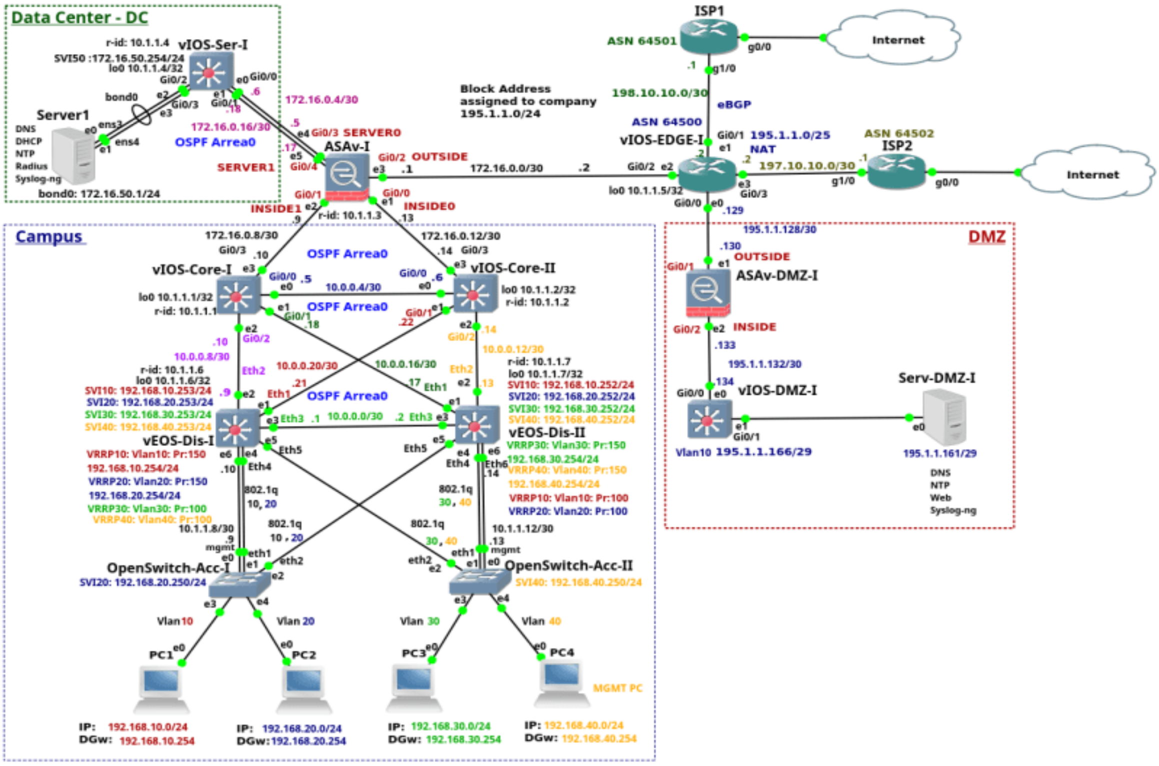
Enterprise Network on GNS3 - Part 1 - Introduction

This lab is inspired by ref. [Enterprise Lab], detailed setup can be find here ref. [Enterprise Lab], I have taken different approach then this lab, here is the document from the Radovan Brezula's blog – Thanks very much, great doc.

Several months ago I had created a simple GNS3 network topology for practicing my networking skills. What had firstly begun as a simple lab, later grew in to a real world enterprise network consisting of a campus, data center, DMZ network blocks and ISPs. During the next several weeks I added new devices into the topology, struggling with no time due to complicated family circumstances. In March 2017 I completely stopped working on this project. Luckily, I was done with the configuration of all devices and I wrote several articles describing my progress. Now, almost a half of the year later, I am ready to share my experience with the blog readers and publish the articles. Below is the list of the articles. I hope you find them useful.

Enterprise Network on GNS3 - Part 1 - Introduction
Enterprise Network on GNS3 - Part 2 - Access Layer
Enterprise Network on GNS3 - Part 3 - Distribution and Core Layers
Enterprise Network on GNS3 - Part 4 - Cisco ASAv-I
Enterprise Network on GNS3 - Part 5 - Data Center
Enterprise Network on GNS3 - Part 6 - Edge Router and ISPs
Enterprise Network on GNS3 - Part 7 - DMZ

The name of the enterprise is CompanyXYZ. The complete enterprise network topology is shown on the picture below. As I have mentioned, it composes of the campus network, data center (DC), DMZ and ISPs.



Picture 1 - **Enterprise Network Running On Laptop with GNS3**

The entire topology is virtualized, running on the ASUS K55VM laptop with the following hardware and software specification:

Host Hardware:
1. CPU: Intel(R) Core(TM) i7-3610QM CPU @ 2.30GHz
2. RAM: 16GB: 2x Kingston 8192 MB DDR3, speed 1600Mhz
3. Ethernet card: RTL8111/8168/8411 PCI Express Gigabit Ethernet Controller

Host Software:
1. OS: Ubuntu 16.04.2 LTS Xenial
2. GNS3: version 1.5.3
3. QEMU emulator and KVM: version 2.8.0
4. Dynamips emulator: version 0.2.16

The enterprise campus network consists of the access, distribution and core layers. The data center is composed of the layer 3 Cisco switch and the server. The design of the DC is very simplified as the network tiers are squeezed to a single switch layer 3 switch. Unlike the campus network, the aim is to show configuration of the services running on the Server1 instead of discussing the complete DC design. The company edge router is connected to the Internet using two Internet Service Providers (ISPs). The Cisco ASA firewall connects a campus network, data Center and the edge router. The edge router connected DMZ to the rest of the enterprise network and to the Internet. The DMZ consists of the Cisco ASA firewall, layer 3 Cisco switch and the DMZ server. The enterprise is connected to the ISP1 and ISP2 routers via enterprise edge router. Both ISP routers are bridged via GNS3 clouds to the laptop Ethernet Card RTL8168 (enp4s0f2) in order to simulate connection to the Internet.

Now we can spend few words about devices in enterprise network and software they are running .

Enterprise Campus Network
1.PC1- PC4: LinuxCore6.3,kernel3.16.6

2.Access switches: Open Switch0.4.0(Linuxcore-4.1-noarch:core-4.1-x86_64)

3.Distribution switches: Arista vEOS,version4.17.2F

4. Core switches: Cisco vIOS l2 software, vios_l2-ADVENTERPRISEK9-M, version 15.2

Firewall ASAv-I: Cisco Adaptive Security Appliance Software Version 9.6(1)

DataCenter:
1. Server: Ubuntu 16.04.3 LTS (GNU/Linux 4.4.0-92-generic x86_64)

2. Switch: Cisco vIOS l2 software, vios_l2-ADVENTERPRISEK9-M, version 15.2

Edge Router: Cisco IOSv software, VIOS-ADVENTERPRISEK9-M, version 15.6(2)T,

DMZ:
1.Firewall: Cisco Adaptive Security Appliance Software Version 9.6(1)

2. Switch: Cisco vIOS l2 Software, vios_l2-ADVENTERPRISEK9-M, version 15.2

3. Server: Ubuntu 16.04.3 LTS (GNU/Linux 4.4.0-92-generic x86_64)

ISPs: Cisco 7206VXR (NPE400), Cisco IOS Software, 7200 Software (C7200-ADVIPSERVICESK9-M), version 15.2(4)S4

Public IP Addresses Assignment

The company has assigned a block of the public IP addresses 195.1.1.0/24. This is the entire class C network. The first a half of the IP addresses range is used for NAT and the second half of the range is used for DMZ. Below is the complete list of used subnets and their assignment.

195.1.1.0/25 - NAT
195.1.1.128/25 - DMZ
195.1.1.128/32 - point-to-point connection - in use
195.1.1.132/32 - point-to-point connection - in use
195.1.1.136/32 - point-to-point connection - free
195.1.1.140/32 - point-to-point connection - free
195.1.1.144/32 - point-to-point connection - free
195.1.1.148/32 - point-to-point connection - free
195.1.1.152/32 - point-to-point connection - free
195.1.1.156/32 - point-to-point connection - free
195.1.1.160/29 - Vlan 10 - in use
195.1.1.192/29 - free
195.1.1.224/29 - free

Note: The router vIOS-EDGE-I has assigned a public IP address 198.10.10.2 from the ISP1 IP address range and the IP address 197.10.10.2 from ISP2 IP address range.

Private IP Addresses Assignment

Users connected to the ports of the access switches have their IP addresses assigned from the networks 192.168.10-40.0/24. Point-to-points links between Distribution and Core switches are configured with IP addresses from the subnets 10.0.0.0/24. Point-to-point links between ASAv-I, campus network and data center are configured with IP addresses from the subnet 172.16.0.0/24. The server Server1 is connected to the Cisco L3 switch vIOS-Ser-I in a DC and it has IP address assigned from the subnet 172.16.50.0/24. Loopback and management IP addresses are assigned from the subnet 10.1.1.0/24.

Users: 192.168.10-40.0/24
Distribution and core layer links: 10.0.0.0/24
ASAv-I, campus and data center links: 172.16.0.0/24
Server1 (DC): 17.16.50.0/24
Loopbacks: 10.1.1.0/24 and management

Services Provided by Servers

Servers Server1 in a DC and the SERV-DMZ-I in DMZ provide the following services.

1. DNS: Domain name resolution for network devices and workstations
2. DHCP: automatic IP address assigment for workstations
3. Syslog: logging for network devices
4. NTP: precise time for network devices
5. Radius: remote authentication for network devices (except DMZ and vIOS-EDGE-I)
6. Web: company WEB server for Internet users (only DMZ)

Interfaces Naming

Each network interface in the topology has assigned two interface names although the both names represent a single interface. The first name is assigned by GNS3 itself (e0, e1, e2 etc.). The second name is the interface name that is shown in the configuration of the device. For instance, the ASAv-I is connected with the vIOS-Core-II with the interface e1. However, the interface e1 is represented by the interface Gi0/0 in the ASA configuration.

Login Credentials

Below is the list of the changed usernames and passwords for all devices in the topology. The string before the slash represents a username and the string after the slash represents the password.

1. Local Credentials for Cisco and Arista Devices

Local User - Level 1
admin/cisco

Local User - Level 15
admin15/cisco15

Local Enable
cisco

2. Radius Credentials for Cisco and Arista Devices

Radius User - Level 1
raadmin/racisco

Radius User - Level 15
raadmin15/racisco15

Radius Enable
racisco

3. Local Credentials for Openswitch Appliance

netop/cisco
Linux: admin/cisco or admin/admin

4. Credentials for PC1 - PC4: tc/tc

5. Credentials for Linux Ubuntu: ubuntu/ubuntu

6. ISP1 and ISP2: **d**evices are not configured for authentication.

Bandwidth Limitation

Cisco ASAv is unlicensed so the traffic rate is limited to 100 kbps and maximum connection limit is set to 100. For this reason, connection to the Internet is limited to 100 kbps.

Configuration Files

OpenSwitch-Acc-I, OpenSwitch-Acc-II, vEOS-DIS-I, vEOS-DIS-II, vIOS-Core-I, vIOS-Core-II, vASA-I, vIOS-Serv-I, vIOS-EDGE-I, ISP1, ISP2, ASAv-DMZ-I, vIOS-DMZ-I.

Issues

I noticed some mysterious issues while running the devices that I could not explain. Luckily, very often restarting a port for a particular device solved a problem. For instance, network traffic originated on ISP1 was sent to the Internet from the Gi0/0. However, the router ISP1 did not forward incoming data traffic to the Internet that entered the interface Gi0/1. In this case, restart of the port Gi0/0 on the ISP1 solved the issue. The other issue that I noticed was about 2% loss of the packets destined for the Internet when both ISP routers were running simultaneously. If the both routers were not needed to run at the same time, shutdown of the ISP2 router represented a workaround. As the last point, I recommend to use vIOS-l2 instead of the OpenSwitch appliances as I have spent hours troubleshooting OpenSwitch unexpected behavior. As I have mentioned, very often temporary shutdown of VLAN or VLAN interface solved a mystery.

Appliances Download

This section contains a list of appliances that I am allowed to share with you.

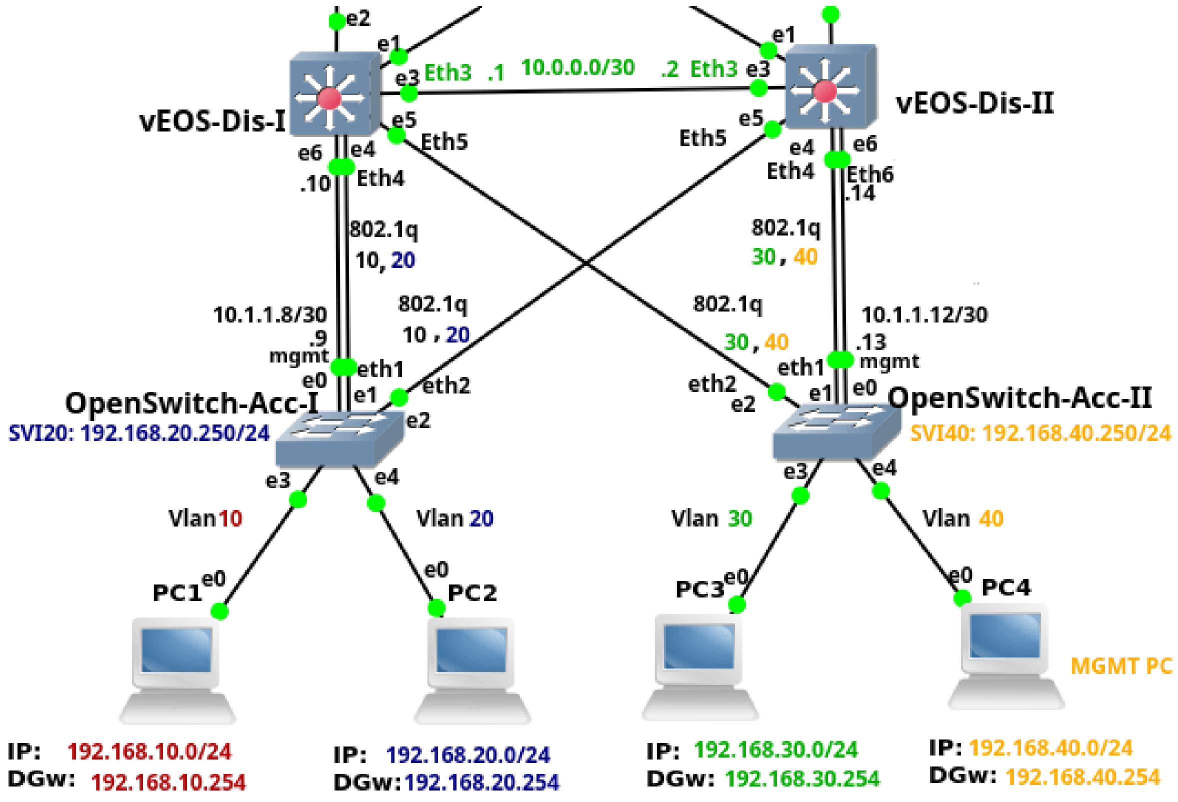
Open switch 0.4.0 VMDK

Enterprise Network on GNS3 - Part 2 - Access Layer

This is the second from the series of the articles that discuss a complete configuration of the enterprise network. Our enterprise campus network consists of the core, distribution and access layer. This network infrastructure design is called a three-tier network model. Each layer has specific function. The access layer provides access for end users to the network . They are two access switches located inside the access layer. The access switches OpenSwitch-Acc-I and OpenSwitch-Acc-II are OpenSwitch Qemu appliances installed on VMware VMDK disks. The switches run OpenSwitch network OS version 0.4.0 and they have assigned 1024 MB memory by GNS3. More details about building OpenSwitch appliance prior to version 2.0 can be found here.

Note: Based on reader's request I share Openswitch 0.4.0 image VMDK image. Username/password is netop/netop and for switch configuration and admin/admin for access to underlying Linux (use sudo su for root access). In case, of trouble, read the section Issue at the end of the tutorial.

The ports Ethernet 3 a and 4 on both switches are configured as access ports and they connect PC1 and PC4 to the campus network. The ports Ethernet 1 and Ethernet 2 are uplinks that connect access switches to the distribution switches. They are configured as trunk ports, carrying traffic from multiple VLANs. Thanks to redundant uplink connection, the access switches remain connected to the upper layer, even in case of the failure one of the distribution switches.



Picture 1 - **Access Switches Connected to Distribution Layer**

End user computers are assigned to VLANs 10, 20, 30 and 40. Thanks to segmentation to VLAN, user traffic is sent to the distribution layer without being spread across the other access switches in campus. The PC4 is connected to the port Ethernet 4 that is assigned to the management VLAN 40. Management of the access switches is provided by connection of the management port Ethernet0 to the port Ethernet6 of the particular distribution switch. The both ports are configured as the routed (layer3) ports and they have assigned IP addresses from the subnet with /30 mask.

The Switch Virtual Onterface (SVI) created on both access switches allow the access switches to synchronize their time with NTP server running on the appliance Server1 172.16.50.1 in the Data Center (DC). The switches also send logs to the syslog-ng server installed on the same appliance.

Note: The configuration files of the both access switches are: OpeSwitch-Acc-I and OpenSwitch-Acc-II.

1. OpenSwitch-Acc-I Configuration

Login to the OpenSwitch OpenSwitch-Acc-I appliance with the default username *netop* and the password *netop*. As a first step, we will change the hostname.

```
switch# conf t
switch(config)# hostname OpenSwitch-Acc-I
```

1.1 VLANs Configuration

The VLANs 10,20 are end user VLANs. The VLAN 999 is "parking" VLAN that is configured on ports that are not used. If someone accidentally brings disabled switchports up, the connection is not working. It is because the VLAN 999 is not configured on uplink trunk ports.

```
OpenSwitch-Acc-I(config)# vlan 10
OpenSwitch-Acc-I(config-vlan)# no shutdown
OpenSwitch-Acc-I(config)# vlan 20
OpenSwitch-Acc-I(configb-vlan)# no shutdown
OpenSwitch-Acc-I(config)# vlan 999
OpenSwitch-Acc-I(config-vlan)# no shutdown
OpenSwitch-Acc-I(config-vlan)# exit
```

Note: If you encounter strange connectivity problem that you cannot troubleshoot, restart of the particular VLAN might help.

1.2 IP Address and Trunk Port Configuration

In order to access the switches remotely, we have to configure the appropriate IP address and mask on the management port. The management port mgmt is the only interface that is presented in underlying Linux Yocto Linux (except the loopback). However it can by comfortably configured using OpenSwitch CLI.

```
OpenSwitch-Acc-I(config)# interface mgmt
OpenSwitch-Acc-I(config-if-mgmt)# ip static 10.1.1.9/30
OpenSwitch-Acc-I(config-if-mgmt)# default-gateway 10.1.1.10
OpenSwitch-Acc-I(config-if-mgmt)# nameserver 172.16.50.1
OpenSwitch-Acc-I(config-if-mgmt)# exit
```

The access switch OpenSwitch-Acc-I has configured SVI20 interface. It allows the switch to access the Server1 located in a DC.

```
OpenSwitch-Acc-I(config)# interface vlan 20
OpenSwitch-Acc-I(config-if-vlan)# ip address 192.168.20.250/24
OpenSwitch-Acc-I(config-if-vlan)# no shutdown
OpenSwitch-Acc-I(config-if-vlan)# exit

OpenSwitch-Acc-I(config)# int eth1
OpenSwitch-Acc-I(config-if)# no routing
OpenSwitch-Acc-I(config-if)# vlan trunk allowed 10,20
OpenSwitch-Acc-I(config-if)# no shutdown

OpenSwitch-Acc-I(config-if)# int eth2
OpenSwitch-Acc-I(config-if)# no routing
OpenSwitch-Acc-I(config-if)# vlan trunk allowed 10,20
OpenSwitch-Acc-I(config-if)# no shutdown

OpenSwitch-Acc-I(config-if)# int eth3
OpenSwitch-Acc-I(config-if)# no routing
OpenSwitch-Acc-I(config-if)# vlan access 10
OpenSwitch-Acc-I(config-if)# no shutdown

OpenSwitch-Acc-I(config-if)# int eth4
OpenSwitch-Acc-I(config-if)# no routing
OpenSwitch-Acc-I(config-if)# vlan access 20
OpenSwitch-Acc-I(config-if)# no shutdown
```

Secure unused interfaces.

```
OpenSwitch-Acc-I(config-if)# int eth5
OpenSwitch-Acc-I(config-if)# no routing
OpenSwitch-Acc-I(config-if)# vlan access 999
OpenSwitch-Acc-I(config-if)# shutdown

OpenSwitch-Acc-I(config-if)# int eth6
OpenSwitch-Acc-I(config-if)# no routing
OpenSwitch-Acc-I(config-if)# vlan access 999
OpenSwitch-Acc-I(config-if)# shutdown

OpenSwitch-Acc-I(config-if)# int eth7
OpenSwitch-Acc-I(config-if)# no routing
OpenSwitch-Acc-I(config-if)# vlan access 999
```

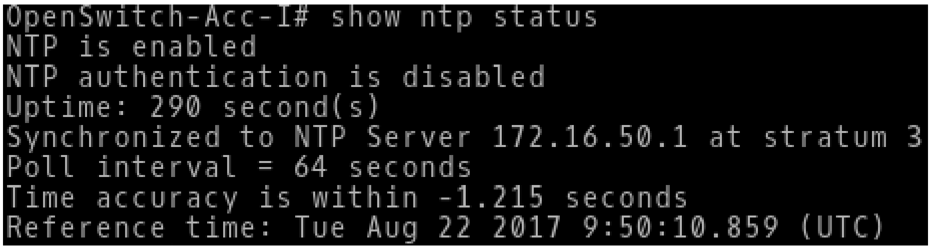
```
OpenSwitch-Acc-I(config-if)# shutdown
OpenSwitch-Acc-I(config-if)# exit
```

To allow the access switch reach NTP and syslog server in the DC, we have to create a static default route for the switch.

```
OpenSwitch-Acc-I(config)# ip route 0.0.0.0/0 192.168.20.254
```

1.3 NTP Configuration

```
OpenSwitch-Acc-I(config)# ntp server 172.16.50.1
OpenSwitch-Acc-I(config)# timezone set europe/bratislava
```



```
OpenSwitch-Acc-I# show ntp status
NTP is enabled
NTP authentication is disabled
Uptime: 290 second(s)
Synchronized to NTP Server 172.16.50.1 at stratum 3
Poll interval = 64 seconds
Time accuracy is within -1.215 seconds
Reference time: Tue Aug 22 2017 9:50:10.859 (UTC)
```

Picture 2 - **Time Synchronization with NTP Server 172.16.50.1**

1.4 Logging

Logs are sent to the syslog-ng server 172.16.50.1 and stored in the directory /var/log/syslog-ng/192.168.20.250/. We collect log messages with the severity notice level 2 and above (0 - debug, 7 - emergency).

```
OpenSwitch-Acc-I(config)# logging 172.16.50.1 severity notice
```

1.5 Password Configuration

Even OpenSwitch version 4.0.0 supports Radius client configuration I was not successful with remote login authentication using Radius server. Therefore we will only change password for default local accounts. To do so we need to switch to underlying Linux Yocto OS. Login as root with no password set and change passwords to cisco for all the accounts below.

```
root@OpenSwitch-Acc-I:~# passwd root
root@OpenSwitch-Acc-I:~# passwd admin
root@OpenSwitch-Acc-I:~# passwd netop
```

2. OpenSwitch-Acc-II Configuration

The configuration of the switch OpenSwitch-Acc-II is similar to the configuration of the switch OpenSwitch-Acc-II. Therefore I only share the configuration without further explanation.

3. PCs Configuration

The PC4 is used for administration of network devices in the topology therefore it has statically configured IP address. The other PCs have their IP addresses assigned from the DHCP server 172.16.50.1. All PCs are Core LInux Qemu appliances, running Core Linux 6.3. They have assigned 64MB RAM by GNS3. Below is a static IP address configuration for PC4.

```
$ vim /opt/bootlocal.sh
```

```
hostname PC4
ifconfig eth0 192.168.40.1 netmask 255.255.255.0
route add default gw 192.168.40.254
echo "nameserver 172.16.50.1" > /etc/resolv.conf
```

To save configuration we need to enter the command below.

```
$ /usr/bin/filetool.sh -b
```

4. Issues

4.1 OpenSwitch

4.1.1 Cannot Boot VMD Image - Error Message "Could not write to allocated cluster for streamOptimized"

If your OpenSwitch VMDK image does not boot and the error message "*qemu-system-x86_64: Could not write to allocated cluster for streamOptimized*" appears in a terminal a quick workaround is converting the VMDK image to other format, such as qcow2 or VDI.

```
$ qemu-img convert -f vmdk OpenSwitch.vmdk -O vdi OpenSwitch.vdi
```

Now, we can run the image with QEMU command:

```
$ /usr/bin/qemu-system-x86_64 -m 2G -enable-kvm OpenSwitch.vdi -serial
telnet:localhost:2222,server,nowait
```

Use telnet to connect to the switch console.

```
$ telnet localhost 2222
```

4.1.2 Cannot Save OpenSwitch Configuration - Error Message - "System is not ready. Please retry after few seconds.."

You must run OpenSwitch with minimum two NICs otherwise system is not ready. In that case, you get an error message - "*System is not ready. Please retry after few seconds..*" The comand below starts an OpenSwitch Qemu instance with two NICs attached.

