.el8.noarch                                                             3/
  Verifying        : dhcp-libs-12:4.3.6-50.el8.x86_64                                                               4/

Installed:
  bind-export-libs-32:9.11.36-13.el8.x86_64           dhcp-client-12:4.3.6-50.el8.x86_64
  dhcp-common-12:4.3.6-50.el8.noarch                  dhcp-libs-12:4.3.6-50.el8.x86_64

Complete!

! Request a DHCP IP address for eth0.
[guestshell@guestshell ~]$
```

sudo dhclient eth0

```
! Validate the leased IP address.
[guestshell@guestshell ~]$
```

sudo ifconfig eth0

```
eth0: flags=4163<UP,BROADCAST,RUNNING,MULTICAST>  mtu 1500
```

inet 10.1.1.12 netmask 255.255.255.0

```
  broadcast 10.1.1.255
        inet6 fe80::5054:ddff:fe85:a0d5  prefixlen 64  scopeid 0x20
        ether 52:54:dd:85:a0:d5  txqueuelen 1000  (Ethernet)
        RX packets 7  bytes 1000 (1000.0 B)
        RX errors 0  dropped 0  overruns 0  frame 0
        TX packets 11  bytes 1354 (1.3 KiB)
        TX errors 0  dropped 0 overruns 0  carrier 0  collisions 0

[guestshell@guestshell ~]$
```

exit

```
exit

! You can validate the leased IP address from Cisco IOS XE too.
513E.D.02-C9300X-12Y-A-17#
```

guestshell run sudo ifconfig eth0

```
eth0: flags=4163<UP,BROADCAST,RUNNING,MULTICAST>  mtu 1500
```

inet 10.1.1.12 netmask 255.255.255.0

```
        broadcast 10.1.1.255
              inet6 fe80::5054:ddff:fe85:a0d5  prefixlen 64  scopeid 0x20
              ether 52:54:dd:85:a0:d5  txqueuelen 1000  (Ethernet)
              RX packets 28  bytes 2344 (2.2 KiB)
              RX errors 0  dropped 0  overruns 0  frame 0
              TX packets 13  bytes 1494 (1.4 KiB)
              TX errors 0  dropped 0 overruns 0  carrier 0  collisions 0
```

使用案例

使用案例1:自动保存SCP服务器上的配置更改

在某些情况下，每次使用命令时自动将交换机配置保存到服务器write memory是有益的。这种做法有助于维护更改记录，并在必要时允许配置回滚。选择服务器时，既可以使用TFTP也可以使用SCP，但SCP服务器提供额外的安全层。

Cisco IOS存档功能提供此功能。但是，SCP凭证在配置中无法隐藏，这是一个重大缺陷；服务器路径在运行配置和启动配置中均以明文显示。

```
Switch#show running-config | section archive
archive
 path scp://cisco:Cisco!123@10.31.121.224/
 write-memory
```

通过使用Guest Shell和Python，可以在保持凭证隐藏的同时实现相同的功能。这通过利用Guest Shell中的环境变量来存储实际SCP凭证来实现。因此，SCP服务器凭证在运行配置中不可见。

在此方法中，运行配置仅显示EEM脚本，而Python脚本使用凭证构建命令copy running-config scp:，并将其传递给要运行的EEM脚本。

在本示例中，请按照以下步骤操作：

1. 将Python脚本复制到/flash/guest-share目录。此脚本读取环境变量SCP_USER和SCP_PASSWORD，并返回命令copy startup-config scp:，以便EEM脚本可以运行它。脚本需要将SCP服务器IP地址作为参数。此外，脚本会维护每次在位于/flash/guest-share/TAC-write-memory-log.txt的持久文件中运行命令时的日志write memory。这是Python脚本：

```
import sys
import os
import cli
from datetime import datetime

# Get SCP server from the command-line argument (first argument passed)
scp_server = sys.argv[1]  # Expects the SCP server address as the first argument
```

```
# Configure CLI to suppress file prompts (quiet mode)
cli.configure("file prompt quiet")