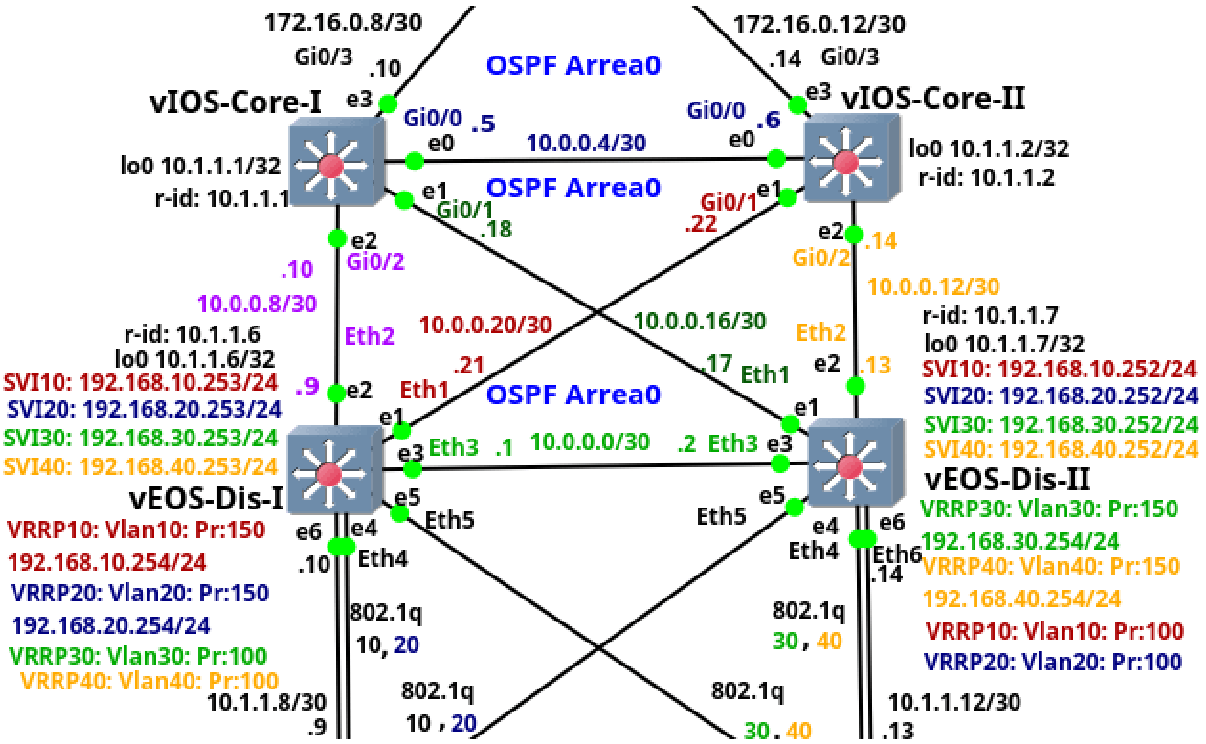
```
$ /usr/bin/qemu-system-x86_64 -m 2G -enable-kvm OpenSwitch.vdi -serial
telnet:localhost:2222,server,nowait  -net nic,id=net0 -device e1000,mac=00:11:22:33:44:00
-net nic,id=net1 -device e1000,mac=00:11:22:33:44:01
```

Enterprise Network on GNS3 - Part 3 - Distribution and Core Layers

Posted on November 1, 2017 by Radovan BrezulaUpdated on November 1, 2017 4 Comments

This is the third from the series of the articles that discuss configuration of the entire enterprise network. The article focuses on the configuration of the distribution and core switches. The distribution layer consists of two multilayer switches vEOS-DIS-I and vEOS-DIS-II. The switches are Arista vEOS version 4.17.2F Qemu appliances installed on VMware disks. Each appliance has assigned 1536 MB RAM.

The distribution switches route traffic between end user VLANs and they connect the lower layer network to a Core layer. The layer 3 (routed) interfaces connect both distribution switches to each other and to the Core switches. The interfaces toward the Access layer are layer 2 (switchports). The OSPF routing protocol is running on the distribution switches so there is only l3 connectivity between distribution and core layer.



Picture 1 - **Distribution and Core Layers of Enterprise Campus Network**

Note: The configuration files of the distribution switches are: vEOS-DIS-I and vEOS-DIS-II.

The core layer consists of the switches vIOS-Core-I and vIOS-Core-II. These are the Cisco vIOS-l2 Qemu appliances on qcow2 disks, version 15.2. Each switch has assigned 768 MB RAM by GNS3. The core layer is completely layer3. It si connected to the lower distribution layer with l3 P2P links configured with the IP addresses from the subnet 10.0.0.0/24. The core switches connect distribution and access layers to Cisco Adaptive Security Virtual Appliance (ASAv) configured with the IP addresses from the subnet 172.16.0.0/24.

Note: The configuration files of the core switches are: vIOS-Core-I and vIOS-Core-II.

1. Distribution Switch vEOS-DIS-I Configuration

Login to the Arista appliance with a default username admin, no password is set. The EOS CLI is Cisco like. As a first step, configure the hostname.

1.1. vEOS-Dis-I Configuration

```
localhost> en
localhost# conf t
localhost(config)# hostname vEOS-Dis-I
```

1.2 Vlan Configuration

```
vEOS-Dis-I(config)# vlan 10
vEOS-Dis-I(config-vlan-10)# vlan 20
vEOS-Dis-I(config-vlan-20)# vlan 30
```

```
vEOS-Dis-I(config-vlan-30)# vlan 40
vEOS-Dis-I(config-vlan-40)# exit
```

1.3 IP Address and Trunk Port Configuration

Assign the IP address 10.1.1.1/32 from the subnet 10.1.1.0/24 to the loopback interface . The interface is used for switch management.

```
vEOS-Dis-I(config)# interface loopback 0
vEOS-Dis-I(config-if-Lo0)# ip address 10.1.1.6/32
```

Now configure trunk ports. Trunk ports are layer2 interfaces (switchports) that carry traffic from multiple VLANs. Ethernet ports Eth4 and Eth5 are configured as trunks on both distribution switches.

```
vEOS-Dis-I(config)# interface eth4
vEOS-Dis-I(config-if-Et4)# description Link to OpenSwitch-Acc-I
vEOS-Dis-I(config-if-Et4)# switchport
vEOS-Dis-I(config-if-Et4)# switchport mode trunk
vEOS-Dis-I(config-if-Et4)# switchport trunk allowed vlan 10,20
vEOS-Dis-I(config-if-Et4)# no shutdown
vEOS-Dis-I(config-if-Et4)# exit

vEOS-Dis-I(config)# interface eth5
vEOS-Dis-I(config-if-Et5)# description Link to OpenSwitch-Acc-II
vEOS-Dis-I(config-if-Et5)# switchport
vEOS-Dis-I(config-if-Et5)# switchport mode trunk
vEOS-Dis-I(config-if-Et5)# switchport trunk allowed vlan 30,40
vEOS-Dis-I(config-if-Et5)# no shutdown
vEOS-Dis-I(config-if-Et4)# exit
```

The ports Eth6 on the both distribution switches are the layer3 (routed) interfaces that connect the management port of the particular access switch to the network. They have the IP addresses assigned from the network 10.1.1.0/24.

```
vEOS-Dis-I(config)# interface eth6
vEOS-Dis-I(config-if-Et6)# description Link to Management OpenSwitch-Acc-I
vEOS-Dis-I(config-if-Et6)# no switchport
vEOS-Dis-I(config-if-Et6)# ip address 10.1.1.10/30
vEOS-Dis-I(config-if-Et6)# no shutdown
vEOS-Dis-I(config-if-Et6)# exit
```

The port eth3 is a routed port between distribution switches. As the port is layer3, there is not a a loop for Ethernet frames thus STP is not needed. All point-to-point (p2p) links in the campus netwrok have IP addresses assigned from the subnet 10.0.0.0/24.

```
vEOS-Dis-I(config)# interface eth3
vEOS-Dis-I(config-if-Et3)# description Link to vEOS-Dis-II
vEOS-Dis-I(config-if-Et3)# no switchport
vEOS-Dis-I(config-if-Et3)# ip address 10.0.0.1/30
```

```
vEOS-Dis-I(config-if-Et3)# no shutdown
vEOS-Dis-I(config-if-Et3)# exit
```

The ports Eth1 and Eth2 connect a distribution switch to the core switches vIOS-Core-I and vIOS-Core-II.

```
vEOS-Dis-I(config)# interface eth1
vEOS-Dis-I(config-if-Et1)# description Link to vIOS-Core-II
vEOS-Dis-I(config-if-Et1)# no switchport
vEOS-Dis-I(config-if-Et1)# ip address 10.0.0.21/30
vEOS-Dis-I(config-if-Et1)# no shutdown
vEOS-Dis-I(config-if-Et1)# exit
```

```
vEOS-Dis-I(config)# interface eth2
vEOS-Dis-I(config-if-Et2)# description Link to vIOS-Core-I
vEOS-Dis-I(config-if-Et2)# no switchport
vEOS-Dis-I(config-if-Et2)# ip address 10.0.0.9/30
vEOS-Dis-I(config-if-Et2)# no shutdown
vEOS-Dis-I(config-if-Et2)# exit
```

Shutdown and describe unused Interfaces to prevent connect another network device accidentally.

```
vEOS-Dis-I(config)# interface eth7
vEOS-Dis-I(config-if-Et7)# desc Unused
vEOS-Dis-I(config-if-Et7)# shutdown
vEOS-Dis-I(config-if-Et7)# exit
```

1.4 Switch Virtual Interfaces and IP Addresses Configuration

We have to create SVI interfaces on both switches and assign particular IP addresses to SVI in order to route between VLAN subnets. The switch vEOS-Dis-I has the IP address 192.168.x.253/24 configured on the interface SVI10, 20, 30 and 40, where x is the VLAN_ID.

```
vEOS-Dis-I(config)# interface vlan 10
vEOS-Dis-I(config-if-Vl10)# ip address 192.168.10.253/24
vEOS-Dis-I(config-if-Vl10)# no shutdown
vEOS-Dis-I(config-if-Vl10)# exit
```

```
vEOS-Dis-I(config)# interface vlan 20
vEOS-Dis-I(config-if-Vl20)# ip address 192.168.20.253/24
vEOS-Dis-I(config-if-Vl20)# no shutdown
vEOS-Dis-I(config-if-Vl20)# exit
```

```
vEOS-Dis-I(config)# interface vlan 30
vEOS-Dis-I(config-if-Vl30)# ip address 192.168.30.253/24
vEOS-Dis-I(config-if-Vl30)# no shutdown
vEOS-Dis-I(config-if-Vl30)# exit
```

```
vEOS-Dis-I(config)# interface vlan 40
vEOS-Dis-I(config-if-Vl40)# ip address 192.168.40.253/24
vEOS-Dis-I(config-if-Vl40)# no shutdown
vEOS-Dis-I(config-if-Vl40)# exit
```

Note: The same SVI interfaces are configured with the IP address 192.168.x.252/24 on the switch vEOS-DIs_II.

1.5 OSPF Protocol and Authentication Configuration

Enable IP routing on the switch with the command below.

```
vEOS-Dis-I(config)# ip routing
```

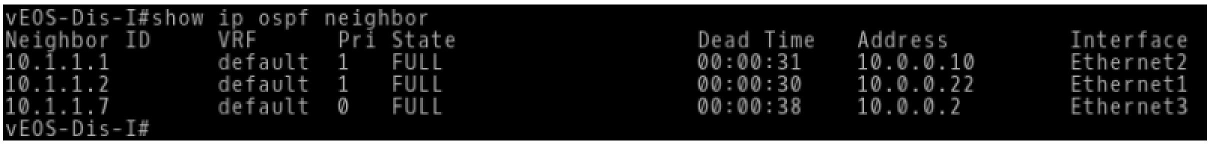
We need to configure Open Shortest Path First (OSPF) to ensure that routes are propagated inside the campus and DC network. However routing updates should be to suppressed on the trunk ports, SVI interfaces and connected management interface of the Access switch. For this reason we configure the interfaces as passive interfaces. Thanks to it, OSPF Hello messages are not sent out of these ports thus adjacency is not formed. This measue also saves CPU cycles of the switch.

```
vEOS-Dis-I(config)# router ospf 1
vEOS-Dis-I(config-router-ospf)# router-id 10.1.1.6
vEOS-Dis-I(config-router-ospf)# network 10.1.1.6/32 area 0
vEOS-Dis-I(config-router-ospf)# network 10.1.1.8 0.0.0.3 area 0
vEOS-Dis-I(config-router-ospf)# network 10.0.0.0/30 area 0
vEOS-Dis-I(config-router-ospf)# network 10.0.0.20/30 area 0
vEOS-Dis-I(config-router-ospf)# network 10.0.0.8/30 area 0
vEOS-Dis-I(config-router-ospf)# network 192.168.10.0/24 area 0
vEOS-Dis-I(config-router-ospf)# network 192.168.20.0/24 area 0
vEOS-Dis-I(config-router-ospf)# network 192.168.30.0/24 area 0
vEOS-Dis-I(config-router-ospf)# network 192.168.40.0/24 area 0
vEOS-Dis-I(config-router-ospf)# passive-interface ethernet 4
vEOS-Dis-I(config-router-ospf)# passive-interface ethernet 5
vEOS-Dis-I(config-router-ospf)# passive-interface Ethernet 6
vEOS-Dis-I(config-router-ospf)# passive-interface vlan 10,20,30,40
```

The password authentication for OSPF neighbors using Message-Digest algorithm 5 (MD5) is configured in order exchange routing updates in a secure manner. To avoid Designated Router (DR) and Backup DR (BDR) election on routed p2p Ethernet links between distribution and Core layer and between distribution switches themsleves, we have to tune OSPF. We will change the default OSPF broadcast network type to OSPF Point-to-Point type. It will reduce the time needed for establishing adjacency because election of the DR and BDR is not performed in this case.

```
vEOS-Dis-I(config)# interface eth1
vEOS-Dis-I(config-if-Et1)# ip ospf authentication message-digest
vEOS-Dis-I(config-if-Et1)# ip ospf message-digest-key 1 md5 #MyPass!034
vEOS-Dis-I(config-if-Et1)# ip ospf network point-to-point
```

```
vEOS-Dis-I(config-if-Et1)# int eth2
vEOS-Dis-I(config-if-Et2)# ip ospf authentication message-digest
vEOS-Dis-I(config-if-Et2)# ip ospf message-digest-key 1 md5 #MyPass!034
vEOS-Dis-I(config-if-Et2)# ip ospf network point-to-point

vEOS-Dis-I(config-if-Et2)# int eth3
vEOS-Dis-I(config-if-Et3)# ip ospf authentication message-digest
vEOS-Dis-I(config-if-Et3)# ip ospf message-digest-key 1 md5 #MyPass!034
vEOS-Dis-I(config-if-Et3)# ip ospf network point-to-point
```



```
vEOS-Dis-I#show ip ospf neighbor
Neighbor ID     VRF      Pri State                  Dead Time   Address         Interface
10.1.1.1        default  1   FULL                   00:00:31    10.0.0.10       Ethernet2
10.1.1.2        default  1   FULL                   00:00:30    10.0.0.22       Ethernet1
10.1.1.7        default  0   FULL                   00:00:38    10.0.0.2        Ethernet3
vEOS-Dis-I#
```

Picture 2 - **Checking OSPF Neighbor Adjacency**

1.6 VRRP Configuration

The Virtual Router Redundancy Protocol (VRRP) is an election protocol that provides automatic assignment of the IP address one of the VRRP routers on the LAN. The VRRP router controlling the IP address associated with a virtual router is called the Master. The Master forwards packets sent to this IP address. The switch vEOS-DIS-I is a Master for the VLAN10 and 20 and it forwards packets that are sent to the IP address 192.168.10.254 and 192.168.20.254 (default gateway). It also acts as a VRRP Backup router for the VLAN30 and 40, forwarding packets from these VLANs in case the Master server (vEOS-DIS-II) fails. Similarly, the vEOS-DIS-II is a Master server for VLAN30 and 40 and the Backup server for VLANs 10 and 20. The priority configured for a VRRP router determines whether the router becomes a Master. The router with a higher priority has the higher probability to be elected as Master router. The switch vEOS-DIS-I has configured VRRP priority 150 for the SVI interfaces 10 and 20, while the switch vEOS-DIS-II uses the default priority 100 for these interfaces. For this reason, the switch vEOS-DIS-I wins an election process and becomes a Master for the VLANs 10 and 20.

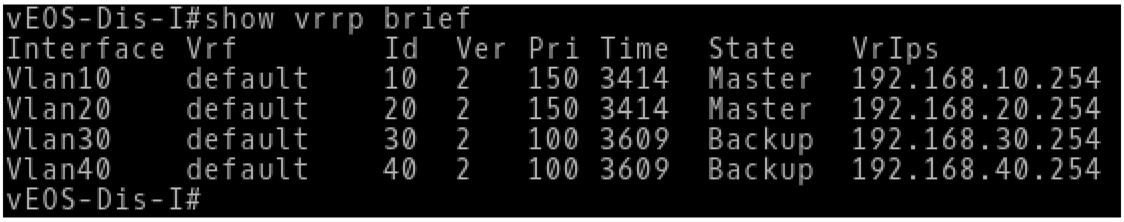
Note: The switch VRRP virtual IP addresses (192.168.x.254, where x is VLAN ID) are the default gateway IP addresses and they are assigned by DHCP server to clients.

```
vEOS-Dis-I(config)# interface vlan 10
vEOS-Dis-I(config-if-Vl10)# vrrp 10 priority 150
vEOS-Dis-I(config-if-Vl10)# vrrp 10 ip 192.168.10.254
vEOS-Dis-I(config-if-Vl10)# vrrp 10 authentication ietf-md5 key-string MiKei10!

vEOS-Dis-I(config)# interface vlan 20
vEOS-Dis-I(config-if-Vl20)# vrrp 20 priority 150
vEOS-Dis-I(config-if-Vl20)# vrrp 20 ip 192.168.20.254
vEOS-Dis-I(config-if-Vl20)# vrrp 20 authentication ietf-md5 key-string Mikei10!

vEOS-Dis-I(config)# interface vlan 30
vEOS-Dis-I(config-if-Vl30)# vrrp 30 priority 100
```

```
vEOS-Dis-I(config-if-Vl30)# vrrp 30 ip 192.168.30.254
vEOS-Dis-I(config-if-Vl30)# vrrp 30 authentication ietf-md5 key-string MiKei10!
```

```
EOS-Dis-I(config)# interface vlan 40
vEOS-Dis-I(config-if-Vl40)# vrrp 40 priority 100
vEOS-Dis-I(config-if-Vl40)# vrrp 40 ip 192.168.40.254
vEOS-Dis-I(config-if-Vl40)# vrrp 40 authentication ietf-md5 key-string MiKei10!
```

Note: We also configure MD5 authentication in order to avoid rogue VRRP server to participate in an election process and potentially become a Master. This is prevention against Man-in-the-Middle attack.



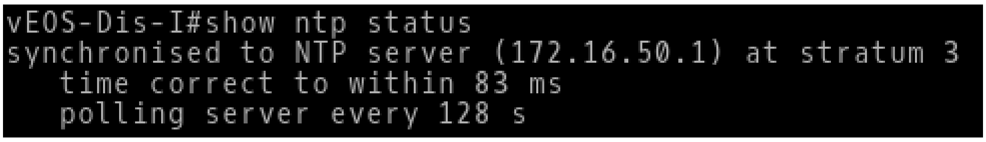
```
vEOS-Dis-I#show vrrp brief
Interface Vrf        Id  Ver Pri Time  State   VrIps
Vlan10    default    10  2   150 3414  Master  192.168.10.254
Vlan20    default    20  2   150 3414  Master  192.168.20.254
Vlan30    default    30  2   100 3609  Backup  192.168.30.254
Vlan40    default    40  2   100 3609  Backup  192.168.40.254
vEOS-Dis-I#
```

Picture 3 - **Checking VRRP States**

1.7 NTP Configuration

The time is synchronized with NTP server running on the Server1 (172.16.50.1).

```
vEOS-Dis-I(config)# ntp server 172.16.50.1
vEOS-Dis-I(config)# clock timezone Europe/Bratislava
vEOS-Dis-I(config)# ntp source loopback 0
```



```
vEOS-Dis-I#show ntp status
synchronised to NTP server (172.16.50.1) at stratum 3
   time correct to within 83 ms
   polling server every 128 s
```

Picture 4 - **Checking NTP Synchronization Status**

1.8 IP Helper Address Configuration

The DHCP server for the PCs assigned to VLANs 10, 20 and 20 is running on the Server1 (172.16.50.1). The DHCP is located in the different subnets than PCs. For this reason we have to enable DHCP relay agent on the SVI interfaces with the command ip helper-address. The command enables the DHCP broadcast to be forwarded to the configured DHCP server as unicasts.

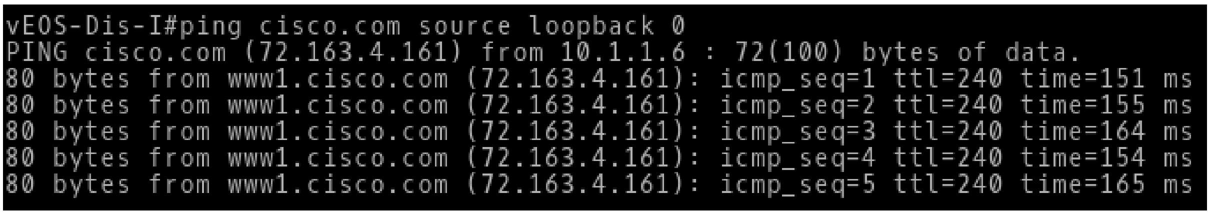
```
vEOS-Dis-I(config)# interface vlan 10
vEOS-Dis-I(config-if-Vl10)# ip helper-address 172.16.50.1
vEOS-Dis-I(config-if-Vl10)# exit
vEOS-Dis-I(config)# interface vlan 20
vEOS-Dis-I(config-if-Vl20)# ip helper-address 172.16.50.1
vEOS-Dis-I(config-if-Vl20)# exit
vEOS-Dis-I(config)# interface vlan 30
```

```
vEOS-Dis-I(config-if-Vl30)# ip helper-address 172.16.50.1
vEOS-Dis-I(config-if-Vl20)# exit
```

Note: We do not need to configure IP helper address for an interface Vlan40 as all the devices in Management VLAN40 have statically configured IP addresses.

1.9 DNS Server Configurations

```
vEOS-Dis-I(config)# ip name-server 172.16.50.1
```



```
vEOS-Dis-I#ping cisco.com source loopback 0
PING cisco.com (72.163.4.161) from 10.1.1.6 : 72(100) bytes of data.
80 bytes from www1.cisco.com (72.163.4.161): icmp_seq=1 ttl=240 time=151 ms
80 bytes from www1.cisco.com (72.163.4.161): icmp_seq=2 ttl=240 time=155 ms
80 bytes from www1.cisco.com (72.163.4.161): icmp_seq=3 ttl=240 time=164 ms
80 bytes from www1.cisco.com (72.163.4.161): icmp_seq=4 ttl=240 time=154 ms
80 bytes from www1.cisco.com (72.163.4.161): icmp_seq=5 ttl=240 time=165 ms
```

Picture 5 - **Checking DNS Configuration Pinging Cisco.com**

1.10 Radius Client Configuration

We use Remote Authentication Dial-In User Service (RADIUS) for centralized authentication of user logging to network devices. The Radius server is running on Server1 (172.16.50.1). First, we create a local user with full access in case RADIUS server is not reachable.

```
vEOS-Dis-I(config)# username admin privilege 15 secret cisco
```

We will do the same for access to a privileged exec mode.

```
vEOS-Dis-I(config)# enable secret cisco
```

A RADIUS server and a Cisco router use a shared secret text string to encrypt passwords and exchange responses. To configure RADIUS to use the AAA security commands, we must specify the host running the RADIUS server daemon and a secret text (key) string that it shares with the router.

```
vEOS-Dis-I(config)# radius-server host 172.16.50.1 auth-port 1812 acct-port
vEOS-Dis-I(config)# radius-server key test123
```

Define a source interface.

```
vEOS-Dis-I(config)# ip radius source-interface loopback 0
```

Define login method. Radius will be used first and if it is not available a local user authentication is used instead.

```
vEOS-Dis-I(config)# aaa authentication login default group radius local
```

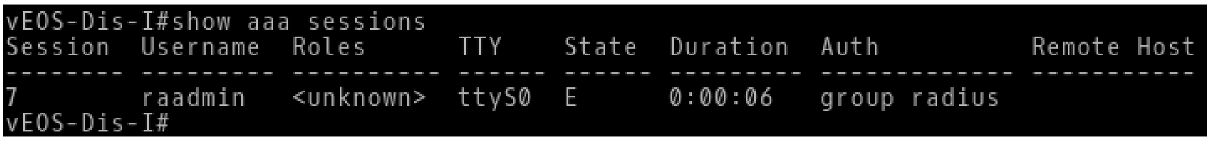
Enable privileged exec mode authentication. First, we are authenticated against the privileged exec password defined in Radius server. If Radius server is not available then locally configured privileged exec password authentication will be used.

vEOS-Dis-I(config)# aaa authentication enable default group radius local

To use Radius server for login to console and VTY we need to enable authorization for console and for exec terminal session.

vEOS-Dis-I(config)# aaa authorization console
vEOS-Dis-I(config)# aaa authorization exec default group radius local

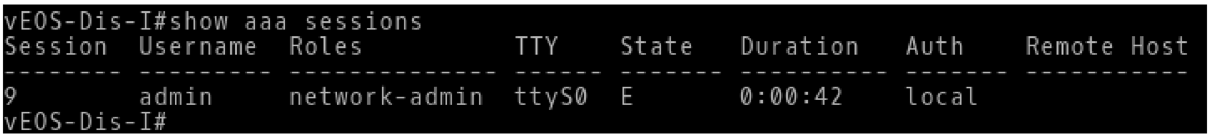
To see the current logged in users and their user-roles use the command *show aaa sessions*. The username *raadmin* defined on RADIUS server is logged.



```
vEOS-Dis-I#show aaa sessions
Session  Username  Roles      TTY    State  Duration  Auth          Remote Host
-------- --------- ---------- ------ ------ --------- ------------- -----------
7        raadmin   <unknown>  ttyS0  E      0:00:06   group radius
vEOS-Dis-I#
```

Picture 6 - **Checking Logged Users when RADIUS Is Reachable**

Now we will use the same command when RADIUS server is not reachable. In this case a local user *admin* is used for logging to console of the switch.



```
vEOS-Dis-I#show aaa sessions
Session  Username  Roles          TTY    State   Duration   Auth    Remote Host
-------- --------- -------------- ------ ------- ---------- ------- -----------
9        admin     network-admin  ttyS0  E       0:00:42    local
vEOS-Dis-I#
```

Picture 7 -**Checking Logged Users when RADIUS Is Not Reachable**

1.11 Logging Configuration

To ensure that logs are stored on a centralized syslog-ng server running on Server1 (172.16.50.1) we will configured following:

Set syslog server logging level 5 - notification.

vEOS-Dis-I(config)# logging trap notifications

Set syslog server IP address and parameters.

vEOS-Dis-I(config)# logging host 172.16.50.1

Configure logging source interface.

vEOS-Dis-I(config)# logging source-interface Loopback0

Log messages are stored in the directory /var/log/syslog-ng/10.1.1.6/. We collect log messages with the severity notice level 5 and lower (0 - system unusable, 7 - debug).

2. Distribution Switch vEOS-DIS-II Configuration

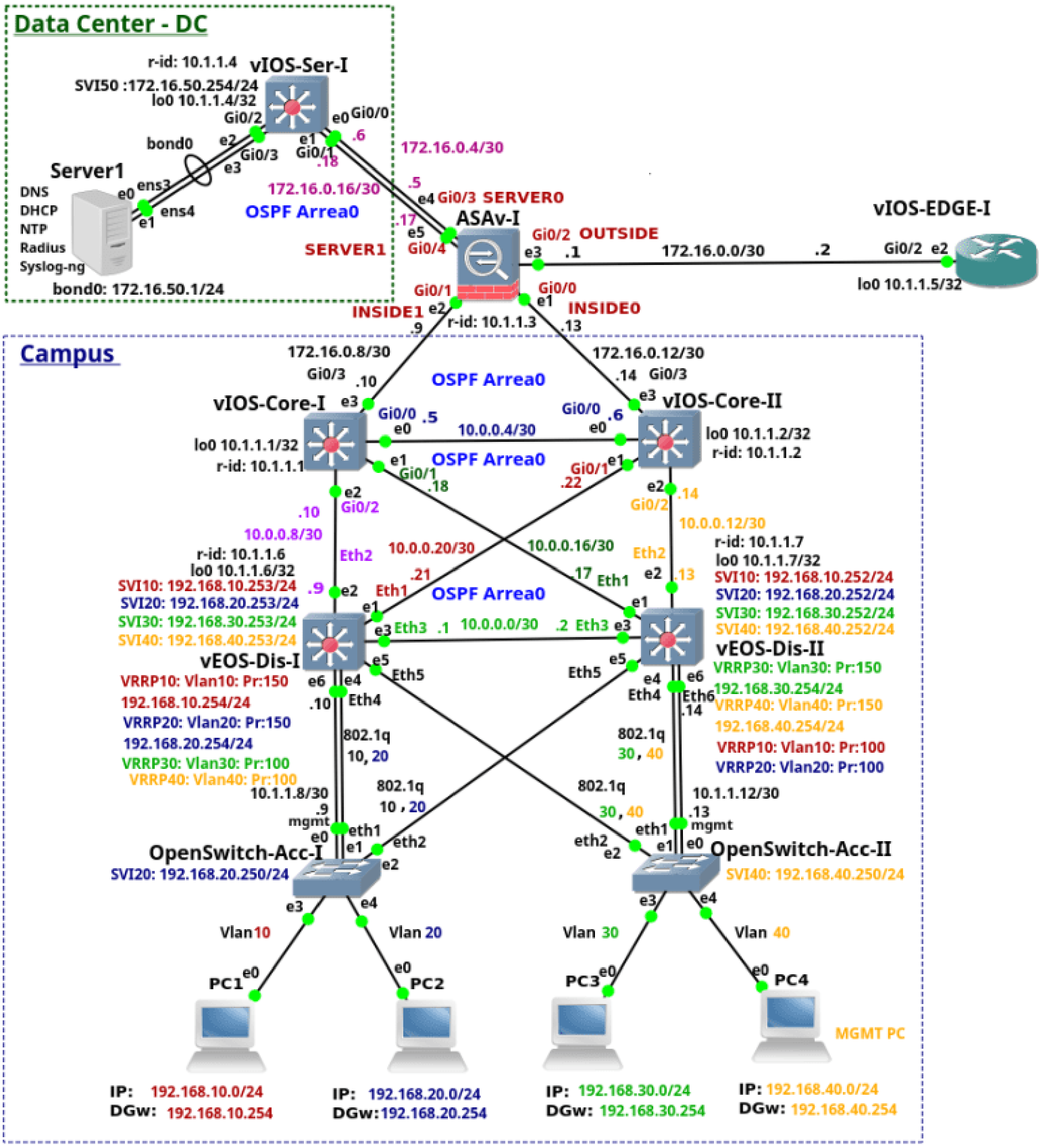
The configuration of the second distribution switch vEOS-DIS-II is similar to the configuration of the switch vEOS-DIS-I. Therefore I only share the configuration of the switch without further explanation.

3. Core Switches vIOS-Core-I and vIOS-Core-II Configuration

The configuration of the both core switches is straightforward so it does not need any explanation. For his reason, I have just attached the configuration files at the begging of the tutorial.

Enterprise Network on GNS3 - Part 4 - Cisco ASAv-I

This is the fourth from the series of the articles that discuss configuration of the enterprise network. The article explains configuration of the device ASAv-I. The device is a Cisco Adaptive Security Virtual Appliance (ASAv) version 9.6(1) installed on qcow2 Qemu disk. The ASAv-I provides traffic filtering and inspection services for the campus network and Data Center (DC). It also connects the campus network and DC to the vIOS-EDGE-I edge router.



Picture 1 - **ASAv-I, Campus, DC and Edge Connection**

Note: The recommended RAM size for ASAv instance is 2048 MB. In order to lower memory consumption, GNS3 is configured to assign 1536 MB to the ASAv.

Note: The interface eth0 on the ASAv-I is referred as the interface Management0/0 in ASAv configuration. The interface eth0 is not connected as we use the inside interfaces for management instead. The first connected interface is then the interface eth1 that is referred as the interface GigabitEthernet0/0 in ASAv CLI. Similarly, the second connected interface eth2 is referred as the GigabitEthernet0/1 and so on.

Note: Here is the configuration file of vASA-I.

ASAv-I Configuration

Once we start ASAv, the Qemu window is launched. However we want to use GNS3 console instead of Qemu console. Therefore we need to redirect vASA output to a serial port. When ASAv boots up, copy the file coredump.cfg to a disk0 in a privileged exec mode (password is not set). Then reboot the ASAv and you should be able to manage ASAv via GNS3 console afterwards.

```
# copy disk0:/coredumpinfo/coredump.cfg disk0:/use_ttyS0
```

As a first step we configure the hostname.

```
ciscoasa> en
ciscoasa# conf t
ciscoasa(config)# hostname ASAv-I
```

1. Interfaces Configuration

The links connecting ASAv-I to the Core switches are configured with the interface name INSIDE0 and INSIDE1. They have assigned a security level 100. The links connecting ASAv-I to the DC are configured with the interface name SERVER0 and SERVER1. They have assigned a security level 50. The link connecting the ASAv-I to the vIOS-EDGE-I router is configured with the interface name OUTSIDE and it has assigned a security level 0.

Thanks to the security levels concept, TCP and UDP traffic from the hosts connected to the inside interfaces (level 100) can reach hosts in DC, behind the server interfaces (level 50) or hosts in the Internet behind the outside interface (level 0). The same is valid for traffic sent from DC to the Internet. In this case, network traffic takes a path from the server interface (level 50) to the outside (level 0) interface and back.

In general, traffic initialized from the interface with a higher security level is allowed to enter the interface with a lower security level and back. However traffic initialized from the interface with a lower security level is not passed to the interface with a higher security level. For this reason traffic initialized behind the outside interface is passed neither to the inside nor to the server interfaces. If we need to allow traffic initialized from host connected to the outside interface (level 0) to enter the interfaces with a higher level (100 or 50, in our case), we have to configure an access-list (ACL). The ACL must explicitly allow particular network traffic (e.g. TCP, UDP or ICMP) to enter the outside interface.

```
ASAv-I(config)# interface Gi0/0
ASAv-I(config-if)# description Link to vIOS-Core-II
ASAv-I(config-if)# nameif INSIDE0
ASAv-I(config-if)# security-level 100
ASAv-I(config-if)# ip address 172.16.0.13 255.255.255.252
ASAv-I(config-if)# no shutdown
ASAv-I(config-if)# exit

ASAv-I(config)# interface Gi0/1
ASAv-I(config-if)# description Link to vIOS-Core-I
ASAv-I(config-if)# nameif INSIDE1
ASAv-I(config-if)# security-level 100
ASAv-I(config-if)# no shutdown
ASAv-I(config-if)# exit

ASAv-I(config)# interface Gi0/2
ASAv-I(config-if)# description Link to vIOS-EDGE-I
ASAv-I(config-if)# nameif OUTSIDE
ASAv-I(config-if)# security-level 0
ASAv-I(config-if)# ip address 172.16.0.1 255.255.255.252
ASAv-I(config-if)# no shutdown
ASAv-I(config-if)# exit

ASAv-I(config)# interface Gi0/3
ASAv-I(config-if)# description Link1 to vIOS-Ser-I
ASAv-I(config-if)# nameif SERVER0
ASAv-I(config-if)# security-level 50
ASAv-I(config-if)# ip address 172.16.0.5 255.255.255.252
ASAv-I(config-if)# no shutdown
ASAv-I(config-if)# exit

ASAv-I(config)# interface Gi0/4
ASAv-I(config-if)# description Link2 to vIOS-Ser-I
ASAv-I(config-if)# nameif SERVER1
ASAv-I(config-if)# security-level 50
ASAv-I(config-if)# ip address 172.16.0.17 255.255.255.252
ASAv-I(config-if)# no shutdown
ASAv-I(config-if)# exit
```

2. Logging Configuration

Enable Logging messages to console, RAM (buffer) and VTY session and configure appropriate logging levels.

```
ASAv-I(config)# logging enable
ASAv-I(config)# logging console 6
ASAv-I(config)# logging buffered 6
ASAv-I(config)# logging monitor 6
```

Configure syslog server server and syslog level 5 - notifications.

```
ASAv-I(config)# logging host SERVER0 172.16.50.1
ASAv-I(config)# logging trap notifications
```

Note: SERVER0 is the interface name.

Turn on monitoring logs on VTY session.

```
ASAv-I# terminal monitor
```

Note: Use command terminal no monitor to turn off displaying logs on VTY session.

Set exec timeout to 0 - you will never be disconnected from console.

```
ASAv-I(config)# console timeout 0
```

3. Default Static Route Configuration

We need to configure a default static route in order to reach hosts in the Internet. This route will be later redistributed to the OSPF process.

```
ASAv-I(config)# route OUTSIDE 0.0.0.0 0.0.0.0 172.16.0.2
```

4. Objects and Object Groups Configuration

Using objects and object groups are reusable components that help to maintain configuration. We can modify an object in one place and have it be reflected in all other places that are referencing it.

```
ASAv-I(config)# object network vlan10_192.168.10
ASAv-I(config-network-object)# subnet 192.168.10.0 255.255.255.0

ASAv-I(config)# object network vlan20_192.168.20
ASAv-I(config-network-object)# subnet 192.168.20.0 255.255.255.0

ASAv-I(config)# object network vlan30_192.168.30
ASAv-I(config-network-object)# subnet 192.168.30.0 255.255.255.0

ASAv-I(config)# object network vlan40_192.168.40
ASAv-I(config-network-object)# subnet 192.168.40.0 255.255.255.0

ASAv-I(config)# object network vlan50_172.16.50
ASAv-I(config-network-object)# subnet 172.16.50.0 255.255.255.0

ASAv-I(config)# object network google_dns1
ASAv-I(config-network-object)# host 8.8.8.8

ASAv-I(config)# object network google_dns2
ASAv-I(config-network-object)# host 8.8.4.4
```

```
ASAv-I(config)# object network server1
ASAv-I(config-network-object)# host 172.16.50.1

ASAv-I(config)# object network vios-l3
ASAv-I(config-network-object)# host 10.1.1.5

ASAv-I(config)# object network loopbacks
ASAv-I(config-network-object)# subnet 10.1.1.0 255.255.255.0

ASAv-I(config)# object-group network mgmt
ASAv-I(config-network-object-group)# network-object object vlan40_192.168.40

ASAv-I(config)# object-group network end_vlans
ASAv-I(config-network-object-group)# network-object object vlan10_192.168.10
ASAv-I(config-network-object-group)# network-object object vlan20_192.168.20
ASAv-I(config-network-object-group)# network-object object vlan30_192.168.30
ASAv-I(config-network-object-group)# network-object object vlan40_192.168.40

ASAv-I(config)# object-group network server_vlans_all
ASAv-I(config-network-object-group)# description All server VLANs
ASAv-I(config-network-object-group)# network-object object vlan50_172.16.50

ASAv-I(config)# object-group network google_dns
ASAv-I(config-network-object-group)# network-object object google_dns1
ASAv-I(config-network-object-group)# network-object object google_dns2

vASA-I(config)# object-group service server1_tcp_out tcp
vASA-I(config-service-object-group)# port-object eq http
vASA-I(config-service-object-group)# port-object eq https
vASA-I(config-service-object-group)# port-object eq domain

vASA-I(config)# object-group service server1_udp_out udp
vASA-I(config-service-object-group)# port-object eq ntp
vASA-I(config-service-object-group)# port-object eq domain
```

5. Management Protocol Configuration

5.1 ICMP ECHO Request and Echo Reply Messages on Inside Interfaces

Allow management (192.168.40.0/24), server (172.16.50.0/24) and loopback (10.1.1.0/24) subnets to ping the ASA inside interfaces.

```
ASAv-I(config)# icmp permit 192.168.40.0 255.255.255.0 INSIDE0
ASAv-I(config)# icmp permit 192.168.40.0 255.255.255.0 INSIDE1
ASAv-I(config)# icmp permit 172.16.50.0 255.255.255.0 SERVER0
ASAv-I(config)# icmp permit 172.16.50.0 255.255.255.0 SERVER1
ASAv-I(config)# icmp permit 10.1.1.0 255.255.255.0 INSIDE0
ASAv-I(config)# icmp permit 10.1.1.0 255.255.255.0 INSIDE1
```

5.2 SSH Access

```
ASAv-I(config)# username admin password cisco
ASAv-I(config)# aaa authentication ssh console LOCAL
ASAv-I(config)# crypto key generate rsa modulus 4096
```

Allow SSH access to INSIDE0 and INSIDE1 interfaces.

```
ASAv-I(config)# ssh 192.168.40.0 255.255.255.0 INSIDE0
ASAv-I(config)# ssh 192.168.40.0 255.255.255.0 INSIDE1
```

Set timeout for ssh session. Timeout is set to maximum value 60 minut.

```
ASAv-I(config)# ssh timeout 60
```

6. OSPF Protocol and Authentication Configuration

The OSPF routing protocol ensures that connectivity is between campus and DC. The static default route pointing to vIOS-EDGE-I is redistributed to OSPF process. Authentication with MD5 algorithm is used in order to prevent peering with a rouge OSPF router.

```
ASAv-I(config)# router ospf 1
ASAv-I(config-router)# router-id 1.1.1.3
ASAv-I(config-router)# network 172.16.0.4 255.255.255.252 area 0
ASAv-I(config-router)# network 172.16.0.8 255.255.255.252 area 0
ASAv-I(config-router)# network 172.16.0.12 255.255.255.252 area 0
ASAv-I(config-router)# network 172.16.0.16 255.255.255.252 area 0
ASAv-I(config-router)# default-information originate
ASAv-I(config-router)# exit

ASAv-I(config)# interface GigabitEthernet 0/0
ASAv-I(config-if)# ospf authentication message-digest
ASAv-I(config-if)# ospf message-digest-key 1 md5 #MyPass!034

ASAv-I(config)# interface GigabitEthernet 0/1
ASAv-I(config-if)# ospf authentication message-digest
ASAv-I(config-if)# ospf message-digest-key 1 md5 #MyPass!034

ASAv-I(config)# interface GigabitEthernet 0/3
ASAv-I(config-if)# ospf authentication message-digest
ASAv-I(config-if)# ospf message-digest-key 1 md5 #MyPass!034

ASAv-I(config)# interface GigabitEthernet 0/4
ASAv-I(config-if)# ospf authentication message-digest
ASAv-I(config-if)# ospf message-digest-key 1 md5 #MyPass!034
```

7. Zone Configuration

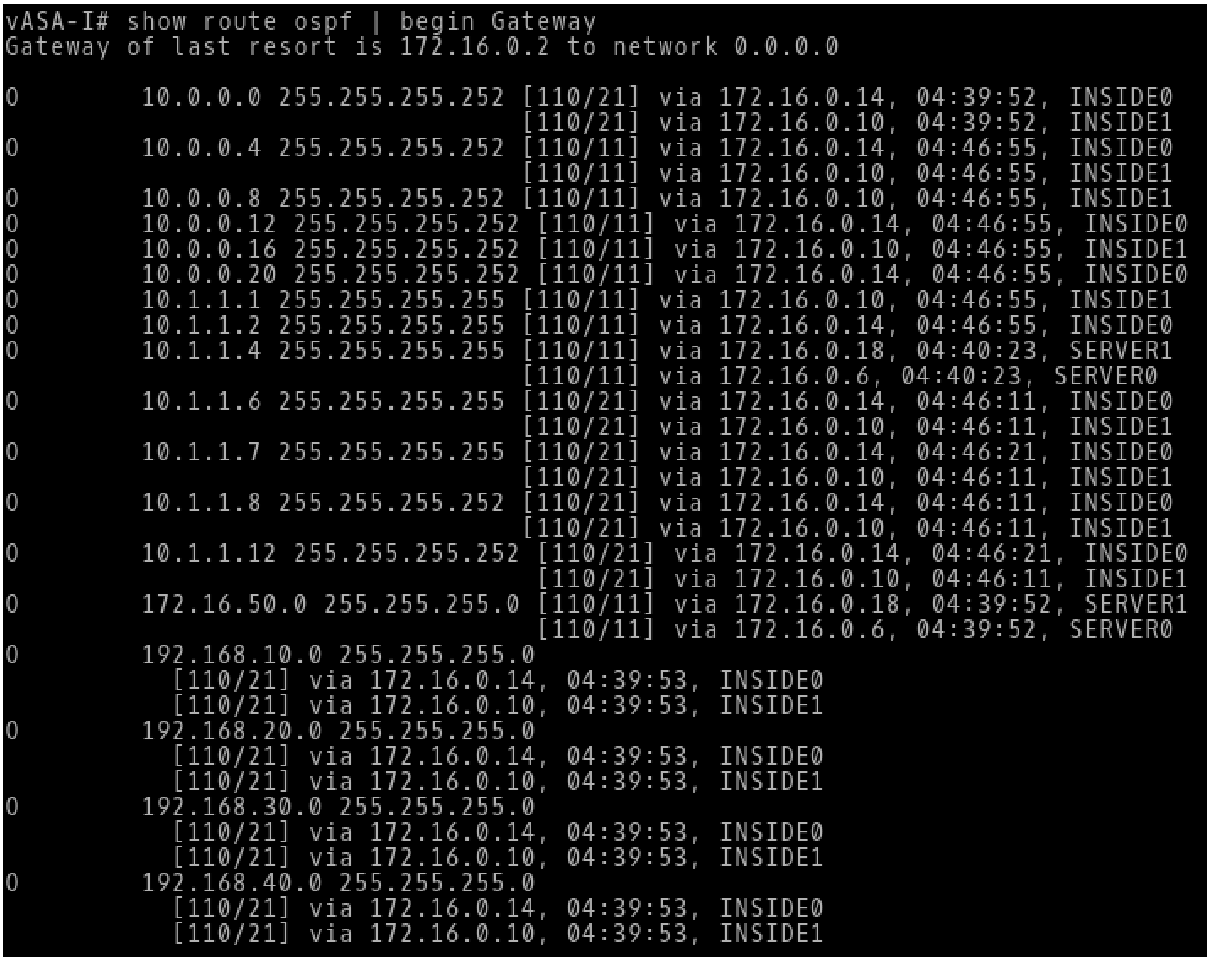
The ASAv-I installs only one route to the subnets: 192.168.x.0/24, 10.0.0.x/30 even they are two paths to these routes available. The first path is via vIOS-Core-I (172.16.0.10) and the second path is via vIOS-Core-II (172.16.0.14). It is because ECMP is not supported across multiple interfaces, so we cannot define a route to the same destination on a different interface.

However, with zones, we can have up to 8 equal cost static or dynamic routes across up to 8 interfaces within a zone. To achieve ECMP via two different interfaces, we will create a zone *inside_zone* and assign Gi0/0 and it Gi0/1 to this zone.

```
ASAv-I(config)# zone inside_zone

ASAv-I(config)# interface gigabitEthernet 0/0
ASAv-I(config-if)# zone-member inside_zone

ASAv-I(config)# interface gigabitEthernet 0/1
ASAv-I(config-if)# zone-member inside_zone
```

Similarly, we will create zone *server_zone* for Gi0/3 and Gi/04.

```
ASAv-I(config)# zone server_zone

ASAv-I(config)# interface gigabitEthernet 0/3
ASAv-I(config-if)# zone-member server_zone

ASAv-I(config)# interface gigabitEthernet 0/4
ASAv-I(config-if)# zone-member server_zone
```



```
vASA-I# show route ospf | begin Gateway
Gateway of last resort is 172.16.0.2 to network 0.0.0.0

O        10.0.0.0 255.255.255.252 [110/21] via 172.16.0.14, 04:39:52, INSIDE0
                                  [110/21] via 172.16.0.10, 04:39:52, INSIDE1
O        10.0.0.4 255.255.255.252 [110/11] via 172.16.0.14, 04:46:55, INSIDE0
                                  [110/11] via 172.16.0.10, 04:46:55, INSIDE1
O        10.0.0.8 255.255.255.252 [110/11] via 172.16.0.10, 04:46:55, INSIDE1
O        10.0.0.12 255.255.255.252 [110/11] via 172.16.0.14, 04:46:55, INSIDE0
O        10.0.0.16 255.255.255.252 [110/11] via 172.16.0.10, 04:46:55, INSIDE1
O        10.0.0.20 255.255.255.252 [110/11] via 172.16.0.14, 04:46:55, INSIDE0
O        10.1.1.1 255.255.255.255 [110/11] via 172.16.0.10, 04:46:55, INSIDE1
O        10.1.1.2 255.255.255.255 [110/11] via 172.16.0.14, 04:46:55, INSIDE0
O        10.1.1.4 255.255.255.255 [110/11] via 172.16.0.18, 04:40:23, SERVER1
                                  [110/11] via 172.16.0.6, 04:40:23, SERVER0
O        10.1.1.6 255.255.255.255 [110/21] via 172.16.0.14, 04:46:11, INSIDE0
                                  [110/21] via 172.16.0.10, 04:46:11, INSIDE1
O        10.1.1.7 255.255.255.255 [110/21] via 172.16.0.14, 04:46:21, INSIDE0
                                  [110/21] via 172.16.0.10, 04:46:11, INSIDE1
O        10.1.1.8 255.255.255.252 [110/21] via 172.16.0.14, 04:46:11, INSIDE0
                                  [110/21] via 172.16.0.10, 04:46:11, INSIDE1
O        10.1.1.12 255.255.255.252 [110/21] via 172.16.0.14, 04:46:21, INSIDE0
                                   [110/21] via 172.16.0.10, 04:46:11, INSIDE1
O        172.16.50.0 255.255.255.0 [110/11] via 172.16.0.18, 04:39:52, SERVER1
                                   [110/11] via 172.16.0.6, 04:39:52, SERVER0
O        192.168.10.0 255.255.255.0
           [110/21] via 172.16.0.14, 04:39:53, INSIDE0
           [110/21] via 172.16.0.10, 04:39:53, INSIDE1
O        192.168.20.0 255.255.255.0
           [110/21] via 172.16.0.14, 04:39:53, INSIDE0
           [110/21] via 172.16.0.10, 04:39:53, INSIDE1
O        192.168.30.0 255.255.255.0
           [110/21] via 172.16.0.14, 04:39:53, INSIDE0
           [110/21] via 172.16.0.10, 04:39:53, INSIDE1
O        192.168.40.0 255.255.255.0
           [110/21] via 172.16.0.14, 04:39:53, INSIDE0
           [110/21] via 172.16.0.10, 04:39:53, INSIDE1
```

Picture 2 - **OSPF Routes**

8. Access Lists (ACLs) Configuration

8.1 Access List out-to-ins

Permit ICMP Echo Reply packets with the source IP address 8.8.8.8 and 8.8.4.4 to end user subnets 192.168.x.0/24. The ACL allows users to check connectivity to Google public DNS with the ping command. Without the access-list, vASA does not pass ICMP Echo Reply packets from the interface outside to the interface inside or server.

```
ASAv-I(config)# access-list out-to-ins extended permit icmp object-group google_dns object-group end_vlans echo-reply
```

Permit ICMP Echo Reply packets with any source IP address to MGMT (192.168.40.0/24), Vlan50 (172.16.50.0/24) and loopback's IP 10.1.1.0/24 subnets.

```
ASAv-I(config)# access-list out-to-ins extended permit icmp any object-group mgmt echo-reply
ASAv-I(config)# access-list out-to-ins extended permit icmp any object loopbacks echo-reply
ASAv-I(config)# access-list out-to-ins extended permit icmp any object vlan50_172.16.50 echo-reply
```

Note: The other way to allow ICMP Echo Reply packets to enter the outside interface is to enable ICMP inspection on ASAv. In this case, the ASAv dynamically allows the corresponding ICMP ECHO Reply to pass through without needing to have access-list. However we do not want all devices in campus or DC to be able ping hosts in the Internet. For this reason we have shown ACL method.