# Get the current date and time
current_time = datetime.now()

# Format the current time for human-readable output and to use in filenames
formatted_time = current_time.strftime("%Y-%m-%d %H:%M:%S %Z")  # e.g., 2025-03-13 14:30:00 UTC
file_name_time = current_time.strftime("%Y-%m-%d_%H_%M_%S")  # e.g., 2025-03-13_14_30_00

# Retrieve SCP user and password from environment variables securely
scp_user = os.getenv('SCP_USER')  # SCP username from environment
scp_password = os.getenv('SCP_PASSWORD')  # SCP password from environment

# Ensure the credentials are set in the environment, raise error if missing
if not scp_user or not scp_password:
    raise ValueError("SCP user or password not found in environment variables!")

# Construct the SCP command to copy the file, avoiding exposure of sensitive data in print
# WARNING: The password should not be shared openly in logs or outputs.
print(f"copy startup-config scp://{scp_user}:{scp_password}@{scp_server}/config-backup-{file_name_

# Save the event in flash memory (log the write operation)
directory = '/flash/guest-share'  # Directory path where log will be saved
file_name = os.path.join(directory, 'TAC-write-memory-log.txt')  # Full path to log file

# Prepare the log entry with the formatted timestamp
line = f'{formatted_time}: Write memory operation.\n'

# Open the log file in append mode to add the new log entry
with open(file_name, 'a') as file:
    file.write(line)  # Append the log entry to the file
```

在本示例中，使用TFTP服务器将Python脚本复制到交换机：

```
<#root>

Switch#

copy tftp://10.207.204.10/cat9k_scp_command.py flash:/guest-share/cat9k_scp_command.py


Accessing tftp://10.207.204.10/cat9k_scp_command.py...
Loading cat9k_scp_command.py from 10.207.204.10 (via GigabitEthernet0/0): !
[OK - 917 bytes]


917 bytes copied in 0.017 secs (53941 bytes/sec)
```

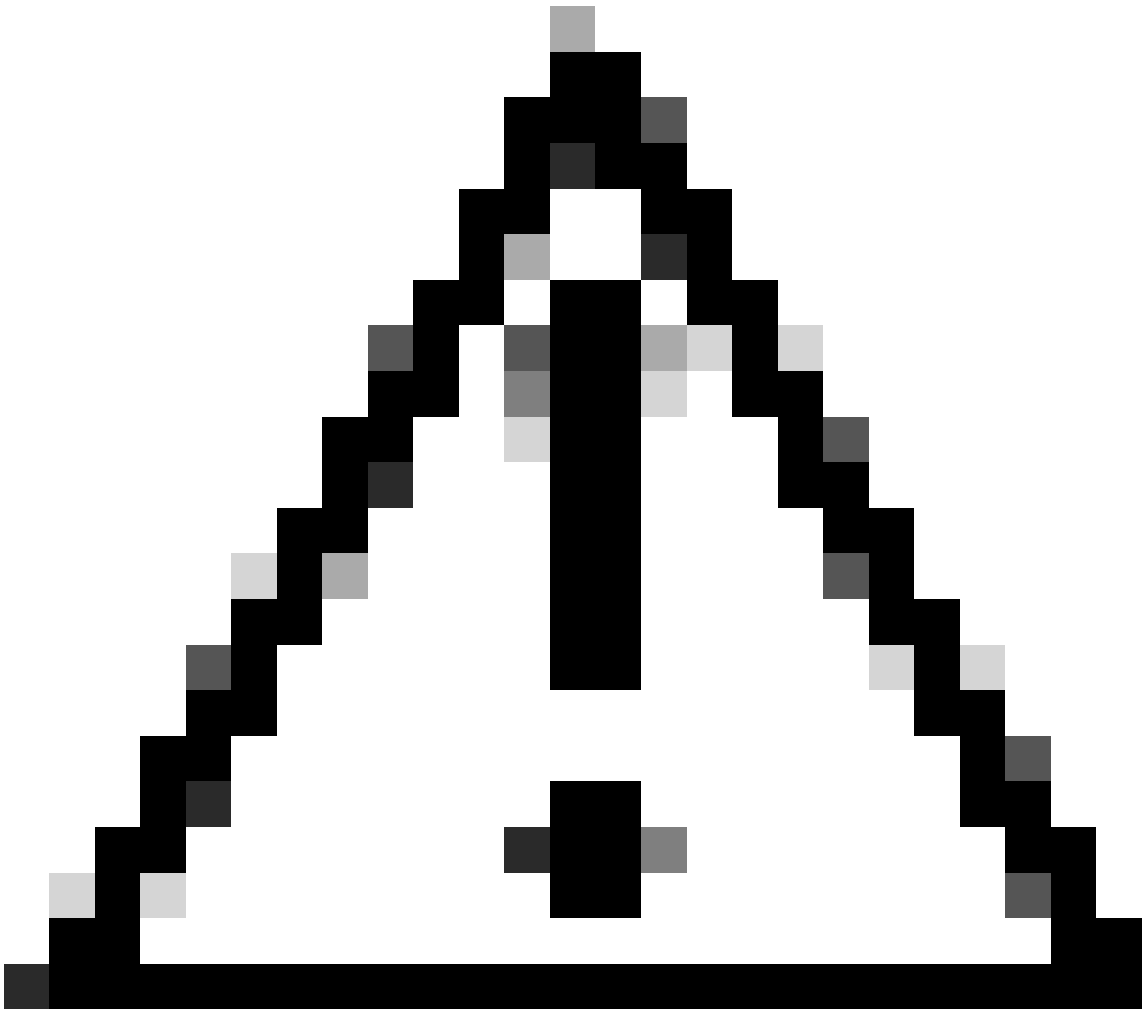
2. 安装EEM脚本。此脚本称为Python脚本。返回在SCP服务器上保存配置所需的命令copy startup-config scp:。然后，EEM脚本运行Python脚本返回的命令。