Permit DNS request/reply from 8.8.8.8 and 8.8.4.4 from/to Server1 - 172.16.50.1.

```
ASAv-I(config)# access-list out-to-ins permit udp object-group google_dns object server1 eq 53
```

Permit NTP request from vIOS-L3 (10.1.1.5) to Server1.

```
ASAv-I(config)# access-list out-to-ins permit udp object vios-l3 object server1 eq 123
```

Permit syslog (UDP 514) traps from vIOS-L3 (10.1.1.5) to Server1.

```
ASAv-I(config)# access-list out-to-ins permit udp object vios-l3 object server1 eq 514
```

Apply ACL out-to-ins to the interface Outside in inbound direction.

```
ASAv-I(config)# interface gi0/2
ASAv-I(config-if)# access-group out-to-ins in interface OUTSIDE
```

8.2 Access List dc-to-ins_out

Permit hosts in subnet (172.16.50.0/24) to send traffic to any IP address, the destination TCP port 80 (http),443 (https) and 53 (DNS).

vASA-I(config)# access-list dc-to-ins_out extended permit tcp object vlan50_172.16.50 any object-group server1_tcp_out

Permit hosts in subnet (172.16.50.0/24) to send traffic to any IP address, the destination UDP port 123 (NTP) and 53 (DNS).

vASA-I(config)# access-list dc-to-ins_out extended permit udp object vlan50_172.16.50 any object-group server1_udp_out

Permit hosts in subnet (172.16.50.0/24) to send to ICMP Echo Request (ping) to any IP address to the IP addresses 8.8.8.8 and 8.8.4.4.

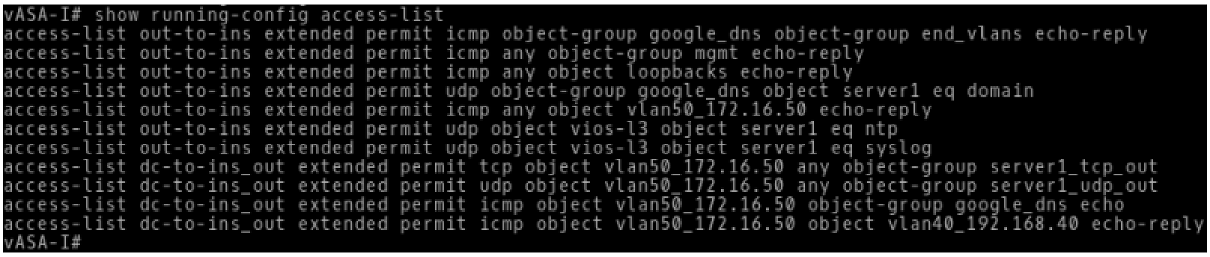
vASA-I(config)# access-list dc-to-ins_out extended permit icmp object vlan50_172.16.50 object-group google_dns echo

Permit hosts in mgmt VLAN40 (192.168.40.0/24) to ping Server1.

vASA-I(config)# access-list dc-to-ins_out extended permit icmp object vlan50_172.16.50 object vlan40_192.168.40 echo-reply

Apply ACL dc-to-ins to the interfaces SERVER0 and SERVER1 in inbound direction.

vASA-I(config)# access-group dc-to-ins_out in interface SERVER0
vASA-I(config)# access-group dc-to-ins_out in interface SERVER1

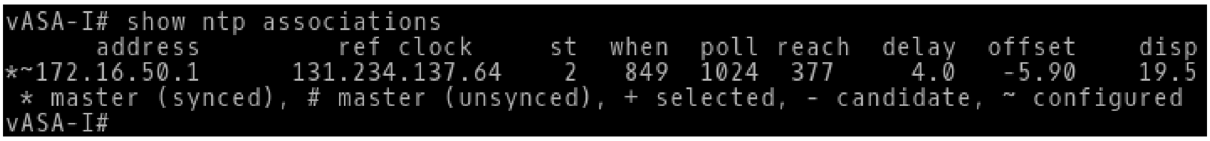


```
vASA-I# show running-config access-list
access-list out-to-ins extended permit icmp object-group google_dns object-group end_vlans echo-reply
access-list out-to-ins extended permit icmp any object-group mgmt echo-reply
access-list out-to-ins extended permit icmp any object loopbacks echo-reply
access-list out-to-ins extended permit udp object-group google_dns object server1 eq domain
access-list out-to-ins extended permit icmp any object vlan50_172.16.50 echo-reply
access-list out-to-ins extended permit udp object vios-l3 object server1 eq ntp
access-list out-to-ins extended permit udp object vios-l3 object server1 eq syslog
access-list dc-to-ins_out extended permit tcp object vlan50_172.16.50 any object-group server1_tcp_out
access-list dc-to-ins_out extended permit udp object vlan50_172.16.50 any object-group server1_udp_out
access-list dc-to-ins_out extended permit icmp object vlan50_172.16.50 object-group google_dns echo
access-list dc-to-ins_out extended permit icmp object vlan50_172.16.50 object vlan40_192.168.40 echo-reply
vASA-I#
```

Picture 3 - **Access-Lists**

9. NTP Configuration

ASAv-I(config)# ntp server 172.16.50.1
ASAv-I(config)# clock timezone UTC+2 +2



```
vASA-I# show ntp associations
      address         ref clock      st  when  poll reach  delay  offset    disp
*~172.16.50.1      131.234.137.64    2   849  1024  377     4.0   -5.90    19.5
 * master (synced), # master (unsynced), + selected, - candidate, ~ configured
vASA-I#
```

Picture 4 - **Checking NTP Associations**

10. Radius Server Configuration

10.1 Create Local User

Create a local user with full access in case Radius servers is not reachable.

```
ASAv-I(config)# username admin password cisco privilege 15
```

We also set password for privileged exec mode.

```
ASAv-I(config)# enable password cisco
```

Now Activate AAA.

```
vIOS-Core-I(config)# aaa new-model
```

10.2 Radius Server

The RADIUS server and a vASA use a shared secret text string to encrypt passwords and exchange responses.To configure RADIUS to use the AAA security commands, we must specify the host running the RADIUS server daemon and a secret text (key) string that it shares with the ASAv.

```
ASAv-I(config)# aaa-server Server1 protocol radius
ASAv-I(config-aaa-server-group)# exit

ASAv-I(config)# aaa-server Server1 (SERVER0) host 172.16.50.1 test123
ASAv-I(config-aaa-server-host)# key test123
ASAv-I(config-aaa-server-host)# authentication-port 1812
ASAv-I(config-aaa-server-host)# accounting-port 1813
```

10.3 Authentication for Access to Serial Console

If all servers in the server group have been deactivated, authentication will be done against the local database.

```
ASAv-I(config)# aaa authentication serial console Server1 LOCAL
```

10.4 Authentication for Access via SSH

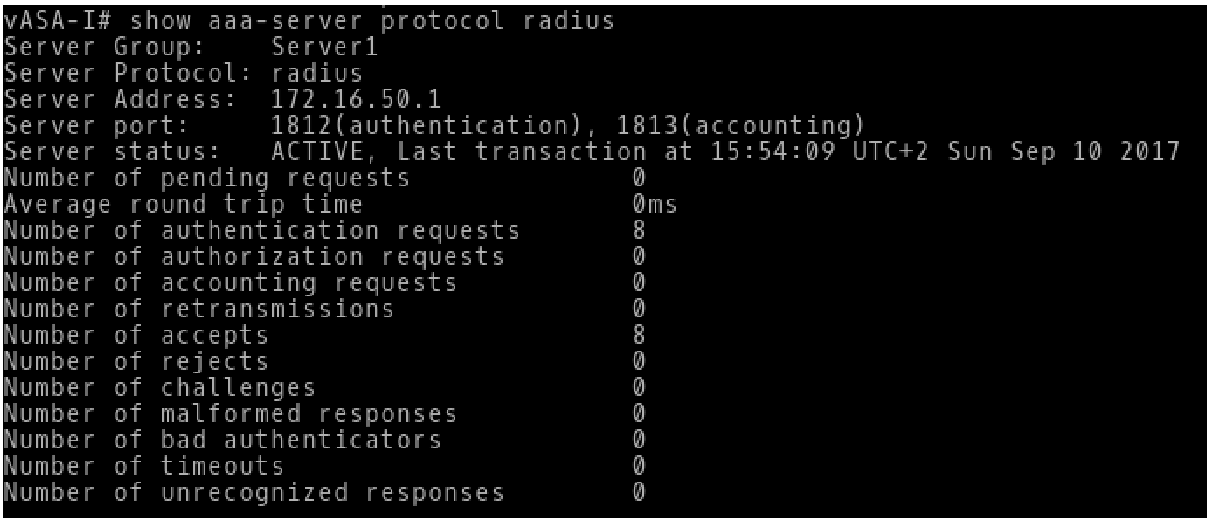
```
ASAv-I(config)# aaa authentication ssh console Server1 LOCAL
```

10.5 Authentication for Access to Privileged Exec Mode (Enable)

```
ASAv-I(config)# aaa authentication enable console Server1 LOCAL
```

Transition a failed AAA server to Active.

```
ASAv-I(config)# aaa-server Server1 active host 172.16.50.1
```



```
vASA-I# show aaa-server protocol radius
Server Group:    Server1
Server Protocol: radius
Server Address:  172.16.50.1
Server port:     1812(authentication), 1813(accounting)
Server status:   ACTIVE, Last transaction at 15:54:09 UTC+2 Sun Sep 10 2017
Number of pending requests              0
Average round trip time                 0ms
Number of authentication requests       8
Number of authorization requests        0
Number of accounting requests           0
Number of retransmissions               0
Number of accepts                       8
Number of rejects                       0
Number of challenges                    0
Number of malformed responses           0
Number of bad authenticators            0
Number of timeouts                      0
Number of unrecognized responses        0
```

Picture 5 - **Checking AAA Server**

11. Application Inspection Configuration

We also need to inspect network traffic on application layer to check both Layer 7 header and the payload of the segments to ensure that packets do not carry harmful content. To add http inspection to the list of default inspected applications, we will create an optional policy-map type http named *http_map.* In case of http protocol violation, TCP traffic is dropped.

ASAv-I(config)# policy-map type inspect http http_map
ASAv-I(config-pmap)# parameters
ASAv-I(config-pmap-p)# protocol-violation action drop-connection log

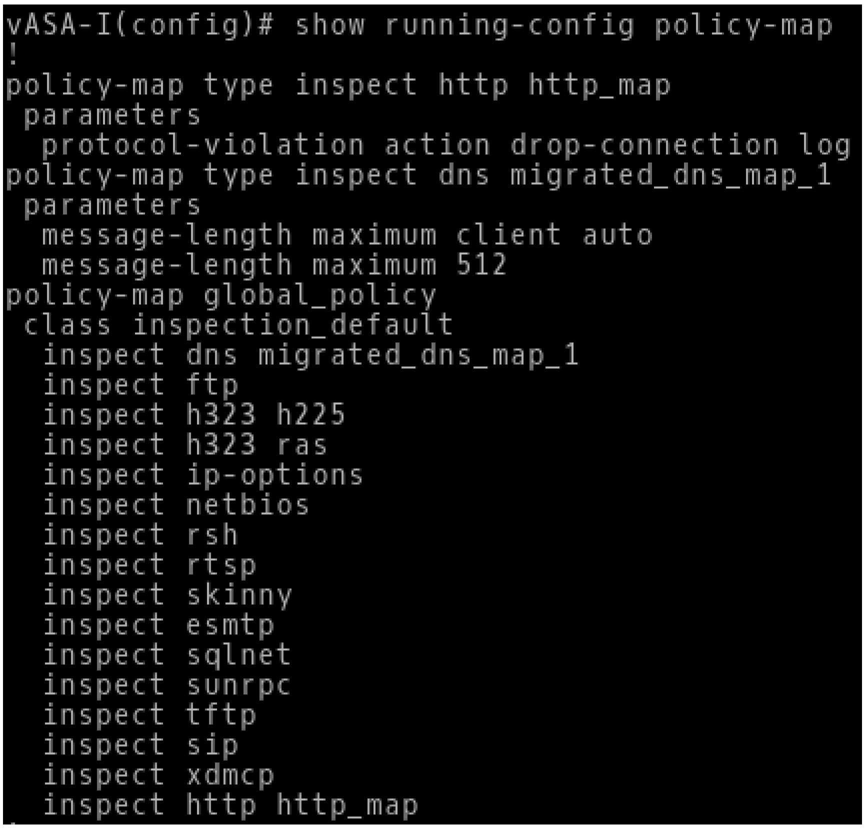
Note: class-maps identify traffic, actions are assigned with policies (policy-map), and then the service policies are activated on interfaces (service-policy).

Assign our http_map policy to the global_policy map.

ASAv-I(config)# policy-map global_policy
ASAv-I(config-pmap)# class inspection_default
ASAv-I(config-pmap-c)# inspect http http_map

ASAv-I(config)# service-policy global_policy global

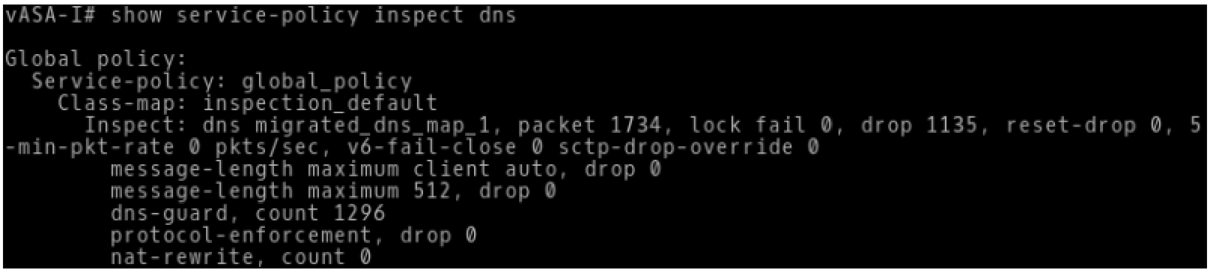
Check inspected protocols in running-config.



```
vASA-I(config)# show running-config policy-map
!
policy-map type inspect http http_map
 parameters
  protocol-violation action drop-connection log
policy-map type inspect dns migrated_dns_map_1
 parameters
  message-length maximum client auto
  message-length maximum 512
policy-map global_policy
 class inspection_default
  inspect dns migrated_dns_map_1
  inspect ftp
  inspect h323 h225
  inspect h323 ras
  inspect ip-options
  inspect netbios
  inspect rsh
  inspect rtsp
  inspect skinny
  inspect esmtp
  inspect sqlnet
  inspect sunrpc
  inspect tftp
  inspect sip
  inspect xdmcp
  inspect http http_map
!
```

Picture 6 - **Checking Inspected Application Protocols**

To show statistic of service-policy inspect for a particular application protocol, use the command below. The command shows statistic for DNS protocol.



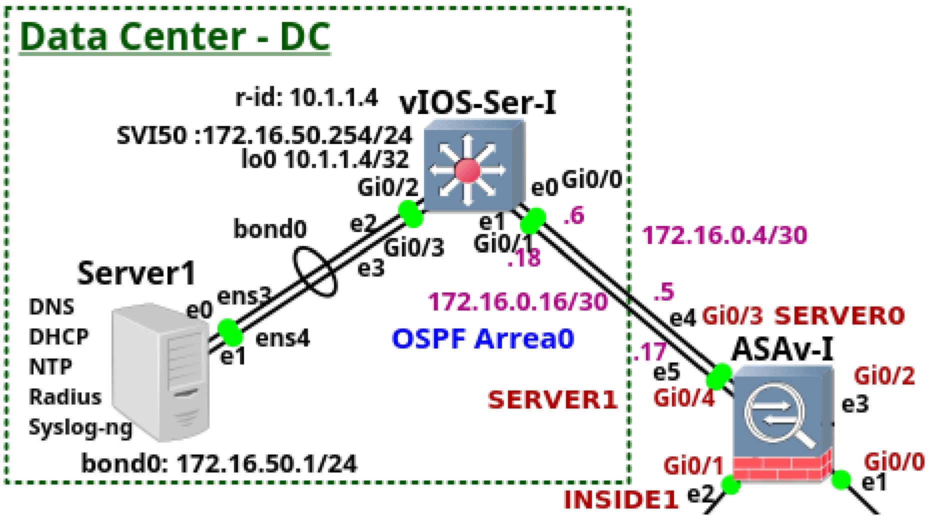
```
vASA-I# show service-policy inspect dns

Global policy:
  Service-policy: global_policy
    Class-map: inspection_default
      Inspect: dns migrated_dns_map_1, packet 1734, lock fail 0, drop 1135, reset-drop 0, 5
-min-pkt-rate 0 pkts/sec, v6-fail-close 0 sctp-drop-override 0
        message-length maximum client auto, drop 0
        message-length maximum 512, drop 0
        dns-guard, count 1296
        protocol-enforcement, drop 0
        nat-rewrite, count 0
```

Picture 7 - **DNS Inspection Statistics**

Enterprise Network on GNS3 - Part 5 - Data Center

The article is the fifth of the series of the articles discussing the enterprise network configuration. The article focus on the Data Center (DC) configuration. DC consists of the two devices - Server1 and the switch vIOS-Ser-I. Of course, the DC network with a single switch and the server is far away from any known DC network design. Typically, modern horizontally scaled large-size Layer 3 DCs consist of thousands of servers connected to the Top of Rack (ToR) l3 switches and they follow leaf and spine design. The DC of this size can be hardly emulated on a single PC. For this reason I only share the configuration of the Cisco L3 switch that is located in our DC. The switch is running Cisco vIOS-L2, version 15.2 and it has assigned 768MB RAM by GNS3.

The switch vIOS-Ser-I connects Ubuntu Linux Server to DC network. The configuration of the services such as bonding, NTP, DHCP, Syslog-ng, DNS and RADIUS running on the server is explained in more details later.

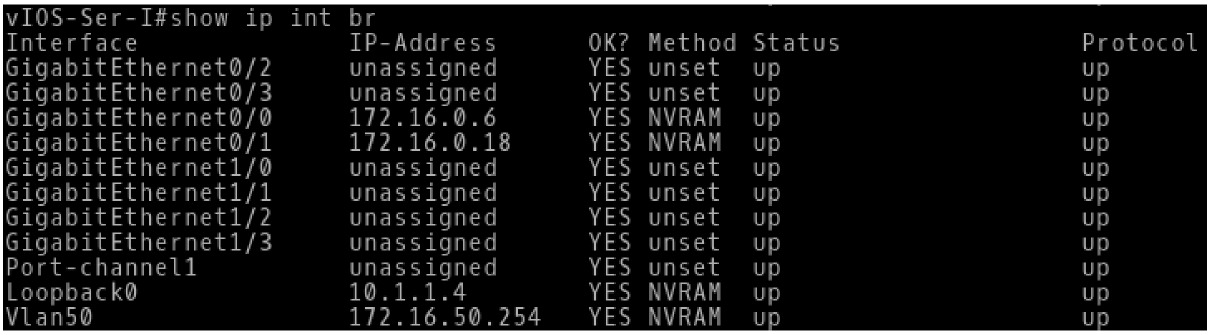


Picture 1 - **Data Center**

Note: The configuration file of the device vIOS-Serv-I is attached here.

1. Switch vIOS-Ser-I Configuration

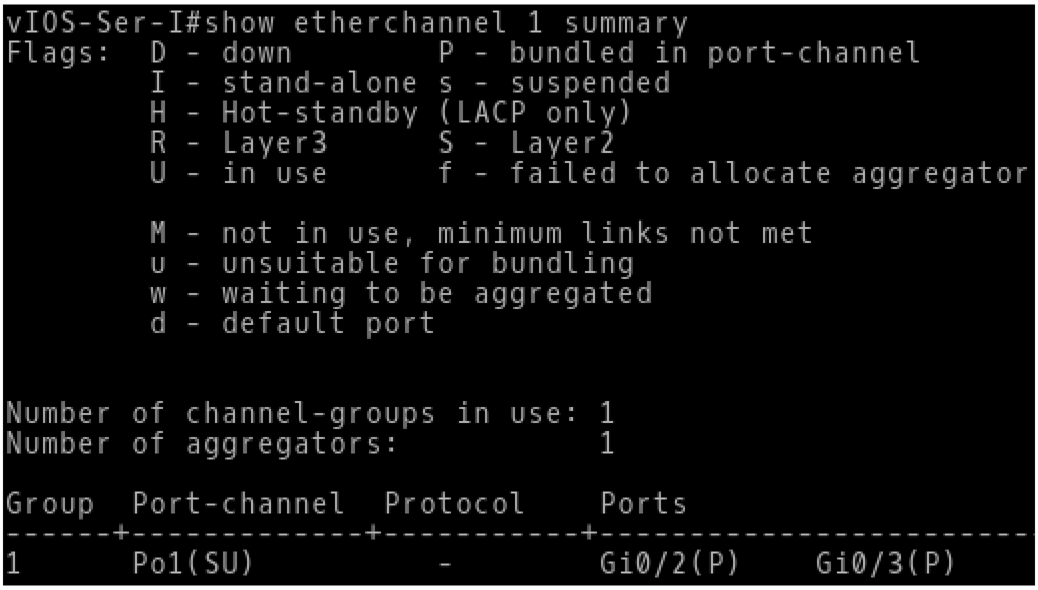
Rather than explaining every line of the configuration, we will discuss how is the vIOS-Serv-I connected into the other devices. The switch is connected with point-to-point layer3 links to the Cisco ASAv-I. The OSPF routing protocol with Message digest (MD5) authentication password is configured on the switch.



```
vIOS-Ser-I#show ip int br
Interface              IP-Address      OK? Method Status                Protocol
GigabitEthernet0/2     unassigned      YES unset  up                    up
GigabitEthernet0/3     unassigned      YES unset  up                    up
GigabitEthernet0/0     172.16.0.6      YES NVRAM  up                    up
GigabitEthernet0/1     172.16.0.18     YES NVRAM  up                    up
GigabitEthernet1/0     unassigned      YES unset  up                    up
GigabitEthernet1/1     unassigned      YES unset  up                    up
GigabitEthernet1/2     unassigned      YES unset  up                    up
GigabitEthernet1/3     unassigned      YES unset  up                    up
Port-channel1          unassigned      YES unset  up                    up
Loopback0              10.1.1.4        YES NVRAM  up                    up
Vlan50                 172.16.50.254   YES NVRAM  up                    up
```

Picture 2 - **List of Interfaces**

The switchports Gi0/2 and Gi0/3 connect the switch to the Server1 and they are configured as the access ports in VLAN50. The links are bonded together as a single etherchannel port (L2 port-channel) using the command *channel-group 1 mode on*. Traffic is loaded based on source XOR destination MAC address across the links.

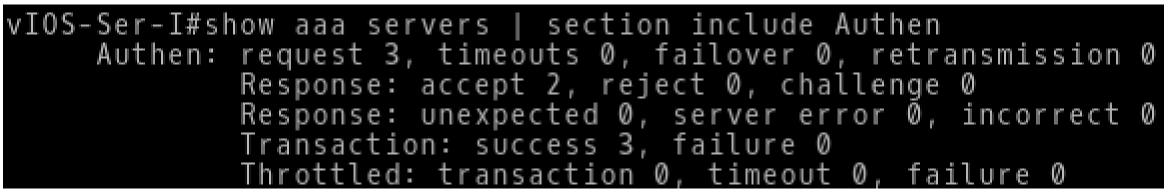


```
vIOS-Ser-I#show etherchannel 1 summary
Flags:  D - down        P - bundled in port-channel
        I - stand-alone s - suspended
        H - Hot-standby (LACP only)
        R - Layer3      S - Layer2
        U - in use      f - failed to allocate aggregator

        M - not in use, minimum links not met
        u - unsuitable for bundling
        w - waiting to be aggregated
        d - default port


Number of channel-groups in use: 1
Number of aggregators:           1

Group  Port-channel  Protocol    Ports
------+-------------+-----------+-----------------------
1      Po1(SU)          -        Gi0/2(P)    Gi0/3(P)
```

Picture 3 - **Etherchannel Summary**

The switch is acting as default gateway with the IP address 172.16.50.254/24 configured on the interface SVI50. This IP address is configured on the Server1 under IPv4 configuration.

The switch is synchronizes its time with the Server1 using NTP. It is also configured to send traps with the severity 5 - notification and lower (1- alerts, 7 - debugging) to syslog-ng daemon running on the Server1. The access to the console and vty lines is authenticated against RADIUS server running on the Server1.



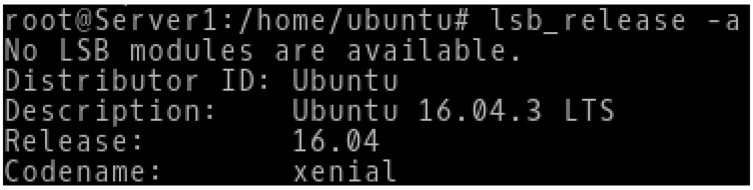
```
vIOS-Ser-I#show aaa servers | section include Authen
     Authen: request 3, timeouts 0, failover 0, retransmission 0
             Response: accept 2, reject 0, challenge 0
             Response: unexpected 0, server error 0, incorrect 0
             Transaction: success 3, failure 0
             Throttled: transaction 0, timeout 0, failure 0
```

Picture 4 - **RADIUS Authentication Checking**

2. Server1 Configuration

2.1 After Installation Steps

The Server1 is running Ubuntu 16.04.3 LTS Xenial. Once Ubuntu is installed, we will fetch the list of available updates and upgrade the current packages with the commands below.



```
root@Server1:/home/ubuntu# lsb_release -a
No LSB modules are available.
Distributor ID: Ubuntu
Description:    Ubuntu 16.04.3 LTS
Release:        16.04
Codename:       xenial
```

Picture 5 - **Ubuntu Linux Version**

```
$ sudo su
# apt-get update && apt-get upgrade
```

I prefer Vim editor to the default installed Nano editor. We can install Vim with the command.

```
# apt-get install vim
```

Change the hostname and add a pair hostname and an IP address 127.0.0.1 into the file /etc/hosts.

```
# vi /etc/hostname
Server1
```

```
# echo "127.0.1.1 Server1" >> /etc/hosts
```

After reboot, the hostname is changed to Server1. Now configure Ubuntu to display a security banner for SSH connections.

```
# vi /etc/issue.net
```

```
Welcome to Server1
All connections are monitored and recorded
Disconnect IMMEDIATELY if you are not an authorized user!
```

Edit a configuration file of OpenSSH sever. Uncomment a line starting with a keyword #Banner.

```
# vi /etc/ssh/sshd_config
Banner /etc/issue.net
```

Restart SSH service.

```
# systemctl restart ssh
```

2.2. Redirecting VGA Output to Serial Port

Server1 appliance is running inside GNS3 topology. GNS3 supports a serial console for connection to a serial port of an appliance. To use a console for Server1, we are going to reconfigure Ubuntu to redirect VGA output to a serial port. Afterwards we can easily connect to his serial port with a right click on the appliance and select *Console* from the list. Below is a minimal configuration of Ubuntu for redirection of VGA to the serial port.

```
$ sudo su
# vi /lib/systemd/system/ttyS0.service
```

```
[Unit]
Description=Serial Console Service

[Service]
ExecStart=/sbin/getty -L 115200 ttyS0 vt102
Restart=always

[Install]
WantedBy=multi-user.target
```

Now reload systemd manager configuration and enable ttyS0 service. Then start ttyS0 service.

```
# systemctl daemon-reload
# systemctl enable ttyS0
# systemctl start ttyS0
```

Reboot the Server1 and connect to its serial port with GNS3.

2.3 Interfaces and Bonding Configuration

First, we need to load a bonding module to Linux kernel.

```
$ sudo su
# modprobe bonding
```

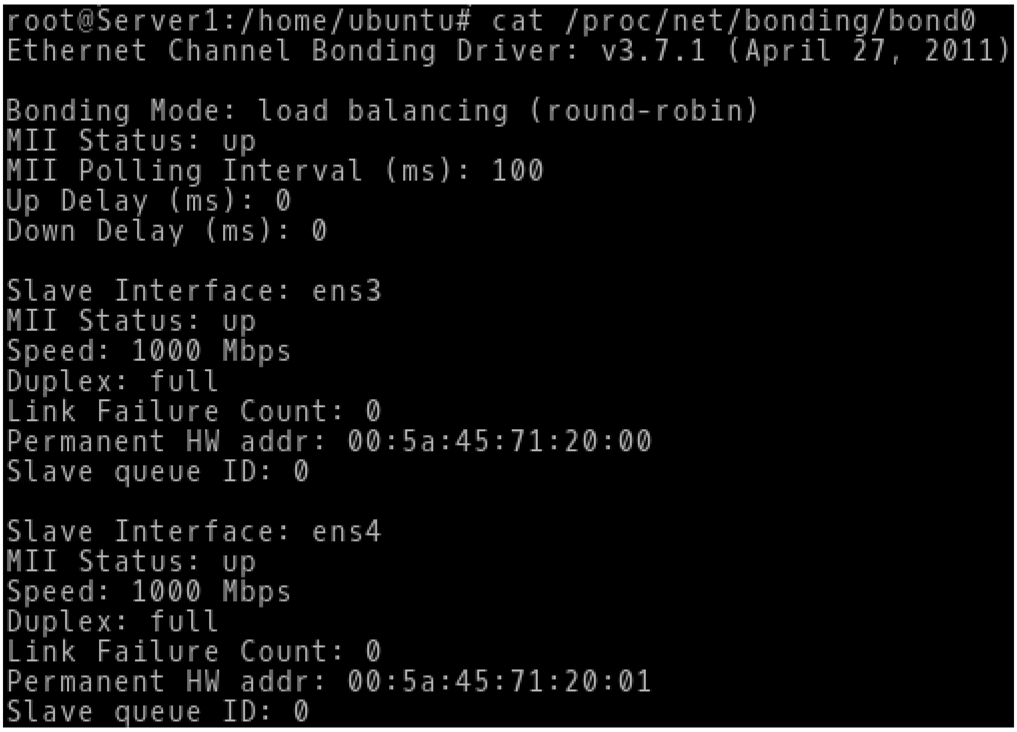
Check if the module is loaded into the kernel.

```
# lsmod | grep bond
bonding 139264 0
```

Configure the kernel to load the bonding module after reboot.

```
# echo "bonding" >> /etc/modules
```

Check available interfaces with the *ifconfig -a* command. They are three Ethernet interfaces presented - bond0, ens3 and ens4. Let's add interfaces ens3 and ens4 to bond0 interface and configure IP address on the bond0. Edit the configuration file /etc/network/interfaces as it is shown here. Afterwards check status of bonding with the command below.



```
root@Server1:/home/ubuntu# cat /proc/net/bonding/bond0
Ethernet Channel Bonding Driver: v3.7.1 (April 27, 2011)

Bonding Mode: load balancing (round-robin)
MII Status: up
MII Polling Interval (ms): 100
Up Delay (ms): 0
Down Delay (ms): 0

Slave Interface: ens3
MII Status: up
Speed: 1000 Mbps
Duplex: full
Link Failure Count: 0
Permanent HW addr: 00:5a:45:71:20:00
Slave queue ID: 0

Slave Interface: ens4
MII Status: up
Speed: 1000 Mbps
Duplex: full
Link Failure Count: 0
Permanent HW addr: 00:5a:45:71:20:01
Slave queue ID: 0
```

Picture 6 - **Checking Bonding Status**

The bonding mode is set to 0 - load balancing and round robin. This is default mode that provides load balancing and fault tolerance.

2.4 Forwarding DNS Server Using Bind

Forwarding Domain Name System (DNS) server forwards DNS requests to an outside resolving server and then caches the results to use for later queries. We install and configure Bind that will forward DNS queries to se Google public DNS servers.

Note: The configuration file /etc/bind/named.conf.options is here.

2.4.1 Install Bind Server Packages

```
$ sudo apt-get update
# sudo apt-get install bind9 bind9-doc
```

2.4.2 Bind Configuration

a) Define Access-List For Clients

Create an access-list which identifies the clients allowed to access DNS server. The access-list should list all the clients' IP subnets. First, modify the Bind configuration file below. All the following configuration changes will be done inside this file. Put the lines below above the line beginning with the options block.

```
# vi /etc/bind/named.conf.options
```

```
acl ourclients {
  10.0.0.0/24;
  10.1.1.0/24;
  192.168.10.0/24;
  192.168.20.0/24;
  192.168.30.0/24;
  192.168.30.0/24;
  172.16.0.0/24;
  172.16.50.0/24;
  localhost;
  localnets;
};
```

b) Allow Recursion and Query

Allow *recursion* and configure a parameter *allow-query* referring to the access-list for our clients. But the lines bellow inside the option block.

```
recursion                                                              yes;
allow-query                                                               {
ourclients;
};
```

c) Configure Forwarders

We need to provide Google public recursive name servers IP addresses 8.8.8.8 and 8.8.4.4. Change the forwarders block as following.

```
forwarders {
8.8.8.8;
8.8.4.4;
};
```

To configure recursive name servers, add the following line below into the forwarders block. DNS server will forward request to Google DNS public servers instead of trying to resolve queries by itself.

```
forward only;
```

d) Enable DNSsec

Enable DNSsec. Change the line *dnssec-validation no* to *dnssec-validation yes* and add the line *dnssec-enable yes*.

```
dnssec-enable yes;
dnssec-validation yes;
```

Check the configuration file for errors with the command below. If there is not an error, the output is blank.

```
# named-checkconf
```

Alternatively, inspect */var/log/syslog* for errors.

e) Logging Queries

Create a directory */var/log/named* that stores Bind log messages and change owner and group to bind.

```
# mkdir /var/log/named/
# chown bind:bind /var/log/named/
```

Add the following commands at the end of /etc/bind/named.conf.options

```
logging {
  channel query_log {
    file "/var/log/named/bind.log" versions 3 size 5m;
    severity info;
    print-time yes;
    print-severity yes;
    print-category yes;
  };
  category queries {
    query_log;
  };
};
```

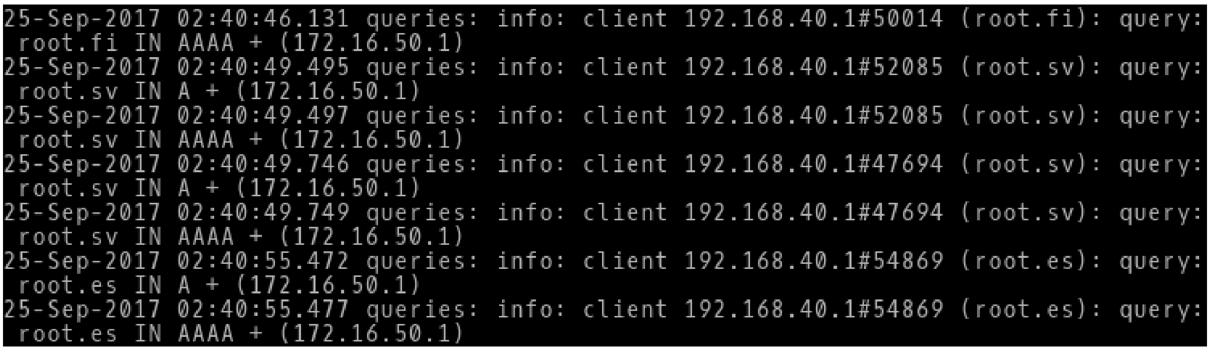
Then add the line *querylog yes* to the option block.

```
querylog yes;
```

Check configuration again with the command below and restart Bind.

```
# named-checkconf
# systemctl restart bind9
```

The log file /var/log/named/bind.log should now contain DNS queries.



```
25-Sep-2017 02:40:46.131 queries: info: client 192.168.40.1#50014 (root.fi): query:
 root.fi IN AAAA + (172.16.50.1)
25-Sep-2017 02:40:49.495 queries: info: client 192.168.40.1#52085 (root.sv): query:
 root.sv IN A + (172.16.50.1)
25-Sep-2017 02:40:49.497 queries: info: client 192.168.40.1#52085 (root.sv): query:
 root.sv IN AAAA + (172.16.50.1)
25-Sep-2017 02:40:49.746 queries: info: client 192.168.40.1#47694 (root.sv): query:
 root.sv IN A + (172.16.50.1)
25-Sep-2017 02:40:49.749 queries: info: client 192.168.40.1#47694 (root.sv): query:
 root.sv IN AAAA + (172.16.50.1)
25-Sep-2017 02:40:55.472 queries: info: client 192.168.40.1#54869 (root.es): query:
 root.es IN A + (172.16.50.1)
25-Sep-2017 02:40:55.477 queries: info: client 192.168.40.1#54869 (root.es): query:
 root.es IN AAAA + (172.16.50.1)
```

Picture 7 - **Logging DNS Queries**

2.5 Network Time Protocol Server Installation and Configuration

NTP server provides precise time for the hosts and network devices. It is running on Server1. Here is the configuration file /etc/ntp.conf.

2.5.1 Install NTP Daemon and Utilities Package

```
$ sudo apt-get install ntp
```

2.5.2 NTP Client Configuration

```
$ sudo su
# vi /etc/ntp.conf
```

a) Specify NTP Public Servers

Comment out the the following lines and specify NTP servers near to you. These are the default pre-configured public NTP servers.

```
#pool 0.ubuntu.pool.ntp.org iburst
#pool 1.ubuntu.pool.ntp.org iburst
#pool 2.ubuntu.pool.ntp.org iburst
#pool 3.ubuntu.pool.ntp.org iburst

#pool ntp.ubuntu.com

# Add the following lines.

server 0.sk.pool.ntp.org
server 1.europe.pool.ntp.org
server 3.europe.pool.ntp.org
```

b) Restrict Access of Public NTP Servers to our NTP Server

```
restrict -4 default kod nomodify notrap nopeer noquery
restrict -6 default kod nomodify notrap nopeer noquery
```

Time will be synchronized with public NTP server but the servers are not allowed to modify the run-time configuration or query our Linux NTP server.

c) Allow Our Hots to Query Time With Our NTP server

Add the following lines.

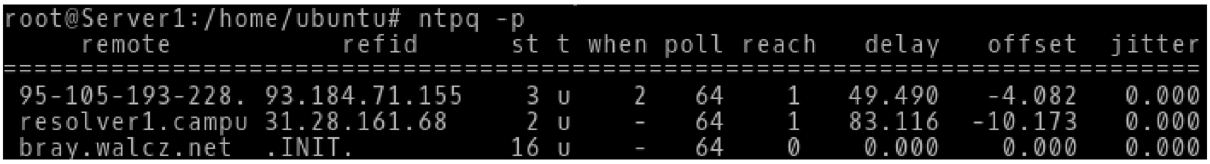
```
restrict 10.1.1.0 mask 255.255.255.0 nomodify notrap
restrict 172.16.0.0 mask 255.255.255.0 nomodify notrap
restrict 10.0.0.0 mask 255.0.0.0 nomodify notrap
restrict 192.168.0.0 mask 255.255.0.0 nomodify notrap
```

Restart NTP service and check status of time synchronization.

```
# systemctl restart ntp
```

Use the *ntpq* utility to monitor NTP daemon ntpd operations.

```
root@Server1:/home/ubuntu# ntpq -p
```



```
root@Server1:/home/ubuntu# ntpq -p
     remote           refid      st t when poll reach   delay   offset  jitter
==============================================================================
 95-105-193-228. 93.184.71.155    3 u    2   64    1   49.490   -4.082   0.000
 resolver1.campu 31.28.161.68     2 u    -   64    1   83.116  -10.173   0.000
 bray.walcz.net  .INIT.          16 u    -   64    0    0.000    0.000   0.000
```

Picture 8 - **Monitoring NTP Daemon Operations With NTP Query Utility**

The actual time can be checked with the date command.

```
root@Server1:/home/ubuntu# date
Thu Apr 6 11:04:42 CEST 2017
```

2.6 DHCP Server Installation and Configuration

We need to run DHCP server on Server1 as we want hosts in the end-user networks (192.168.10-30.x/24) and the network 172.16.50.0/24 to obtain their IP addresses automatically. In order to get this configuration working the command i*p helper-address 172.16.50.1* must be configured under SVI 10, 20 and 30 configuration. We have already done it in Part3.

Install ISC DHCP server for automatic IP address assignment for clients on the subnets 192.168.x.0/24 and 172.16.50.0/24.

```
$ sudo apt-get install isc-dhcp-server
```

Add the lines below into DHCP configuration file */etc/dhcp/dhcpd.conf*. The configuration file is here.

```
# vi /etc/dhcp/dhcpd.conf

option domain-name "mycompany.sk";

default-lease-time 600;
max-lease-time 7200;

subnet 172.16.50.0 netmask 255.255.255.0 {
  range 172.16.50.1 172.16.50.1;
  option routers 172.16.50.254;
  option subnet-mask 255.255.255.0;
  option broadcast-address 172.16.50.255;
  option domain-name-servers 172.16.50.1;
  option ntp-servers 172.16.50.1;
}
subnet 192.168.10.0 netmask 255.255.255.0 {
  range 192.168.10.1 192.168.10.240;
  option routers 192.168.10.254;
  option subnet-mask 255.255.255.0;
  option broadcast-address 192.168.10.255;
  option domain-name-servers 172.16.50.1;
  option ntp-servers 172.16.50.1;
}

subnet 192.168.20.0 netmask 255.255.255.0 {
  range 192.168.20.1 192.168.20.240;
  option routers 192.168.20.254;
  option subnet-mask 255.255.255.0;
  option broadcast-address 192.168.20.255;
  option domain-name-servers 172.16.50.1;
  option ntp-servers 172.16.50.1;
}

subnet 192.168.30.0 netmask 255.255.255.0 {
  range 192.168.30.1 192.168.30.240;
  option routers 192.168.30.254;
  option subnet-mask 255.255.255.0;
  option broadcast-address 192.168.30.255;
  option domain-name-servers 172.16.50.1;
  option ntp-servers 172.16.50.1;
}
```

Now we need to specify the interface, DHCP should listen to. Add the interface bond0 to the file */etc/default/isc-dhcp-server*. Also check if the path to DHCP configuration file */etc/dhcp/dhcpd.conf* is correct.

```
# vi /etc/default/isc-dhcp-server

DHCPD_CONF=/etc/dhcp/dhcpd.conf

INTERFACES="bond0"
```

Now we can enable and start DHCP service. Leased IP addresses are stored in the file /var/lib/dhcp/dhcpd.leases.

```
# sudo systemctl enable isc-dhcp-server
# sudo systemctl start isc-dhcp-server
```

2.7 FreeRADIUS Installation and Configuration

If we want to have the login access to the network devices authenticated in centralized manner, FreeRadius is a need. It is cost-free and highly effective solution.

2.7.1 Install and Configure Freeradius

```
$ sudo apt-get install freeradius
```

Add the list of the clients into FreeRADIUS configuration with the same shared key test123. Below is the example for ASAv-I and vIOS-Core-I devices.

```
# vi /etc/freeradius/clients.conf
```

```
client 172.16.0.5/32 {
  secret = test123
  shortname = ASAv-I
  nastype = cisco
}

client 172.16.0.17/32 {
  secret = test123
  shortname = ASAv-I
  nastype = cisco
}

client 10.1.1.1/32 {
  secret = test123
  shortname = vIOS-Core-I
  nastype = cisco
}
```

Add following lines to the users configuration file as it is shown below. The configuration file is here.

```
# vi /etc/freeradius/users
```

```
# User privilege level 1
raadmin Cleartext-Password := "racisco"
Service-Type = NAS-Prompt-User,

# User privilege level 15
raadmin15 Cleartext-Password := "racisco15"
Service-Type = NAS-Prompt-User,
cisco-avpair = "shell:priv-lvl=15"

# Enable password
$enab15$ Cleartext-Password := "racisco"
Service-Type = NAS-Prompt-User,
```

To log authentication requests, change the lines below from *no* to *yes* in the file */etc/freeradius/radiusd.conf*. By default, logs are stored in the file */var/log/freeradius/radius.log*.

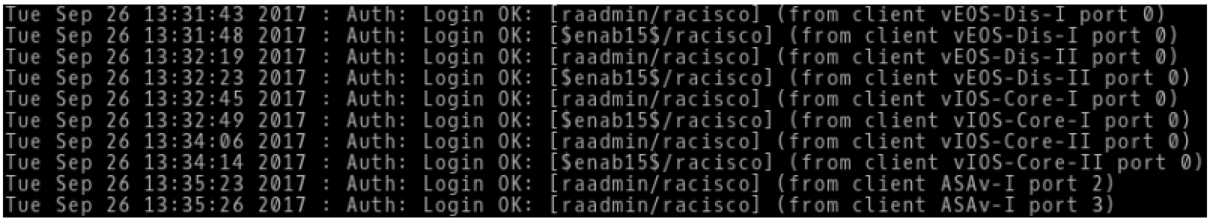
```
# vi /etc/freeradius/radiusd.conf
```

```
auth = yes
```

```
auth_badpass = yes
auth_goodpass = yes
```

Restart FreeRadius service.

```
# systemctl restart freeradius
```



```
Tue Sep 26 13:31:43 2017 : Auth: Login OK: [raadmin/racisco] (from client vEOS-Dis-I port 0)
Tue Sep 26 13:31:48 2017 : Auth: Login OK: [$enab15$/racisco] (from client vEOS-Dis-I port 0)
Tue Sep 26 13:32:19 2017 : Auth: Login OK: [raadmin/racisco] (from client vEOS-Dis-II port 0)
Tue Sep 26 13:32:23 2017 : Auth: Login OK: [$enab15$/racisco] (from client vEOS-Dis-II port 0)
Tue Sep 26 13:32:45 2017 : Auth: Login OK: [raadmin/racisco] (from client vIOS-Core-I port 0)
Tue Sep 26 13:32:49 2017 : Auth: Login OK: [$enab15$/racisco] (from client vIOS-Core-I port 0)
Tue Sep 26 13:34:06 2017 : Auth: Login OK: [raadmin/racisco] (from client vIOS-Core-II port 0)
Tue Sep 26 13:34:14 2017 : Auth: Login OK: [$enab15$/racisco] (from client vIOS-Core-II port 0)
Tue Sep 26 13:35:23 2017 : Auth: Login OK: [raadmin/racisco] (from client ASAv-I port 2)
Tue Sep 26 13:35:26 2017 : Auth: Login OK: [raadmin/racisco] (from client ASAv-I port 3)
```

Picture 9 - **Logged Authentication Requests**

Note: If you want to check debug messages, stop freeradius service and start it with parameter -X (full debugging).

```
# freeradius -X
```

2.8. Syslog-ng Installation and Configuration

We want each device to send logs to one central location. For this purpose, we will install syslog-ng on Server1. The logs are stored inside the directory tree /var/log/syslog-ng/IP/year/month/day where IP is the IP address of a particular device.

```
$ sudo apt-get install syslog-ng
$ sudo su
```

Configure Syslog-ng. Here is the configuration file */etc/syslog-ng/conf.d/firewalls.conf*.

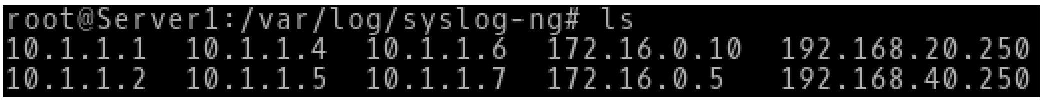
```
# cd /etc/syslog-ng/conf.d
```

```
# vi firewalls.conf
```

```
options {
  create_dirs(yes);
  owner(ubuntu);
  group(ubuntu);
  perm(0640);
  dir_owner(ubuntu);
  dir_group(ubuntu);
  dir_perm(0750);
};

source s_net {
  tcp(ip(0.0.0.0) port(514));
  udp(ip(0.0.0.0) port(514));
};
```

```
destination d_host-specific {
   file("/var/log/firewalls/$HOST/$YEAR/$MONTH/$HOST-$YEAR-$MONTH-
$DAY.log");
};

log {
  source(s_net);
  destination(d_host-specific);
};
```

```
# service syslog-ng restart
```

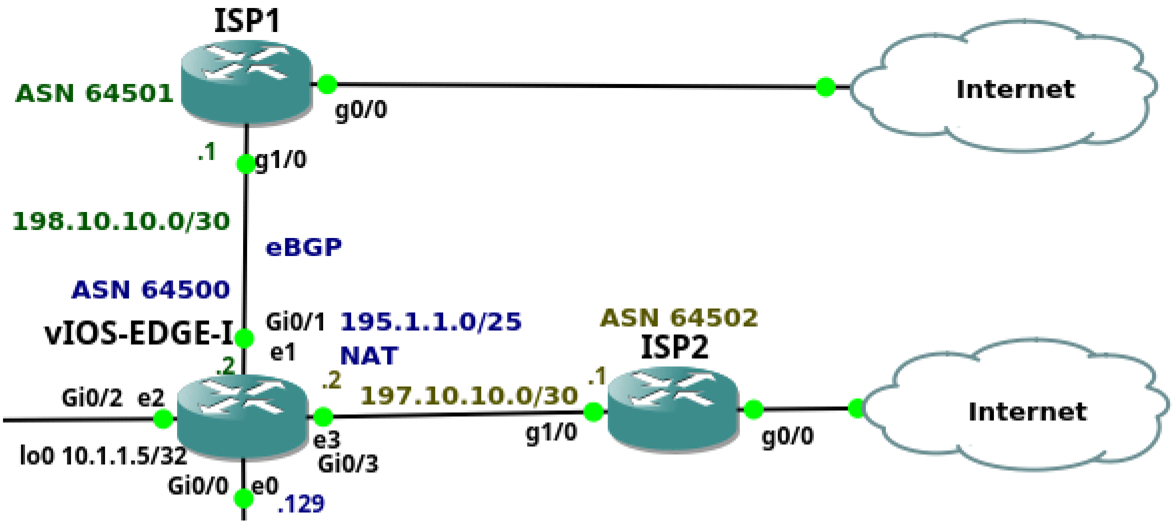


```
root@Server1:/var/log/syslog-ng# ls
10.1.1.1  10.1.1.4  10.1.1.6  172.16.0.10  192.168.20.250
10.1.1.2  10.1.1.5  10.1.1.7  172.16.0.5   192.168.40.250
```

Picture 10 - **Received Logs from Devices Stored In Directories**

Enterprise Network on GNS3 - Part 6 - Edge Router and ISPs

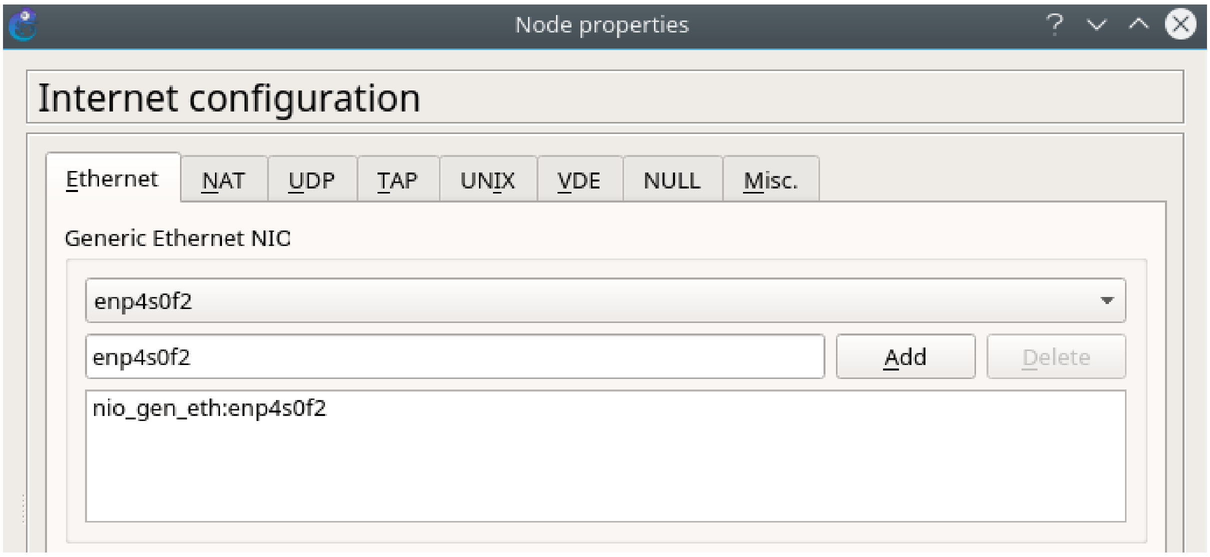
This is the sixth article from the series of the articles discussing the configuration of an entire enterprise network. The article explains the configuration of the edge router vIOS-EDGE-I and configuration of ISP routers. Now let's say few words about the router vIOS-EDGE-I. The router is Cisco IOSv Qemu appliance, version 15.6(2)T. It has assigned 512MB RAM by GNS3. The router connects all three parts of the company network to the Internet. These parts are the the campus network, data center and DMZ.