```
event manager applet Python-config-backup authorization bypass
```

```
event cli pattern "^write|write memory|copy running-config startup-config" sync no skip no maxrur
action 0000 syslog msg "Config save detected, TAC EEM-python started."
action 0005 cli command "enable"
action 0015 cli command "guestshell run python3 /bootflash/guest-share/cat9k_scp_command.py 10.31
action 0020 regexp "(^.*)\n" "$_cli_result" match command
action 0025 cli command "$command"
action 0030 syslog msg "TAC EEM-python script finished with result: $_cli_result"
```

3. 将Guest Shell环境变量插入到文件中，以设置这些变量~/.bashrc。这样可以确保每次打开访客外壳时环境变量都是持久的，即使在重新加载交换机后也是如此。添加以下两行：

```
export SCP_USER="cisco"
export SCP_PASSWORD="Cisco!123"
```



警告：本示例中使用的凭证仅用于教育目的。它们不能用于生产环境。用户需要用自己的安全环境特定凭证替换这些凭证。

这是向文件添加这些变量的过程~/.bashrc:

<#root>

```
! 1. Enter a Guest Shell bash session.
Switch#

guestshell run bash



! 2. Locate the ~/.bashrc file.
[guestshell@guestshell ~]$

ls ~/.bashrc

/home/guestshell/.bashrc

! 3. Add the SCP_USER and SCP_PASSWORD environment variables at the end of the ~/.bashrc file.
[guestshell@guestshell ~]$

echo 'export SCP_USER="cisco"' >> ~/.bashrc


[guestshell@guestshell ~]$

echo 'export SCP_PASSWORD="Cisco!123"' >> ~/.bashrc



! 4. To validate these 2 new lines were added correctly, display the content of the ~/.bashrc file
[guestshell@guestshell ~]$

cat ~/.bashrc

# .bashrc

# Source global definitions
if [ -f /etc/bashrc ]; then
        . /etc/bashrc
fi

# User specific environment
if ! [[ "$PATH" =~ "$HOME/.local/bin:$HOME/bin:" ]]
then
    PATH="$HOME/.local/bin:$HOME/bin:$PATH"
fi
export PATH

# Uncomment the following line if you don't like systemctl's auto-paging feature:
# export SYSTEMD_PAGER=

# User specific aliases and functions
[guestshell@guestshell ~]$ echo 'export SCP_USER="cisco"' >> ~/.bashrc
[guestshell@guestshell ~]$ echo 'export SCP_PASSWORD="Cisco!123"' >> ~/.bashrc
[guestshell@guestshell ~]$ cat ~/.bashrc
# .bashrc

# Source global definitions
if [ -f /etc/bashrc ]; then
        . /etc/bashrc
fi
```

```
# User specific environment
if ! [[ "$PATH" =~ "$HOME/.local/bin:$HOME/bin:" ]]
then
    PATH="$HOME/.local/bin:$HOME/bin:$PATH"
fi
export PATH

# Uncomment the following line if you don't like systemctl's auto-paging feature:
# export SYSTEMD_PAGER=

# User specific aliases and functions

export SCP_USER="cisco"
export SCP_PASSWORD="Cisco!123"

! 5. Reload the ~/.bashrc file in the current session.
[guestshell@guestshell ~]$

source ~/.bashrc



! 6. Validate that the environment variables are added, then exit the Guest Shell session.
[guestshell@guestshell ~]$

printenv | grep SCP
SCP_USER=cisco
SCP_PASSWORD=Cisco!123

[guestshell@guestshell ~]$ exit

Switch#
```

4. 手动运行Python脚本，以验证它返回正确的命令copy，并将操作记录到永久文件TAC-write-memory-log.txt中。

```
<#root>

Switch#

guestshell run python3 /flash/guest-share/cat9k_scp_command.py 10.31.121.224
copy startup-config scp://cisco:Cisco!123@10.31.121.224/config-backup-2025-01-25_18_35_18.txt


Switch#

dir flash:guest-share/

Directory of flash:guest-share/

286725  -rw-              368  Jan 25 2025 18:35:18 +00:00

TAC-write-memory-log.txt

286726  -rw-              903  Jan 25 2025 18:34:45 +00:00  cat9k_scp_command.py
286723  -rw-              144  Jan 25 2025 15:07:07 +00:00  TAC-shutdown-log.txt
286722  -rw-              977  Jan 25 2025 14:50:56 +00:00  cat9k_noshut.py

11353194496 bytes total (3751542784 bytes free)

Switch#
```

```
more flash:/guest-share/TAC-write-memory-log.txt
2025-01-25 18:35:18 : Write memory operation.
```

5. 测试EEM脚本。此EEM脚本还会发送包含复制操作结果的系统日志，无论复制操作成功还是失败。以下是成功运行的示例：

```
<#root>

Switch#

write memory

Building configuration...
[OK]
Switch#
*Jan 25 19:23:22.189: %HA_EM-6-LOG: Python-config-backup: Config save detected, TAC EEM-python sta
*Jan 25 19:23:42.885: %HA_EM-6-LOG: Python-config-backup:

TAC EEM-python script finished with result:
Writing config-backup-2025-01-25_19_23_26.txt !
8746 bytes copied in 15.175 secs (576 bytes/sec)

Switch#


Switch#

more flash:guest-share/TAC-write-memory-log.txt
2025-01-25 19:23:26 : Write memory operation.
```

要测试传输失败，请关闭SCP服务器。这是此失败运行的结果：

```
<#root>

Switch#

write

Building configuration...
[OK]
Switch#
*Jan 25 19:25:31.439: %HA_EM-6-LOG: Python-config-backup: Config save detected, TAC EEM-python sta
*Jan 25 19:26:06.934: %HA_EM-6-LOG: Python-config-backup:

TAC EEM-python script finished with result:
Writing config-backup-2025-01-25_19_25_36.txt % Connection timed out; remote host not responding

%Error writing scp://*:*@10.31.121.224/config-backup-2025-01-25_19_25_36.txt (Undefined error)

Switch#
Switch#

Switch#
Switch#
```

```
more flash:guest-share/TAC-write-memory-log.txt

2025-01-25 19:23:26 : Write memory operation.