Picture 1 - **Company Connection to the Internet via vIOS-EDGE-I**

The company has assigned the prefix 195.1.1.0/24. Devices located in DMZ have assigned the prefix 195.1.1.128/25. The prefix 195.1.1.0/25 is assigned for devices hidden behind NAT. NAT is configured on vIOS-EDGE-I router, translating campus and data center subnets to the subnet 195.1.1.128/25. The router is connected to the upstream providers via their Ethernet ports Gi0/1 and Gi0/3. This is a single multi homed topology when a company is connected to two upstream providers with a single edge router. The entire prefix 195.1.1.0/24 is advertised to the both ISPs via BGP routing protocol. When one of the ISP goes down, the incoming traffic to the prefix 195.1.1.0/24 is not no affected. The outgoing traffic from the edge router to the Internet is primary sent to ISP1. If the ISP1 goes down, traffic is sent via ISP2.

Routers ISP1 and ISP2 are Cisco 7206 routers, emulated by Dynamips. They are running IOS version 15.2(4)S4 and they have assigned 512MB RAM by GNS3. Both routers are bridged to the interface enp4s0f2 by GNS3 cloud via their interfaces Gi0/0. The interface enps4s0f2 is NIC presented in my laptop. The NIC is connected to the SOHO router that connects home network to the Internet. The routers ISP1 and IPS2 receive the IP addresses on the ports GigabitEthernet0/0 ports from DHCP server running on SOHO router. DHCP server configured on SOHO router assigns IP address in a range 172.17.100.2/16 - 172.17.100.100/16 along with the IP address of the default gw 172.17.100.1.



Generic Ethernet NIC

enp4s0f2

enp4s0f2

nio_gen_eth:enp4s0f2

Picture 2 - **ISP1 Connection to SOHO Network Using GNS3 Cloud**

Note: The configuration files are: vIOS-EDGE-I, ISP1 and ISP2.

1. Router vIOS-EDGE-I Configuration

Firstly, we change the hostname of the edge router.

```
Router> en
Router# conf t
Router(config)# hostname vIOS-EDGE-I
```

1.1 Create Local User and Set password to Privileged Exec Mode

Create a local user. We do not want to authenticate users accessing Edge Router using RADIUS.

```
vIOS-EDGE-I(config)# username admin secret cisco
```

We will also set password for privileged exec mode.

```
vIOS-EDGE-I(config)# enable secret cisco
```

1.2 IP Addresses Configuration

```
vIOS-EDGE-I(config)# interface GigabitEthernet 0/0
vIOS-EDGE-I(config-if)# description Link to ASA-DMZ-I
vIOS-EDGE-I(config-if)# ip address 195.1.1.129 255.255.255.252
vIOS-EDGE-I(config-if)# no shutdown
```

```
vIOS-EDGE-I(config)# interface GigabitEthernet 0/2
vIOS-EDGE-I(config-if)# description Link to ASAv-I
vIOS-EDGE-I(config-if)# ip address 172.16.0.2 255.255.255.252
```

```
vIOS-EDGE-I(config-if)# no shutdown
vIOS-EDGE-I(config-if)# exit

vIOS-EDGE-I(config)# interface GigabitEthernet 0/1
vIOS-EDGE-I(config-if)# description Link to ISP1
vIOS-EDGE-I(config-if)# ip address 198.10.10.2 255.255.255.252
vIOS-EDGE-I(config-if)# no shutdown
vIOS-EDGE-I(config-if)# exit

vIOS-EDGE-I(config)# interface GigabitEthernet 0/3
vIOS-EDGE-I(config-if)# description Link to ISP2
vIOS-EDGE-I(config-if)# ip address 197.10.10.2 255.255.255.252
vIOS-EDGE-I(config-if)# no shutdown
vIOS-EDGE-I(config-if)# exit

vIOS-EDGE-I(config)# interface loopback 0
vIOS-EDGE-I(config-if)# description Management
vIOS-EDGE-I(config-if)# ip address 10.1.1.5 255.255.255.255
vIOS-EDGE-I(config-if)# no shutdown
vIOS-EDGE-I(config-if)# exit
```

1.3 Network Address Translation - NAT Configuration

Configure Port Address Translation (PAT) to translate all campus subnets network and a data center subnet into public IP address pool 195.1.1.0/25.

Standard access-list 1 selects subnets that are going to be translated.

```
vIOS-EDGE-I(config)# access-list 1 permit 192.168.10.0 0.0.0.255
vIOS-EDGE-I(config)# access-list 1 permit 192.168.20.0 0.0.0.255
vIOS-EDGE-I(config)# access-list 1 permit 192.168.30.0 0.0.0.255
vIOS-EDGE-I(config)# access-list 1 permit 192.168.40.0 0.0.0.255
vIOS-EDGE-I(config)# access-list 1 permit 10.0.0.0 0.0.0.255
vIOS-EDGE-I(config)# access-list 1 permit 10.1.1.0 0.0.0.255
vIOS-EDGE-I(config)# access-list 1 permit 172.16.0.0 0.0.0.255
vIOS-EDGE-I(config)# access-list 1 permit 172.16.50.0 0.0.0.255
vIOS-EDGE-I(config)# access-list 1 deny any
```

Define NAT pool of inside global addresses.

```
vIOS-EDGE-I(config)# ip nat pool 1 195.1.1.1 195.1.1.127 netmask 255.255.255.128
```

Configure NAT Overload (Port Address Translation).

```
vIOS-EDGE-I(config)# ip nat inside source list 1 pool 1 overload
```

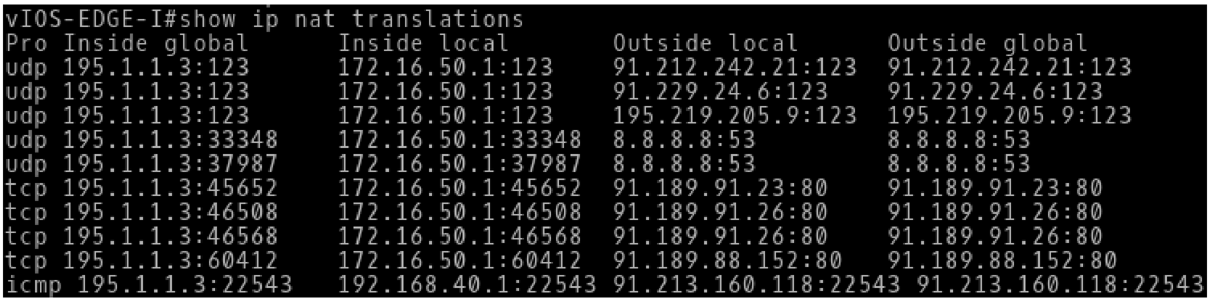
Define inside and outside interfaces.

```
vIOS-EDGE-I(config)# interface GigabitEthernet 0/0
vIOS-EDGE-I(config-if)# ip nat outside
```

```
vIOS-EDGE-I(config)# interface GigabitEthernet 0/1
vIOS-EDGE-I(config-if)# ip nat outside
```

```
vIOS-EDGE-I(config)# interface GigabitEthernet 0/2
vIOS-EDGE-I(config-if)# ip nat inside
```

```
vIOS-EDGE-I(config)# interface gigabitEthernet 0/2
vIOS-EDGE-I(config-if)# ip nat outside
```



```
vIOS-EDGE-I#show ip nat translations
Pro Inside global       Inside local       Outside local        Outside global
udp 195.1.1.3:123       172.16.50.1:123    91.212.242.21:123    91.212.242.21:123
udp 195.1.1.3:123       172.16.50.1:123    91.229.24.6:123      91.229.24.6:123
udp 195.1.1.3:123       172.16.50.1:123    195.219.205.9:123    195.219.205.9:123
udp 195.1.1.3:33348     172.16.50.1:33348  8.8.8.8:53           8.8.8.8:53
udp 195.1.1.3:37987     172.16.50.1:37987  8.8.8.8:53           8.8.8.8:53
tcp 195.1.1.3:45652     172.16.50.1:45652  91.189.91.23:80      91.189.91.23:80
tcp 195.1.1.3:46508     172.16.50.1:46508  91.189.91.26:80      91.189.91.26:80
tcp 195.1.1.3:46568     172.16.50.1:46568  91.189.91.26:80      91.189.91.26:80
tcp 195.1.1.3:60412     172.16.50.1:60412  91.189.88.152:80     91.189.88.152:80
icmp 195.1.1.3:22543    192.168.40.1:22543 91.213.160.118:22543 91.213.160.118:22543
```

Picture 3 - **NAT Translation**

1.4 Static Routes Configuration

We need to configure static routes pointing back to campus and data center networks hidden behind NAT.

```
vIOS-EDGE-I(config)# ip route 172.16.0.0 255.255.0.0 172.16.0.1
vIOS-EDGE-I(config)# ip route 192.168.0.0 255.255.192.0 172.16.0.1
vIOS-EDGE-I(config)# ip route 10.0.0.0 255.0.0.0 172.16.0.1
```

We also need a static route pointing toward DMZ.

```
vIOS-EDGE-I(config)# ip route 195.1.1.128 255.255.255.128 195.1.1.130
```

1.5 eBGP Configuration

We need a static route to 195.1.1.0/24 pointing to a null interface that we will be advertised to ISP1 and ISP2 via BGP.

```
vIOS-EDGE-I(config)# ip route 195.1.1.0 255.255.255.0 null0
```

Our company has assigned AS number 64500. We need to define both neighbors ISP1 - 198.10.10.1 (ASN 64501) and ISP2 - 197.10.10.1 (ASN 64502). We will also configure BGP peers authentication to validate BGP neighbors. Password is set to *sop1md5pass* for ISP1 and *isp2md5pass* for ISP2 BGP neighbors. To prevent hijacking BGP neighbor session we use ttl-security mechanism that also protects eBGP peering session from CPU utilization-based attacks using forged IP packets. The parameter ttl-security defines the number of the hops between the vIOS-EDGE-I router and its BGP neighbors. In our case, the hop count is 1 as the neighbors are directly connected to the edge router. The expected incoming TTL value is then 254 (255 minus 1). The edge router accepts the peering session only if the TTL value is 254 or greater. For instance, if the neighbor is two hops away, we must set ttl-security value to 2 and accepted TTL is 253 or greater. The edge router then accept BGP peering session if the BGP neighbor router is 1 or maximum 2 hop away.

Note: The number of hops between vIOS-EDGE-I and its BGP neighbors can be easily found out with the trace command.

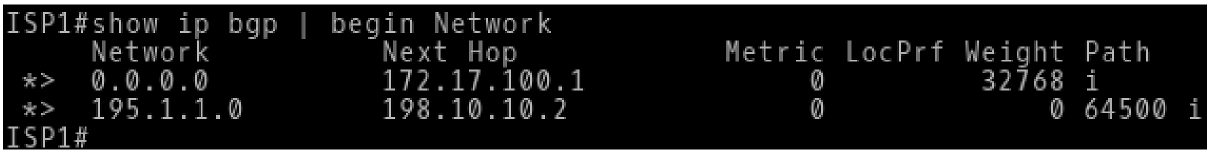
```
vIOS-EDGE-I(config)# router bgp 64500
vIOS-EDGE-I(config-router)# neighbor 198.10.10.1 remote-as 64501
vIOS-EDGE-I(config-router)# neighbor 198.10.10.1 password isp1md5pass
vIOS-EDGE-I(config-router)# neighbor 197.10.10.1 remote-as 64502
vIOS-EDGE-I(config-router)# neighbor 197.10.10.1 password isp2md5pass
vIOS-EDGE-I(config-router)# network 195.1.1.0 mask 255.255.255.0
vIOS-EDGE-I(config-router)# neighbor isp-group peer-group
vIOS-EDGE-I(config-router)# neighbor isp-group ttl-security hops 1
vIOS-EDGE-I(config-router)# neighbor isp-group filter-list 10 out
vIOS-EDGE-I(config-router)# neighbor 198.10.10.1 peer-group isp-group
vIOS-EDGE-I(config-router)# neighbor 198.10.10.1 route-map setlocalin in
vIOS-EDGE-I(config-router)# neighbor 197.10.10.1 peer-group isp-group
```

The prefix 195.1.1.0/24 is aannouncedto the ISP1 and ISP2 peers with the network command. To prevent becoming a transit AS, advertisements received from ISP1 router are not advertised to ISP2 and vice versa. Only local prefix 195.1.1.0/24 originating on the edge router vIOS_EDGE-I is advertised to the peers. The BGP AS path filter 10 contains a regular expression ^$ that matches only empty ASN in AS_PATH attribute. The AS path filter 10 is then applied for outgoing routes for isp-group that includes both ISPs - BGP neighbors 198.10.10.1 and 197.10.10.1.

Note: The ASN 64500 is added to the AS_PATH attribute after the filter is applied.

```
vIOS-EDGE-I(config)# ip as-path access-list 10 permit ^$
```

To ensure that vIOS-EDGE-I is not a transit AS, we inspect BGP routing table of ISP1 router. There should not be any prefixes received via BGP update messages, except the prefix 195.1.1.0/24 from ASN 64500.



```
ISP1#show ip bgp | begin Network
     Network          Next Hop            Metric LocPrf Weight Path
 *>  0.0.0.0          172.17.100.1             0         32768 i
 *>  195.1.1.0        198.10.10.2              0             0 64500 i
ISP1#
```

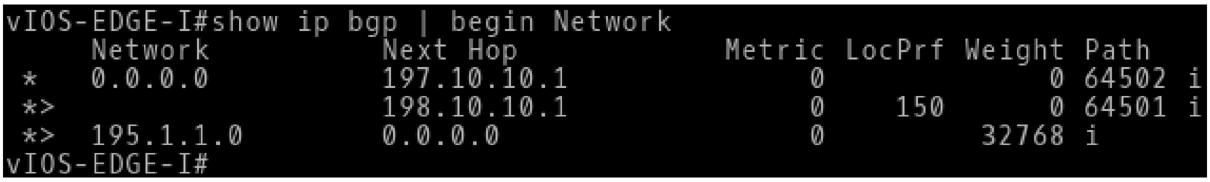
Picture 4 - **Inspecting BGP Table of ISP1**

As we have already mentioned, the router ISP1 is preferred gateway to the Internet. For this reason, we will configure local preference 150 for prefixes received from the neighbor 198.10.10.1 (ISP1). As the prefixes received from the neighbor 197.10.10.1 (ISP2) have a default local preference set to 100, prefixes received from ISP1 will be preffered and traffic is forwarded via ISP1.

```
vIOS-EDGE-I(config)# route-map setlocalin permit 10
vIOS-EDGE-I(config-route-map)# set local-preference 150
```

Note: The route-map *setlocalin* is applied for the neighbor 198.10.10.1 to incoming routes.

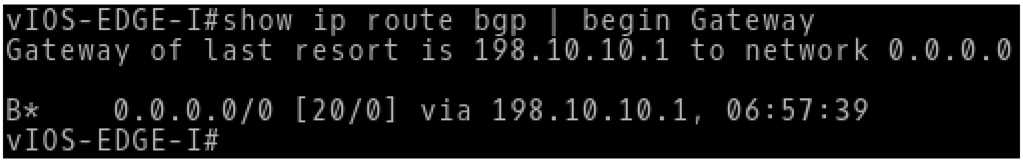
The BGP table of the vIOS-EDGE-I is shown on the picture 5. The prefix 0.0.0.0 is received from the neighbor 197.10.10.1 (AS 64502) and from the neighbor 198.10.10.1 (AS 64501). However the path via 198.10.10.1 is preferred because the local preference is set to 150 for all prefixes received from this neighbor. For this reason, the route 0.0.0.0 with the next hop 198.10.10.1 is installed into the routing table of vIOS-EDGE-I router.



```
vIOS-EDGE-I#show ip bgp | begin Network
     Network          Next Hop            Metric LocPrf Weight Path
 *   0.0.0.0          197.10.10.1              0             0 64502 i
 *>                   198.10.10.1              0    150      0 64501 i
 *>  195.1.1.0        0.0.0.0                  0         32768 i
vIOS-EDGE-I#
```

Picture 5 - **Inspecting BGP Table of vIOS-EDGE-I**

The routes received via BGP that are installed in a routing table of the router vIOS-EDGE-I are shown on the picture 6.

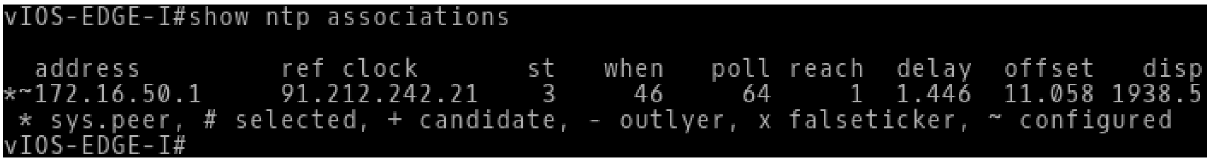


```
vIOS-EDGE-I#show ip route bgp | begin Gateway
Gateway of last resort is 198.10.10.1 to network 0.0.0.0

B*    0.0.0.0/0 [20/0] via 198.10.10.1, 06:57:39
vIOS-EDGE-I#
```

Picture 6 - **Inspecting BGP Routes Installed Into Routing Table of vIOS-EDGE-I**

1.6 NTP Configuration

vIOS-EDGE-I(config)# ntp server 172.16.50.1
vIOS-EDGE-I(config)# clock timezone UTC+2 +2
vIOS-EDGE-I(config)# ntp source loopback 0



```
vIOS-EDGE-I#show ntp associations

  address         ref clock       st   when   poll reach  delay  offset   disp
*~172.16.50.1     91.212.242.21    3     46     64     1  1.446  11.058 1938.5
 * sys.peer, # selected, + candidate, - outlyer, x falseticker, ~ configured
vIOS-EDGE-I#
```

Picture 7 - **Checking NTP Synchronization**

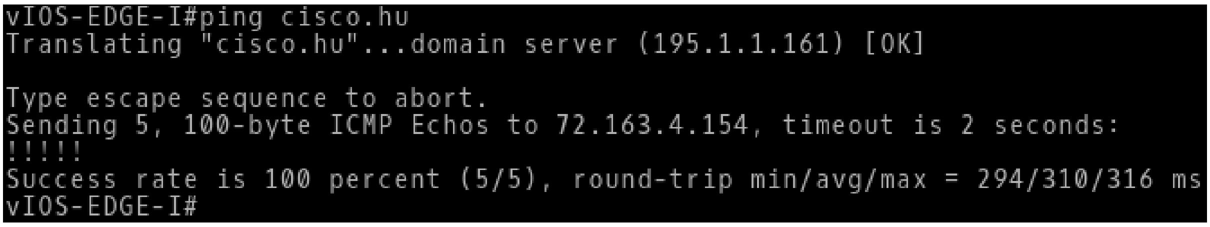
1.7 Logging Configuration

vIOS-EDGE-I(config)# logging trap notifications
vIOS-EDGE-I(config)# logging host 172.16.50.1
vIOS-EDGE-I(config)# logging source-interface loopback 0

1.8 DNS Client Configuration

vIOS-EDGE-I(config)# ip name-server 195.1.1.161
vIOS-EDGE-I(config)# ip domain-lookup

To check if the company DNS server 195.1.1.161 located DMZ is working, we will ping a domain cisco.hu. The domain name is translated to the IP address 72.163.4.154.



```
vIOS-EDGE-I#ping cisco.hu
Translating "cisco.hu"...domain server (195.1.1.161) [OK]

Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 72.163.4.154, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 294/310/316 ms
vIOS-EDGE-I#
```

Picture 8 - **Checking Company DNS Server Located in DMZ**

1.9 SSH Access and VTY Access-list Configuration

In order to manage vIOS-EDGE-I router remotely we will configure the router to support SSH access.

```
vIOS-EDGE-I(config)# ip domain name companyXYZ.sk
vIOS-EDGE-I(config)# ip ssh version 2

vIOS-EDGE-I(config)# crypto key generate rsa modulus 4096

vIOS-EDGE-I(config)# line vty 0 924
vIOS-EDGE-I(config-line)# login local
vIOS-EDGE-I(config-line)# transport input ssh
```

We certainly do not wish to expose VTY access to the vIOS-EDGE-I for the entire world. For this reason, we create a named standard access-list *ssh-access* that permits login to VTY from the management subnet 192.168.40.0/24 only.

```
vIOS-EDGE-I(config)# ip access-list standard ssh-access
vIOS-EDGE-I(config-std-nacl)# permit 192.168.40.0 0.0.0.255
vIOS-EDGE-I(config-std-nacl)# deny any
```

Afterwards we can configure the access-list *ssh-access* under vty configuration in incoming direction.

```
vIOS-EDGE-I(config)# line vty 0 924
vIOS-EDGE-I(config-line)# access-class ssh-access in
```

2. ISP1 Router Configuration

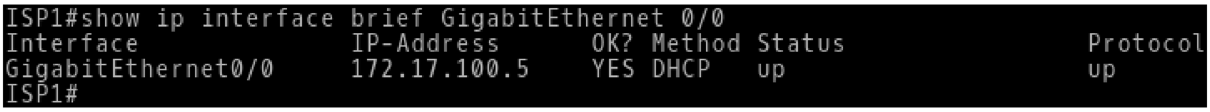
To simulate service provider's router, we are going to deploy a basic configuration on the ISP1 router that connects the company network to the Internet.

2.1 IP Address Configuration

The interface GigabitEthernet0/0 connects the router ISP1 to the GNS3 cloud. The IP address on this interface is obtained from DHCP server that is running on SOHO router.

```
ISP1(config)# interface GigabitEthernet 0/0
ISP1(config-if)# description Link to Simulated Internet
ISP1(config-if)# ip address dhcp
ISP1(config-if)# ip nat outside
ISP1(config-if)# no shutdown

ISP1(config)# interface gigabitEthernet 1/0
ISP1(config-if)# description Link to Company Inc.
ISP1(config-if)# ip address 198.10.10.1 255.255.255.252
ISP1(config-if)# ip nat inside
ISP1(config-if)# no shutdown
```

As we can see, the IP address received from the DHCP server is 172.17.100.5/16.



```
ISP1#show ip interface brief GigabitEthernet 0/0
Interface              IP-Address      OK? Method Status                Protocol
GigabitEthernet0/0     172.17.100.5    YES DHCP   up                    up
ISP1#
```

Picture 9 - **Checking the IP Address from DHCP server with IP address 172.17.100.1**

2.2 eBGP Configuration

The company has agreement with the ISP1 that the ISP advertises only the prefix 0.0.0.0 (a static default route) toward vIOS-EDGE-I router (198.10.10.2). No other prefixes are being advertised toward the enterprise router. To fulfill this requirement, ISP creates a prefix-list *static_default* on its router that permits the prefix 0.0.0.0/0.

```
ISP1(config)# ip prefix-list static_default permit 0.0.0.0/0
```

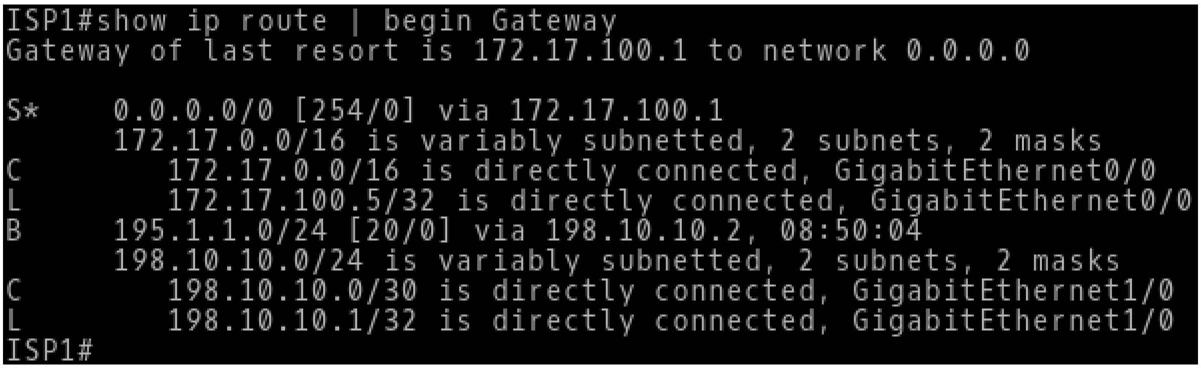
The prefix-list *static_default* is added to the route-map *static_default*.

```
ISP1(config)# route-map static_default permit 10
ISP1(config-route-map)# match ip address prefix-list static_default
```

The route-map is then applied for a neighbor 198.10.10.2 for outgoing routes.

```
ISP1(config)# router bgp 64501
ISP1(config-router)# neighbor 198.10.10.2 remote-as 64500
ISP1(config-router)# neighbor 198.10.10.2 ttl-security hops 1
ISP1(config-router)# neighbor 198.10.10.2 password isp1md5pass
ISP1(config-router)# neighbor 198.10.10.2 route-map static_default out
ISP1(config-router)# network 0.0.0.0 mask 0.0.0.0
```

Note: We do not need to create a static default route pointing to a null interface because the static default route exists in the ISP1 routing table. The route is received from the DHCP server 172.17.100.1.



```
ISP1#show ip route | begin Gateway
Gateway of last resort is 172.17.100.1 to network 0.0.0.0

S*    0.0.0.0/0 [254/0] via 172.17.100.1
      172.17.0.0/16 is variably subnetted, 2 subnets, 2 masks
C        172.17.0.0/16 is directly connected, GigabitEthernet0/0
L        172.17.100.5/32 is directly connected, GigabitEthernet0/0
B     195.1.1.0/24 [20/0] via 198.10.10.2, 08:50:04
      198.10.10.0/24 is variably subnetted, 2 subnets, 2 masks
C        198.10.10.0/30 is directly connected, GigabitEthernet1/0
L        198.10.10.1/32 is directly connected, GigabitEthernet1/0
ISP1#
```

Picture 10 - **Routing Table of ISP1 Router**

2.3 NAT Configuration

We need to translate the entire subnet 195.1.1.0/24 and the subnet 198.10.10.0/30 to the IP address that is received from the DHCP server on interface GigabitEthernet0/0 of ISP1 router. In our case, the obtained IP address is 172.17.100.5.