2025-01-25 19:25:36 : Write memory operation.
```

使用案例2:监控STP拓扑更改的增量

此示例对于监控与生成树不稳定相关的问题，以及确定哪个接口正在接收拓扑更改通知(TCN)非常有用。 EEM脚本以指定的时间间隔定期运行，并调用运行show命令并检查TCN是否增加的Python脚本。

如果仅使用EEM命令创建此脚本，则需要使用循环和多个正则表达式匹配，这将非常麻烦。因此，此示例展示EEM脚本如何将此复杂逻辑委派给Python。

在本示例中，请按照以下步骤操作：

1. 将Python脚本复制到/flash/guest-share/目录。此脚本执行以下任务：
    1. 它会运行show spanning-tree detail命令并解析输出，以将每个VLAN的TCN信息保存在字典中。
    2. 它将解析的TCN信息与上次运行脚本时的JSON文件中的数据进行比较。对于每个VLAN，如果TCN增加，系统将会发送一条系统日志消息，其中包含类似于以下示例的信息：

```
*Jan 31 18:57:37.852: %GUESTSHELL-5-PYTHON_SCRIPT: Message from tty73(user id: shxUnknownTTY
```

    3. 它将当前TCN信息保存在JSON文件中，以便在下次运行期间进行比较。这是Python脚本：

```
import os
import json
import cli
import re
from datetime import datetime


def main():
    # Get TCNs by running the CLI command to show spanning tree details
    tcns = cli.cli("show spanning-tree detail")

    # Parse the output into a dictionary of VLAN details
    parsed_tcns = parse_stp_detail(tcns)

    # Path to the JSON file where VLAN TCN data will be stored
    file_path = '/flash/guest-share/tcns.json'

    # Initialize an empty dictionary to hold stored TCN data
    stored_tcn = {}
```

```
    # Check if the file exists and process it if it does
    if os.path.exists(file_path):
        try:
            # Open the JSON file and parse its contents into stored_tcn
            with open(file_path, 'r') as f:
                stored_tcn = json.load(f)
                result = compare_tcn_sets(stored_tcn, parsed_tcns)

                # Check each VLAN in the result and log changes if TCN increased
                for vlan_id, vlan_data in result.items():
                    if vlan_data['tcn_increased']:
                        log_message = (
                            f"TCNs increased in VLAN {vlan_id} "
                            f"from {vlan_data['old_tcn']} to {vlan_data['new_tcn']}. "
                            f"Last TCN seen on {vlan_data['source_interface']}."
                        )
                        # Send log message using CLI
                        cli.cli(f"send log facility GUESTSHELL severity 5 mnemonics PYTHON_S

        except json.JSONDecodeError:
            print("Error: The file contains invalid JSON.")
        except Exception as e:
            print(f"An error occurred: {e}")

    # Write the current TCN data to the JSON file for future comparison
    with open(file_path, 'w') as f:
        json.dump(parsed_tcns, f, indent=4)


def parse_stp_detail(cli_output: str):
    """
    Parses the output of "show spanning-tree detail" into a dictionary of VLANs and their TC

    Args:
        cli_output (str): The raw output from the "show spanning-tree detail" command.

    Returns:
        dict: A dictionary where the keys are VLAN IDs and the values contain TCN details.
    """
    vlan_info = {}

    # Regular expressions to match various parts of the "show spanning-tree detail" output
    vlan_pattern = re.compile(r'^\s*(VLAN|MST)(\d+)\s*', re.MULTILINE)
    tcn_pattern = re.compile(r'^\s*Number of topology changes (\d+)\s*', re.MULTILINE)
    last_tcn_pattern = re.compile(r'last change occurred (\d+:\d+:\d+) ago\s*', re.MULTILINE
    last_tcn_days_pattern = re.compile(r'last change occurred (\d+d\d+h) ago\s*', re.MULTILI
    tcn_interface_pattern = re.compile(r'from ([a-zA-Z]+[\d+\/]+\d+)\s*', re.MULTILINE)

    # Find all VLAN blocks in the output
    vlan_blocks = vlan_pattern.split(cli_output)[1:]
    vlan_blocks = [item for item in vlan_blocks if item not in ["VLAN", "MST"]]

    for i in range(0, len(vlan_blocks), 2):
        vlan_id = vlan_blocks[i].strip()

        # Match the relevant patterns for TCN and related details
        tcn_match = tcn_pattern.search(vlan_blocks[i + 1])
        last_tcn_match = last_tcn_pattern.search(vlan_blocks[i + 1])
        last_tcn_days_match = last_tcn_days_pattern.search(vlan_blocks[i + 1])
        tcn_interface_match = tcn_interface_pattern.search(vlan_blocks[i + 1])
```

```
            # Parse the TCN details and add to the dictionary
            if last_tcn_match:
                tcn = int(tcn_match.group(1))
                last_tcn = last_tcn_match.group(1)
                source_interface = tcn_interface_match.group(1) if tcn_interface_match else None
                vlan_info[vlan_id] = {
                    "id_int": int(vlan_id),
                    "tcn": tcn,
                    "last_tcn": last_tcn,
                    "source_interface": source_interface,
                    "tcn_in_last_day": True
                }
            elif last_tcn_days_match:
                tcn = int(tcn_match.group(1))
                last_tcn = last_tcn_days_match.group(1)
                source_interface = tcn_interface_match.group(1) if tcn_interface_match else None
                vlan_info[vlan_id] = {
                    "id_int": int(vlan_id),
                    "tcn": tcn,
                    "last_tcn": last_tcn,
                    "source_interface": source_interface,
                    "tcn_in_last_day": False
                }

        return vlan_info


    def compare_tcn_sets(set1, set2):
        """
        Compares two sets of VLAN TCN data to determine if TCN values have increased.

        Args:
            set1 (dict): The first set of VLAN TCN data.
            set2 (dict): The second set of VLAN TCN data.

        Returns:
            dict: A dictionary indicating whether the TCN has increased for each VLAN.
        """
        tcn_changes = {}

        # Compare TCN values for VLANs that exist in both sets
        for vlan_id, vlan_data_1 in set1.items():
            if vlan_id in set2:
                vlan_data_2 = set2[vlan_id]
                tcn_increased = vlan_data_2['tcn'] > vlan_data_1['tcn']
                tcn_changes[vlan_id] = {
                    'tcn_increased': tcn_increased,
                    'old_tcn': vlan_data_1['tcn'],
                    'new_tcn': vlan_data_2['tcn'],
                    'source_interface': vlan_data_2['source_interface']
                }
            else:
                tcn_changes[vlan_id] = {
                    'tcn_increased': None,  # No comparison if VLAN is not in set2
                    'old_tcn': vlan_data_1['tcn'],
                    'new_tcn': None
                }

        # Check for VLANs in set2 that are not in set1
        for vlan_id, vlan_data_2 in set2.items():
            if vlan_id not in set1:
                tcn_changes[vlan_id] = {
```

```
                    'tcn_increased': None,  # No comparison if VLAN is not in set1
                    'old_tcn': None,
                    'new_tcn': vlan_data_2['tcn']
                }

    return tcn_changes


if __name__ == "__main__":
    main()
```

在本示例中，使用TFTP服务器将Python脚本复制到交换机：

```
<#root>

Switch#

copy tftp://10.207.204.10/cat9k_tcn.py flash:/guest-share/cat9k_tcn.py

Accessing tftp://10.207.204.10/cat9k_tcn.py...
Loading cat9k_tcn.py from 10.207.204.10 (via GigabitEthernet0/0): !
[OK - 5739 bytes]


5739 bytes copied in 0.023 secs (249522 bytes/sec)
```

2. 安装EEM脚本。在本示例中，EEM脚本的唯一任务是运行Python脚本，该脚本在检测到TCN增量时发送日志消息。在本示例中，EEM脚本每5分钟运行一次。