ISP1(config)# ip access-list standard 1
ISP1(config-std-nacl)# permit 195.1.1.0 0.0.0.255
ISP1(config-std-nacl)# permit 198.10.10.0 0.0.0.3
ISP1(config-std-nacl)# deny any

And finally, we will configure PAT on the interface GigabitEthernet 0/0.

SP1(config)# ip nat inside source list 1 interface GigabitEthernet 0/0 overload

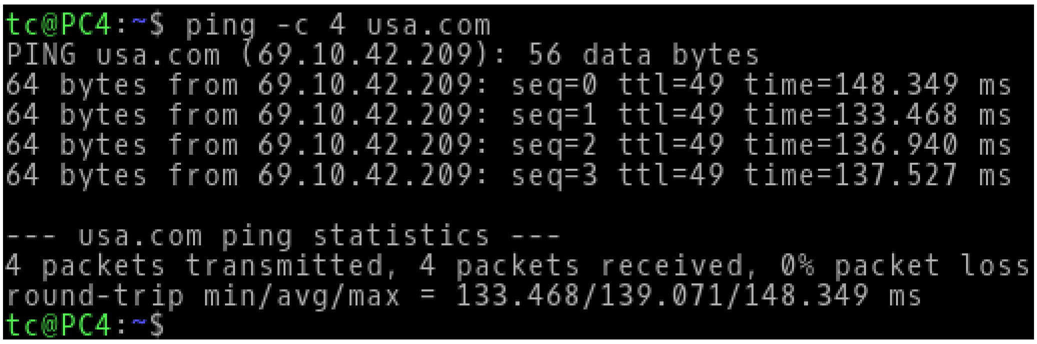
2.4 DNS Configuration

We will configure ISP1 router to use Google public DNS server 8.8.8.8 and 8.8.4.4.

ISP1(config)# ip domain-lookup
ISP1(config)# ip name-server 8.8.8.8 8.8.4.4

2.5 Testing Connectivity

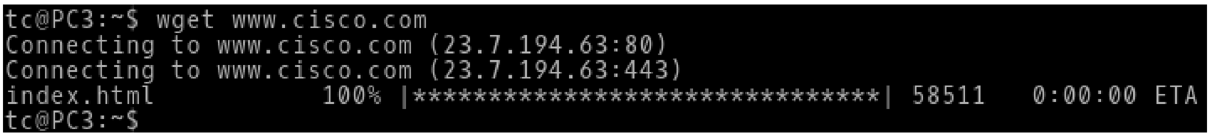
As the last step, we will test IPv4 connectivity from the host 192.168.40.1 to the Internet. Issue the ping command below.



```
tc@PC4:~$ ping -c 4 usa.com
PING usa.com (69.10.42.209): 56 data bytes
64 bytes from 69.10.42.209: seq=0 ttl=49 time=148.349 ms
64 bytes from 69.10.42.209: seq=1 ttl=49 time=133.468 ms
64 bytes from 69.10.42.209: seq=2 ttl=49 time=136.940 ms
64 bytes from 69.10.42.209: seq=3 ttl=49 time=137.527 ms

--- usa.com ping statistics ---
4 packets transmitted, 4 packets received, 0% packet loss
round-trip min/avg/max = 133.468/139.071/148.349 ms
tc@PC4:~$
```

Picture 11 - T**esting Connectivity to the Internet with ICMP ECHO Request**

We can point the host 192.168.30.1 to download a file index.html from web server Cisco.com with *wget* command.

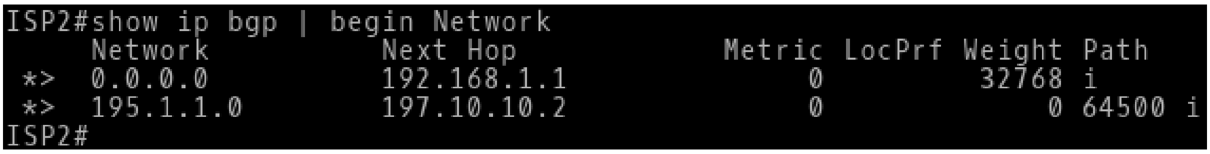


```
tc@PC3:~$ wget www.cisco.com
Connecting to www.cisco.com (23.7.194.63:80)
Connecting to www.cisco.com (23.7.194.63:443)
index.html           100% |*******************************| 58511   0:00:00 ETA
tc@PC3:~$
```

Picture 12 - **Downloading File from Web Server in the Internet**

3. ISP2 Router Configuration

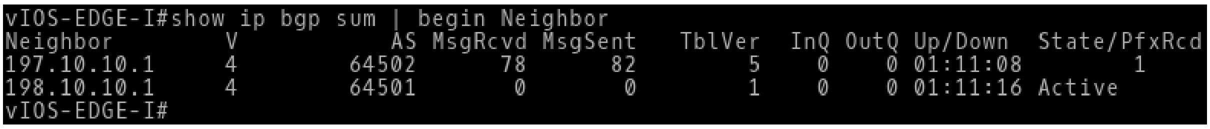
Configuration of the router ISP2 is similar to the configuration of the ISP1. For this reason we only share the configuration file of ISP2. The IP address assigned from the DHCP server to the interface GigabitEthernet0/0 of ISP2 is 172.17.100.7/16. Below is the BGP table of ISP2.



```
ISP2#show ip bgp | begin Network
     Network          Next Hop            Metric LocPrf Weight Path
 *>  0.0.0.0          192.168.1.1              0         32768 i
 *>  195.1.1.0        197.10.10.2              0             0 64500 i
ISP2#
```

Picture 13 - **BGP Table of Router ISP2**

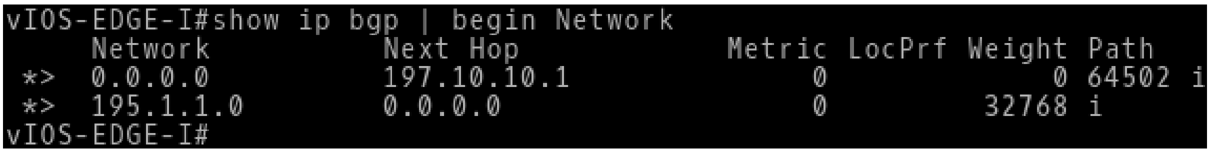
We will test connectivity from management PC4 (192.168.40.1) to the Internet. Let's shutdown ISP1 router and inspect available BGP peers on VIOS-EDGE-I. The neighbor 198.10.10.1 (ISP1) is in Active state. It means that the edge router is trying to establish BGP peer session. We also see that a single prefix is received from the neighbor 197.10.10.1 (ISP2).



```
vIOS-EDGE-I#show ip bgp sum | begin Neighbor
Neighbor        V           AS MsgRcvd MsgSent   TblVer  InQ OutQ Up/Down  State/PfxRcd
197.10.10.1     4        64502      78      82        5    0    0 01:11:08        1
198.10.10.1     4        64501       0       0        1    0    0 01:11:16 Active
vIOS-EDGE-I#
```

Picture 14 - **BGP Neighbors on vIOS-EDGE-I Router**

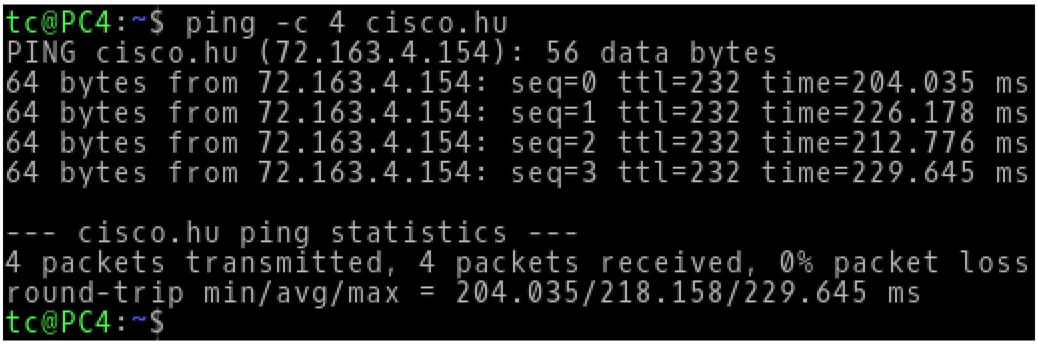
Below is the BGP table of the router vIOS-EDGE-I.



```
vIOS-EDGE-I#show ip bgp | begin Network
     Network          Next Hop            Metric LocPrf Weight Path
 *>  0.0.0.0          197.10.10.1              0             0 64502 i
 *>  195.1.1.0        0.0.0.0                  0         32768 i
vIOS-EDGE-I#
```

Picture 15 - **BGP Table of Router vIOS-EDGE-I**

Now issue the ping command on PC4 to cisco.hu. Traffic is forwarded from vIOS-EDGE-I to ISP2 router and from the SOHO router to the Internet.



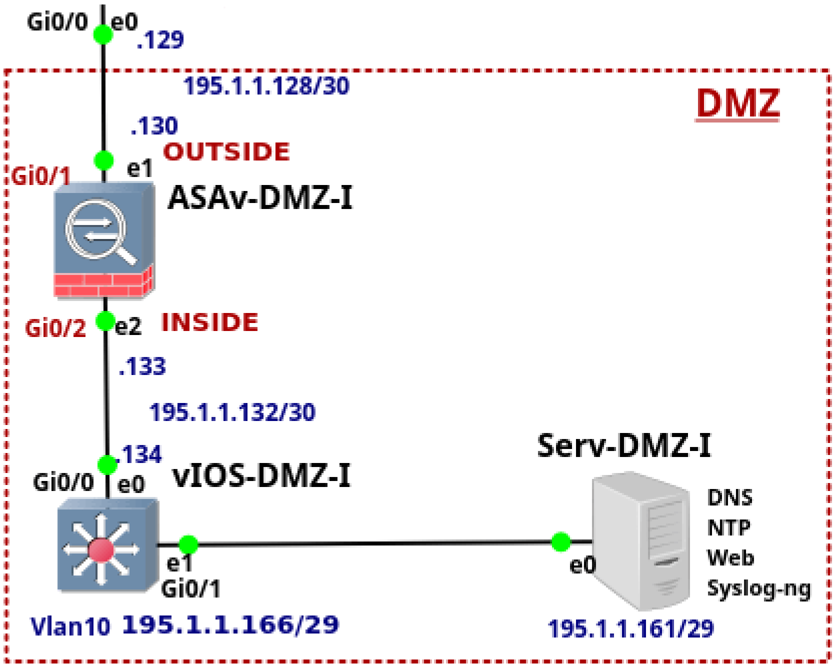
```
tc@PC4:~$ ping -c 4 cisco.hu
PING cisco.hu (72.163.4.154): 56 data bytes
64 bytes from 72.163.4.154: seq=0 ttl=232 time=204.035 ms
64 bytes from 72.163.4.154: seq=1 ttl=232 time=226.178 ms
64 bytes from 72.163.4.154: seq=2 ttl=232 time=212.776 ms
64 bytes from 72.163.4.154: seq=3 ttl=232 time=229.645 ms

--- cisco.hu ping statistics ---
4 packets transmitted, 4 packets received, 0% packet loss
round-trip min/avg/max = 204.035/218.158/229.645 ms
tc@PC4:~$
```

Picture 16 - **Testing Connectivity to the Internet from PC4**

Enterprise Network on GNS3 - Part 7 - DMZ

Posted on March 2, 2018 by Radovan BrezulaUpdated on March 2, 2018 1 Comment

This is the last article from the series of the articles discussing configuration of the enterprise network. The article explains the configuration of Demilitarized Zone (DMZ). Our DMZ consists of three devices - ASAv-DMZ-I, a multilayer switch vIOS-DMZ-I and Serv-DMZ-I. All the devices in DMZ are run by Qemu hypervisor. The ASAv_DMZ-I device is Cisco Adaptive Security Appliance Software version 9.6.1 and it has assigned 2048 MB RAM by GNS3. The device vIOS-DMZ-I is Cisco vIOS-L2 version 15.2 and it has assigned 512 MB RAM by GNS3. And finally, the device Serv-DMZ-I is Linux Ubuntu 16.04.3 LTS with 1024 MB RAM assigned by GNS3. The server Serv-DMZ-I provides DNS, NTP, Syslog services for devices in DMZ and a public web service for all hosts in the Internet.



Picture 1 - **Demilitarized Zone - DMZ**

All devices located in DMZ have their IP addresses assigned from the subnet 195.1.1.128/25. The subnet 195.1.1.128/27 is further divided with /30 mask, creating 8 subnets suitable for point-to-point link configuration . Servers located in DMZ are assigned to different VLANs. Currently, there is only server Serv-DMZ-I deployed in DMZ and configured with the IP addresses 195.1.1.161/29. The server is assigned to VLAN10 on the switch vIOS-DMZ-I. The subnet reserved for devices in VLAN10 is 195.1.1.160/29 with the default gateway IP address 196.1.1.166.

Note: The configuration files are: ASAv-DMZ-I, vIOS-DMZ-I, named.conf.options, ntp.conf, dmz.conf.

1. ASAv-DMZ-I Configuration

1.1 Initial Configuration

Password to privileged exec mode is not set. As for cable connection the interface eth0 is not connected. The interface eth0 is the Management0/0 interface on ASAv. We are not going to use the interface Management0/0. The first connected interface eth1 is represented by the Interface GigabitEthernet0/0 in ASAv CLI. The second connected interface eth2 is represented by the interface GigabitEthernet0/1 in ASAv CLI etc.

```
ciscoasa> en
ciscoasa# conf t
ciscoasa(config)# hostname ASAv-DMZ-I
```

1.2 Login Credentials

Access to all devices located in DMZ is authenticated against a user created in a local database of a particular device.

```
ASAv-DMZ-I(config)# username admin password cisco
ASAv-DMZ-I(config)# enable password cisco
```

Let's configure authentication for access to the ASAv-DMZ-I console against a local user.

```
ASAv_DMZ-I(config)# aaa authentication serial console LOCAL
```

If we want to use GNS3 for ASAv administration, we need to configure vASA to redirect its output to a serial port. To do so, copy a file coredump.cfg to disk0.

```
ASAv_DMZ-I# copy disk0:/coredumpinfo/coredump.cfg disk0:/use_ttyS0
```

1.3 IP Addresses and Security Levels

The switch vIOS-DMZ-I is an access switch that connects servers to the network. The switch is connected to ASAv-DMZ-I GigabitEthernet0/0 interface. The security level configured on the interface GigabitEthernet0/0 is set to 100. The security level for the interface GigabitEthernet0/2 is set to 0. The interface GigabitEthernet0/2 connects ASAv_DMZ-I to the device vIOS-EDGE-I. Thanks to this security level configuration, all devices inside DMZ can initialize connection to the Internet. However, hosts in the Internet cannot initialize connection to devices in DMZ. To allow connection initialized from outside to inside for a particular network traffic, the appropriate access-list must be configured on ASAv-DMZ-I.

```
ASAv_DMZ-I(config)# interface Gi0/0
ASAv_DMZ-I(config-if)# description Link to vIOS-EDGE-I
ASAv_DMZ-I(config-if)# nameif OUTSIDE
ASAv_DMZ-I(config-if)# security-level 0
ASAv_DMZ-I(config-if)# ip address 195.1.1.130 255.255.255.252
ASAv_DMZ-I(config-if)# no shutdown
ASAv_DMZ-I(config-if)# exit

ASAv_DMZ-I(config)# interface Gi0/2
ASAv_DMZ-I(config-if)# description Link to vIOS-DMZ-I
```

```
ASAv_DMZ-I(config-if)# nameif INSIDE
ASAv_DMZ-I(config-if)# security-level 100
ASAv_DMZ-I(config-if)# ip address 195.1.1.133 255.255.255.252
ASAv_DMZ-I(config-if)# no shutdown
ASAv_DMZ-I(config-if)# exit
```

1.4 Static Routes

Configure a static default route pointing toward the router vIOS-EDGE-I.

```
ASAv_DMZ-I(config)# route OUTSIDE 0.0.0.0 0.0.0.0 195.1.1.129
```

Configure a static route pointing to devices inside DMZ.

```
ASAv-DMZ-I(config)# route INSIDE 195.1.1.192 255.255.255.192 195.1.1.134
ASAv-DMZ-I(config)# route INSIDE 195.1.1.160 255.255.255.224 195.1.1.134
```

1.5 Objects and Object Group

Define object-groups and objects network type.

```
ASAv-DMZ-I(config)# object network serv-dmz-i
ASAv-DMZ-I(config-network-object)# host 195.1.1.161

ASAv-DMZ-I(config)# object network public_add
ASAv-DMZ-I(config-network-object)# subnet 195.1.1.0 255.255.255.0

ASAv-DMZ-I(config)# object network google_dns1
ASAv-DMZ-I(config-network-object)# host 8.8.8.8

vASA-I(config)# object network google_dns2
vASA-I(config-network-object)# host 8.8.4.4

ASAv-DMZ-I(config)# object network vios-edge-i_gi0_0
ASAv-DMZ-I(config-network-object)# host 195.1.1.129

ASAv-DMZ-I(config)# object-group network google_dns
ASAv-DMZ-I(config-network-object-group)# network-object object google_dns1
ASAv-DMZ-I(config-network-object-group)# network-object object google_dns2
```

1.6 Access Lists

Allow SSH access from 195.1.1.0/24 to 195.1.1.0/24 through ASAv-DMZ-I. It allows to manage devices in DMZ from the campus network and data center.

```
ASAv-DMZ-I(config)# access-list out-to-ins extended permit tcp object public_add object public_add eq ssh
```

Allow ICMP ECHO Request from 195.1.1.0/24 to DMZ.

```
ASAv-DMZ-I(config)# access-list out-to-ins extended permit icmp object public_add object public_add echo
```

Allow ICMP ECHO Reply from Google 8.8.8.8 and 8.8.4.4

```
ASAv-DMZ-I(config)# access-list out-to-ins extended permit icmp object-group google_dns object public_add echo-reply
```

Allow access from the Internet to web server 195.1.1.161 port 80, 443

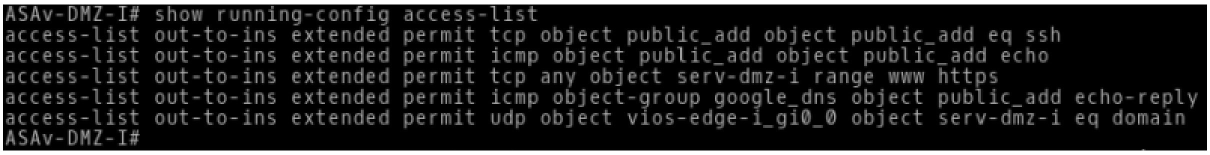
```
ASAv-DMZ-I(config)# access-list out-to-ins extended permit tcp any object serv-dmz-i range www https
```

Allow DNS requests from 195.1.1.129 (vIOS-EDGE-I) to DNS server 195.1.1.161 port 53

```
ASAv-DMZ-I(config)# access-list out-to-ins extended permit udp object vios-edge-i_gi0_0 object serv-dmz-i eq 53
```

Apply the access-list out-to-ins in incoming direction to the outside interface.

```
ASAv-DMZ-I(config)# access-group out-to-ins in interface OUTSIDE
```



```
ASAv-DMZ-I# show running-config access-list
access-list out-to-ins extended permit tcp object public_add object public_add eq ssh
access-list out-to-ins extended permit icmp object public_add object public_add echo
access-list out-to-ins extended permit tcp any object serv-dmz-i range www https
access-list out-to-ins extended permit icmp object-group google_dns object public_add echo-reply
access-list out-to-ins extended permit udp object vios-edge-i_gi0_0 object serv-dmz-i eq domain
ASAv-DMZ-I#
```

Picture 2 - **ASAv-DMZ-I Access-List Out-to-Ins**

1.7 SSH Access

```
ASAv-DMZ-I(config)# aaa authentication ssh console LOCAL
ASAv-DMZ-I(config)# crypto key generate rsa modulus 4096
ASAv-DMZ-I(config)# ssh key-exchange group dh-group14-sha1%
```

Allow SSH access to OUTSIDE interfaces from subnet 195.1.1.0/25.

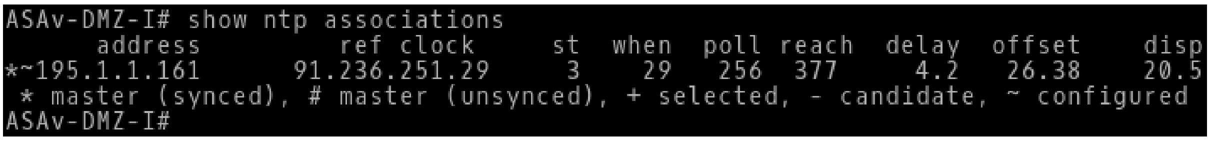
```
ASAv-DMZ-I(config)# ssh 195.1.1.0 255.255.255.128 OUTSIDE
```

Set timeout for ssh session to maximum value 60 minut.

```
ASAv-DMZ-I(config)# ssh timeout 60
```

1.8 NTP

```
ASAv-DMZ-I(config)# ntp server 172.16.50.1
ASAv-DMZ-I(config)# clock timezone UTC+2 +2
```



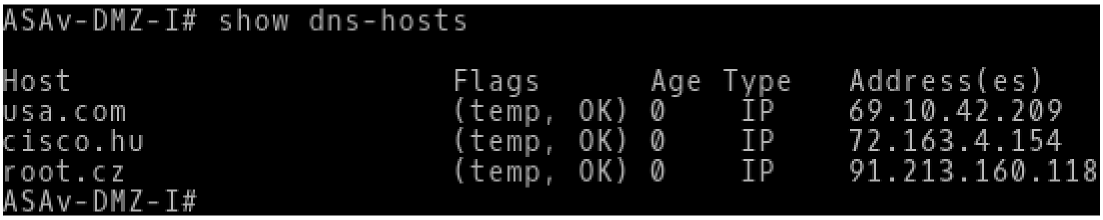
```
ASAv-DMZ-I# show ntp associations
      address         ref clock      st  when  poll reach  delay  offset    disp
*~195.1.1.161       91.236.251.29     3    29   256   377     4.2   26.38    20.5
 * master (synced), # master (unsynced), + selected, - candidate, ~ configured
ASAv-DMZ-I#
```

Picture 3 - **Time Synchronization Checking**

1.9 DNS Client

```
ASAv-DMZ-I(config)# dns server-group DefaultDNS
ASAv-DMZ-I(config-dns-server-group)# name-server 195.1.1.161
ASAv-DMZ-I(config-dns-server-group)# exit
```

```
ASAv-DMZ-I(config)# dns domain-lookup INSIDE
```



```
ASAv-DMZ-I# show dns-hosts

Host                     Flags      Age Type   Address(es)
usa.com                  (temp, OK) 0    IP    69.10.42.209
cisco.hu                 (temp, OK) 0    IP    72.163.4.154
root.cz                  (temp, OK) 0    IP    91.213.160.118
ASAv-DMZ-I#
```

Picture 4 - **Displaying DNS Cache**

1.10 Logging Configuration

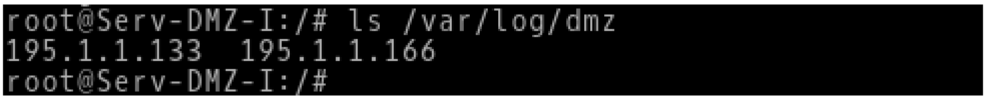
Logging information messages to console, RAM (buffer) and VTY session.

```
ASAv_DMZ-I(config)# logging enable
ASAv_DMZ-I(config)# logging console 6
ASAv_DMZ-I(config)# logging buffered 6
ASAv_DMZ-I(config)# logging monitor 6
```

Configure a remote syslog-ng server that is running on the server Serv-DMZ-I. Set syslog level 5 (notifications), including lower levels (level 1 are alerts).

```
ASAv-DMZ-I(config)# logging host INSIDE 195.1.1.161
ASAv_DMZ-I(config)# logging trap notifications
```

Log traps are sent to the server Serv-DMZ-I and they are stored in the directory /var/log/dmz.



```
root@Serv-DMZ-I:/# ls /var/log/dmz
195.1.1.133  195.1.1.166
root@Serv-DMZ-I:/#
```