```
event manager applet tcn_monitor authorization bypass
 event timer watchdog time 300
 action 0000 syslog msg "TAC EEM-python script started."
 action 0005 cli command "enable"
 action 0015 cli command "guestshell run python3 /bootflash/guest-share/cat9k_tcn.py"
 action 0020 syslog msg "TAC EEM-python script finished."
```

3. 要验证脚本的功能，您可以手动运行Python脚本，或者等待5分钟让EEM脚本调用该脚本。在这两种情况下，只有当VLAN的TCN增加时，系统才会发送系统日志。

```
<#root>

Switch#

more flash:/guest-share/tcns.json


{
"0001": {
"id_int": 1,
"tcn": 20,
```

```
"last_tcn": "00:01:18",
"source_interface": "TwentyFiveGigE1/0/5",
"tcn_in_last_day": true
},
"0010": {
"id_int": 10,
"tcn": 2,
"last_tcn": "00:00:22",
"source_interface": "TwentyFiveGigE1/0/1",
"tcn_in_last_day": true
},
"0020": {
"id_int": 20,
"tcn": 2,
"last_tcn": "00:01:07",
"source_interface": "TwentyFiveGigE1/0/2",
"tcn_in_last_day": true
},
"0030": {
"id_int": 30,
"tcn": 1,
"last_tcn": "00:01:18",
"source_interface": "TwentyFiveGigE1/0/3",
"tcn_in_last_day": true
}
}
```

```
Switch#
guestshell run python3 /flash/guest-share/cat9k_tcn.py

Switch#
*Feb 17 21:34:45.846: %GUESTSHELL-5-PYTHON_SCRIPT: Message from tty73(user id: shxUnknownTTY): TCN
Switch#
```

4. 通过等待EEM脚本每五分钟运行一次来测试该脚本。如果任何VLAN的TCN增加，系统将会发送系统日志消息。在本例中，我们注意到VLAN 30上的TCN不断增加，而接收这些固定TCN的接口是Twe1/0/3。

```
<#root>

*Feb 17 21:56:23.563: %HA_EM-6-LOG: tcn_monitor: TAC EEM-python script started.
*Feb 17 21:56:26.039: %GUESTSHELL-5-PYTHON_SCRIPT: Message from tty73(user id: shxUnknownTTY):
TCNs increased in VLAN 0030 from 3 to 5. Last TCN seen on TwentyFiveGigE1/0/3.
*Feb 17 21:56:26.585: %HA_EM-6-LOG: tcn_monitor: TAC EEM-python script finished.
*Feb 17 22:01:23.563: %HA_EM-6-LOG: tcn_monitor: TAC EEM-python script started.
```

```
*Feb 17 22:01:26.687: %HA_EM-6-LOG: tcn_monitor: TAC EEM-python script finished.
*Feb 17 22:06:23.564: %HA_EM-6-LOG: tcn_monitor: TAC EEM-python script started.
*Feb 17 22:06:26.200: %GUESTSHELL-5-PYTHON_SCRIPT: Message from tty73(user id: shxUnknownTTY):

TCNs increased in VLAN 0030 from 5 to 9. Last TCN seen on TwentyFiveGigE1/0/3.

*Feb 17 22:06:26.787: %HA_EM-6-LOG: tcn_monitor: TAC EEM-python script finished.
*Feb 17 22:11:23.564: %HA_EM-6-LOG: tcn_monitor: TAC EEM-python script started.
*Feb 17 22:11:26.079: %GUESTSHELL-5-PYTHON_SCRIPT: Message from tty73(user id: shxUnknownTTY):

TCNs increased in VLAN 0030 from 9 to 12. Last TCN seen on TwentyFiveGigE1/0/3.

*Feb 17 22:11:26.686: %HA_EM-6-LOG: tcn_monitor: TAC EEM-python script finished.
```

相关信息

- 可编程性配置指南，Cisco IOS XE Cupertino 17.9.x(章节：访客外壳)
- 了解EEM的最佳实践和有用的脚本
- Cisco Catalyst 9000系列交换机上的应用托管白皮书

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