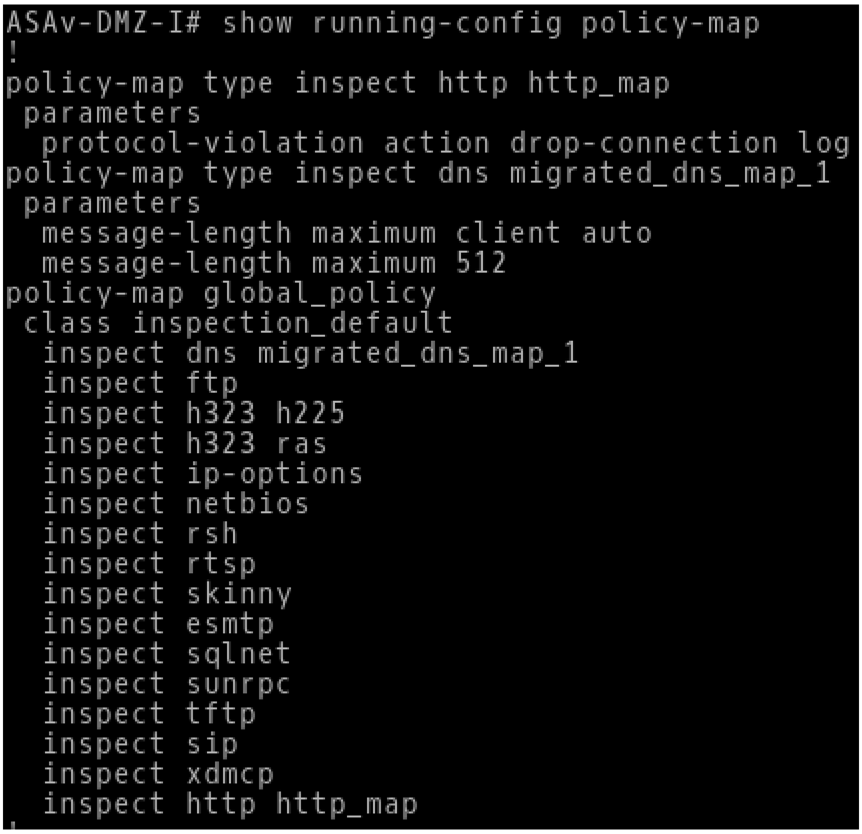
Picture 5 - **Content of DMZ Directory**

1.11 Traffic Inspection

ASAv-DMZ-I(config)# policy-map type inspect http http_map
ASAv-DMZ-I(config-pmap)# parameters
ASAv-DMZ-I(config-pmap-p)# protocol-violation action drop-connection log

ASAv-DMZ-I(config)# policy-map global_policy
ASAv-DMZ-I(config-pmap)# class inspection_default
ASAv-DMZ-I(config-pmap-c)# inspect http http_map

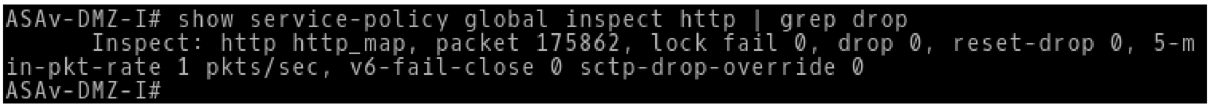
ASAv-DMZ-I(config)# service-policy global_policy global



```
ASAv-DMZ-I# show running-config policy-map
!
policy-map type inspect http http_map
 parameters
  protocol-violation action drop-connection log
policy-map type inspect dns migrated_dns_map_1
 parameters
  message-length maximum client auto
  message-length maximum 512
policy-map global_policy
 class inspection_default
  inspect dns migrated_dns_map_1
  inspect ftp
  inspect h323 h225
  inspect h323 ras
  inspect ip-options
  inspect netbios
  inspect rsh
  inspect rtsp
  inspect skinny
  inspect esmtp
  inspect sqlnet
  inspect sunrpc
  inspect tftp
  inspect sip
  inspect xdmcp
  inspect http http_map
!
```

Picture 6 - **List of Inspected Protocols**

Check HTTP traffic inspection statistics.



```
ASAv-DMZ-I# show service-policy global inspect http | grep drop
      Inspect: http http_map, packet 175862, lock fail 0, drop 0, reset-drop 0, 5-m
in-pkt-rate 1 pkts/sec, v6-fail-close 0 sctp-drop-override 0
ASAv-DMZ-I#
```

Picture 7 - **Checking HTTP Traffic Inspection Statistic**

2. Switch vIOS-DMZ-I Configuration

We do not need to discuss every line of vIOS-DMZ-I configuration as the switch contains only basic configuration which does not need detailed explanation. We will just summarize some ideas that help us to understand how the switch is configured.

2.1 IP Addresses, VLAN, VTP and SVI Port

The interface GigabitEthernet0/0 is connected to ASAv-DMZ-I and it is configured as a routed interface. The interface GigabitEthernet0/1 is configured as the switchport with VLAN10. It connects the server Serv-DMZ-I to the network.

```
vIOS-DMZ-I(config)# interface GigabitEthernet0/0
vIOS-DMZ-I(config-if)# description Link to ASAv-DMZ-I
vIOS-DMZ-I(config-if)# no switchport
vIOS-DMZ-I(config-if)# ip address 195.1.1.134 255.255.255.252
vIOS-DMZ-I(config-if)# no shutdown
vIOS-DMZ-I(config-if)# exit

vIOS-DMZ-I(config)# interface GigabitEthernet0/1
vIOS-DMZ-I(config-if)# description Link to Serv-DMZ-I
vIOS-DMZ-I(config-if)# switchport mode access
vIOS-DMZ-I(config-if)# switchport access vlan 10
vIOS-DMZ-I(config-if)# no shutdown
vIOS-DMZ-I(config-if)# exit

vIOS-DMZ-I(config)# vlan 10
vIOS-DMZ-I(config-vlan)# name Servers_DMZ
vIOS-DMZ-I(config-vlan)# exit
```

We do not use VLAN Trunk Protocol (VTP) in DMZ thus we will disable VTP protocol. As a result, VLANs must be configured locallyon all switches in DMZ. It prevents to delete VLANs either accidentally by network admins or intentionally in cause of L2 attacks. The command *vtp mode off* also prevents a switch to forwards VTP advertisements.

```
vIOS-DMZ-I(config)# vtp mode off
```

Below is the configuration of the default gateway IP address for the subnet 195.1.1.160/29. The IP address 195.1.1.166/29 is configured on interface VLAN10.

```
vIOS-DMZ-I(config)# interface vlan 10
vIOS-DMZ-I(config-if)# ip address 195.1.1.166 255.255.255.248
vIOS-DMZ-I(config-if)# no shutdown
```

2.2 Static Default Routing

```
vIOS-DMZ-I(config)# ip route 0.0.0.0 0.0.0.0 195.1.1.133
```

2.3 Console Authentication, Privileged Exec Mode and SSH

```
vIOS-DMZ-I(config)# username admin secret cisco
vIOS-DMZ-I(config)# enable secret cisco

vIOS-DMZ-I(config)# line console 0
vIOS-DMZ-I(config-line)# login local
```

```
vIOS-DMZ-I(config)# ip ssh version 2
vIOS-DMZ-I(config)# ip domain-name companyXYZ.sk
vIOS-DMZ-I(config)# crypto key generate rsa modulus 4096
```

```
vIOS-DMZ-I(config)# line vty 0 1500
vIOS-DMZ-I(config-line)# transport input ssh
vIOS-DMZ-I(config-line)# login local
```

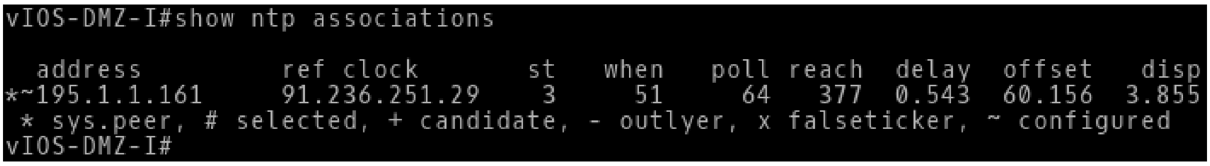
SSH access-list allows connections to the VTY line only from the subnet 195.1.1.0/27.

```
vIOS-DMZ-I(config)# ip access-list standard ssh-access
vIOS-DMZ-I(config-std-nacl)# permit 195.1.1.0 0.0.0.127
vIOS-DMZ-I(config-std-nacl)# deny any
vIOS-DMZ-I(config-std-nacl)# exit
```

```
vIOS-DMZ-I(config)# line vty 0 1500
vIOS-DMZ-I(config-line)# access-class ssh-access in
vIOS-DMZ-I(config-line)# exit
```

2.4 NTP

```
vIOS-DMZ-I(config)# ntp server 172.16.50.1
vIOS-DMZ-I(config)# clock timezone UTC+2 +2
```



```
vIOS-DMZ-I#show ntp associations

  address         ref clock       st   when   poll reach  delay  offset   disp
*~195.1.1.161     91.236.251.29    3     51     64   377  0.543  60.156  3.855
 * sys.peer, # selected, + candidate, - outlyer, x falseticker, ~ configured
vIOS-DMZ-I#
```

Picture 8 - **Time Synchronization Checking**

2.5 DNS Client

```
vIOS-DMZ-I(config)# ip name-server 195.1.1.161
vIOS-DMZ-I(config)# ip domain lookup
```

2.6 Logging

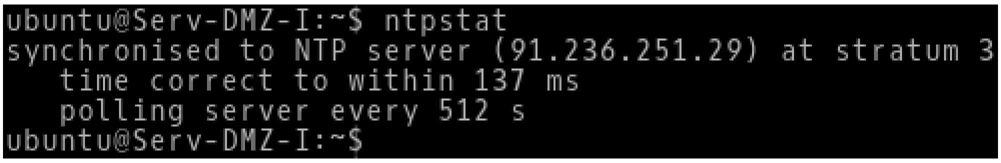
```
vIOS-DMZ-I(config)# logging host 195.1.1.161
vIOS-DMZ-I(config)# logging trap notifications
```

3. Server Serv-DMZ-I Configuration

The server Serv-DMZ-I provides DNS, NTP, Web and Syslog services for all devices in DMZ. We have already described the configuration of DNS, NTP and Syslog-ng in Part 5 - Data Center Configuration. Therefore, I am not going to discuss the configuration again. Rather, we will introduce several commands that can be used during troubleshooting.

3.1 Checking NTP

Below is the output of the *ntpstat* command that reports the synchronization state of the NTP daemon running on Serv-DMZ-I. The system is synchronized to a NTP server 91.236.251.29 and the approximate time accuracy is 137 ms.

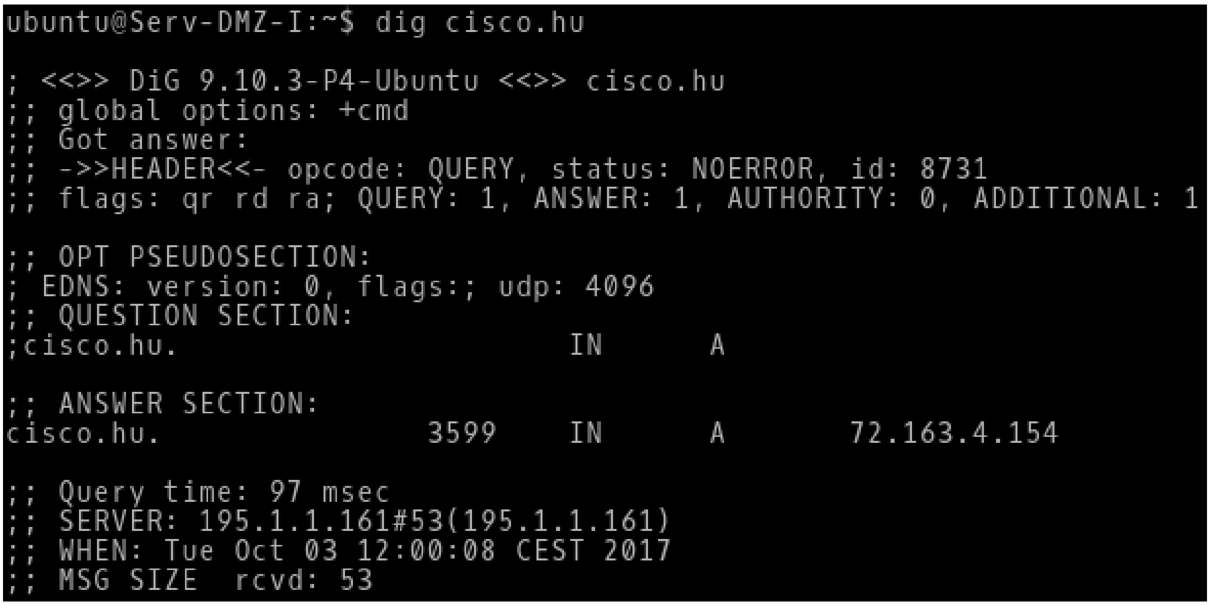


```
ubuntu@Serv-DMZ-I:~$ ntpstat
synchronised to NTP server (91.236.251.29) at stratum 3
   time correct to within 137 ms
   polling server every 512 s
ubuntu@Serv-DMZ-I:~$
```

Picture 9 - **Checking Synchronization State of NTP Daemon**

3.2 Checking DNS

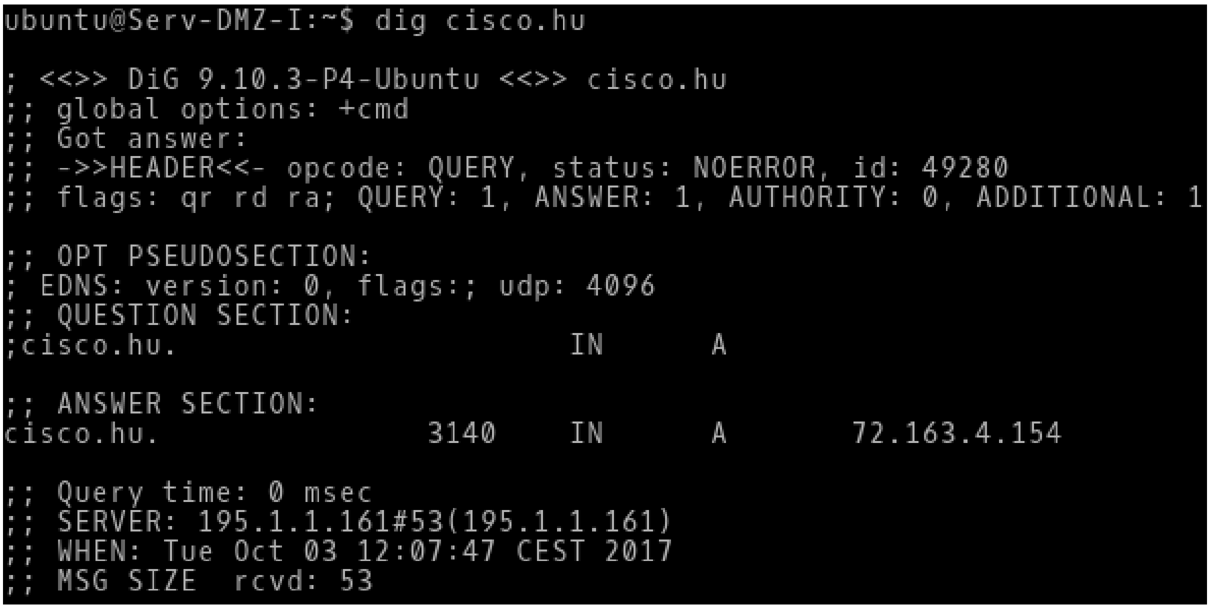
Below is the output of dig command used to perform DNS lookup IP address for the domain cisco.hu. The answer is 72.163.4.154, DNS server is 195.1.1.161 (Serv-DMZ-I) and the query took 97 ms.



```
ubuntu@Serv-DMZ-I:~$ dig cisco.hu

; <<>> DiG 9.10.3-P4-Ubuntu <<>> cisco.hu
;; global options: +cmd
;; Got answer:
;; ->>HEADER<<- opcode: QUERY, status: NOERROR, id: 8731
;; flags: qr rd ra; QUERY: 1, ANSWER: 1, AUTHORITY: 0, ADDITIONAL: 1

;; OPT PSEUDOSECTION:
; EDNS: version: 0, flags:; udp: 4096
;; QUESTION SECTION:
;cisco.hu.                      IN      A

;; ANSWER SECTION:
cisco.hu.               3599    IN      A       72.163.4.154

;; Query time: 97 msec
;; SERVER: 195.1.1.161#53(195.1.1.161)
;; WHEN: Tue Oct 03 12:00:08 CEST 2017
;; MSG SIZE  rcvd: 53
```

Picture 10 - **Querying DNS Server 195.1.1.161**

If we try to send query for domain cisco.hu once again, the response is almost identical except the query time that is 0 ms. The IP address for the domain cisco.hu is cached thus no DNS query is sent.

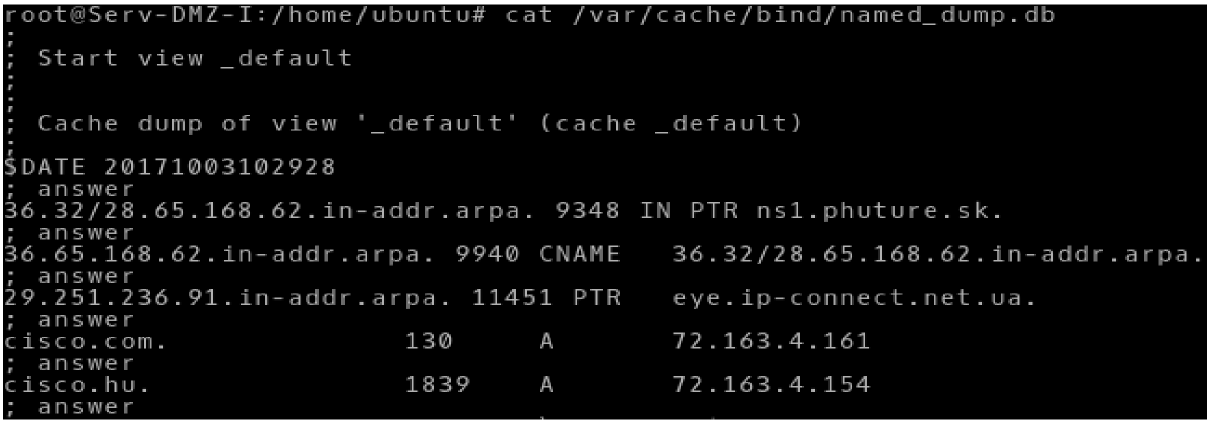


```
ubuntu@Serv-DMZ-I:~$ dig cisco.hu

; <<>> DiG 9.10.3-P4-Ubuntu <<>> cisco.hu
;; global options: +cmd
;; Got answer:
;; ->>HEADER<<- opcode: QUERY, status: NOERROR, id: 49280
;; flags: qr rd ra; QUERY: 1, ANSWER: 1, AUTHORITY: 0, ADDITIONAL: 1

;; OPT PSEUDOSECTION:
; EDNS: version: 0, flags:; udp: 4096
;; QUESTION SECTION:
;cisco.hu.                      IN      A

;; ANSWER SECTION:
cisco.hu.               3140    IN      A       72.163.4.154

;; Query time: 0 msec
;; SERVER: 195.1.1.161#53(195.1.1.161)
;; WHEN: Tue Oct 03 12:07:47 CEST 2017
;; MSG SIZE  rcvd: 53
```

Picture 11 - **Querying DNS Server 195.1.1.161**

To inspect Bind9 DNS cache first make a dump of database with the command below. Then check the content of the file */var/cache/bind/named_dump.db*.

```
root@Serv-DMZ-I:/home/ubuntu# rndc dumpdb
```



```
root@Serv-DMZ-I:/home/ubuntu# cat /var/cache/bind/named_dump.db
;
; Start view _default
;
;
; Cache dump of view '_default' (cache _default)
;
$DATE 20171003102928
; answer
36.32/28.65.168.62.in-addr.arpa. 9348 IN PTR ns1.phuture.sk.
; answer
36.65.168.62.in-addr.arpa. 9940 CNAME   36.32/28.65.168.62.in-addr.arpa.
; answer
29.251.236.91.in-addr.arpa. 11451 PTR   eye.ip-connect.net.ua.
; answer
cisco.com.               130     A       72.163.4.161
; answer
cisco.hu.                1839    A       72.163.4.154
; answer
```

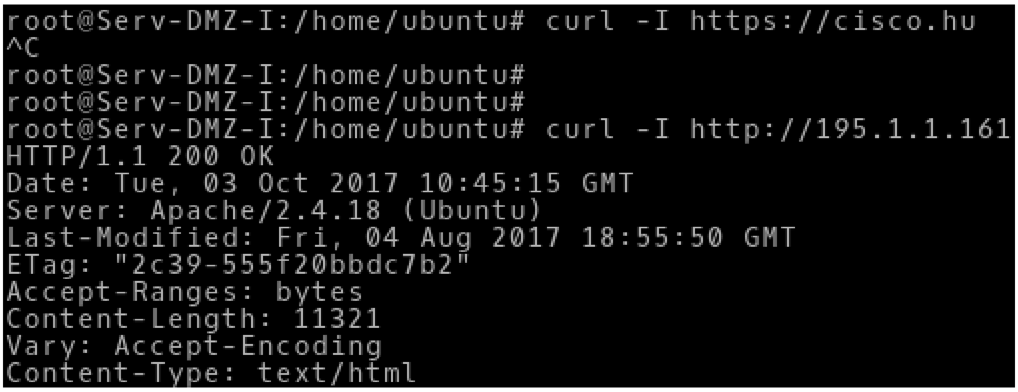
Picture 12 - **Content of Dumped Bind9 Database**

3.3 Checking Web Server

First, we install Apache2 we server with the command below.

```
# apt-get install apache2
```

We will use *curl* command to check web server type and its version. The server Serv-DMZ-I is running Apache 2.4.18.



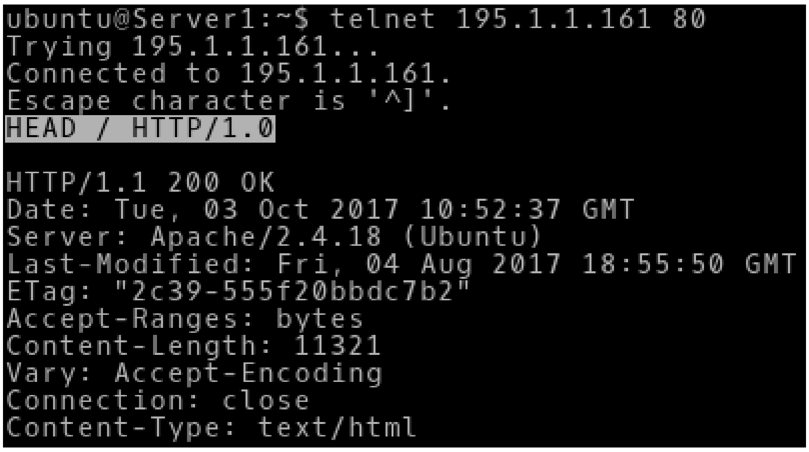
```
root@Serv-DMZ-I:/home/ubuntu# curl -I https://cisco.hu
^C
root@Serv-DMZ-I:/home/ubuntu#
root@Serv-DMZ-I:/home/ubuntu#
root@Serv-DMZ-I:/home/ubuntu# curl -I http://195.1.1.161
HTTP/1.1 200 OK
Date: Tue, 03 Oct 2017 10:45:15 GMT
Server: Apache/2.4.18 (Ubuntu)
Last-Modified: Fri, 04 Aug 2017 18:55:50 GMT
ETag: "2c39-555f20bbdc7b2"
Accept-Ranges: bytes
Content-Length: 11321
Vary: Accept-Encoding
Content-Type: text/html
```

Picture 13 - **Checking Web Server with Curl Command**

If curl command is not available, the same information can be get with the telnet command. You need to enter *HEAD / HTTP/1.0* once you are connected to web server. Then press Enter twice.

ubuntu@Server1:~$ telnet 195.1.1.161 80

HEAD / HTTP/1.0

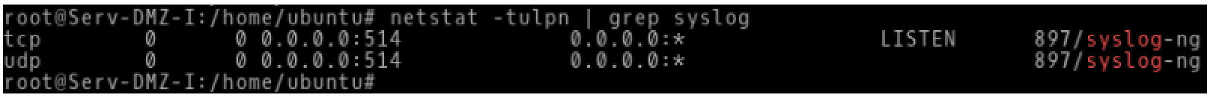


```
ubuntu@Server1:~$ telnet 195.1.1.161 80
Trying 195.1.1.161...
Connected to 195.1.1.161.
Escape character is '^]'.
HEAD / HTTP/1.0

HTTP/1.1 200 OK
Date: Tue, 03 Oct 2017 10:52:37 GMT
Server: Apache/2.4.18 (Ubuntu)
Last-Modified: Fri, 04 Aug 2017 18:55:50 GMT
ETag: "2c39-555f20bbdc7b2"
Accept-Ranges: bytes
Content-Length: 11321
Vary: Accept-Encoding
Connection: close
Content-Type: text/html
```

Picture 14 - **Checking Web Server with Telnet Command**

3.4 Checking Syslog-ng

Check if syslog-ng is listening on a particular socket.



```
root@Serv-DMZ-I:/home/ubuntu# netstat -tulpn | grep syslog
tcp        0      0 0.0.0.0:514             0.0.0.0:*               LISTEN      897/syslog-ng
udp        0      0 0.0.0.0:514             0.0.0.0:*                           897/syslog-ng
root@Serv-DMZ-I:/home/ubuntu#
```

Picture 15 - **Checking Syslog-ng Socket**

In our case, syslog-ng is listening on all IP addresses and TCP/UDP port 514. If not, you can check the configuration file for typos with the command below

.root@Serv-DMZ-I:/home/ubuntu# syslog-ng --syntax-only