VIRTUAL ROUTING AND FORWARDING (VRF)

SONYA LAO
CCNP P1/2

Purpose

The purpose of this lab is to learn the usage of the Virtual Routing and Forwarding protocol. We applied our existing knowledge of internal routing protocols, addressing, and sub-interfaces to simulate a situation in which VRFs would be useful.

Background Information

Imagine that you and your family (the Red family) share a house with the Blue family. You are from rival spy agencies. The layout of the house is exactly the same on both sides, and you share the same home address, but you and your family must stay in your area of the house, to avoid spilling top secret information. Whenever your family receives mail, the mailman has 2 separate folders for the Red and Blue family, again to avoid mixing any top secret information. Virtual Routing and Forwarding is the same way. It allows for multiple instances of a routing table to exist on a router. The router creates virtual routing instances that are separate from the physical interface. The router can have the same default gateway (home addresses) for both VRFs, but the information coming in will always be separated into different routing tables.

Lab Summary

First, I created my topology. Switch 1 and Switch 3 are in the Google VRF, while Switch 2 and Switch 4 are in the Microsoft VRF. S1 and S2 are in the same subnet, but should not be able to ping each other. Router 4 and Router 6 should each have the same address on both interfaces connected to the switches. First, I set the appropriate IP address on each VLAN 1 of the four switches, placing S1 and S2 in the same subnet, and S3 and S4 in a different subnet. The end goal is to have S1 and S3 be in one VRF, and S2 and S4 in another. S1 should not be able to ping S2 or S4.

Next, I created the Microsoft and Google VRFs on every router. Then I applied the VRF to the appropriate interfaces. Since the `ip vrf forwarding` command resets the addressing of the interface, I applied the command first, before entering the appropriate IP address on each interface. For interface g0/1/0 on R4 and R6, and interface g0/1 and g0/0 on R5, I created sub interfaces so that the packets would be able to be routed through R5. I gave them 802.1q encapsulation, and used the same command to associate the sub-interface with a VRF. Next, I configured OSPF on all routers. OSPF with the VRF extension is configured for each individual VRF, so the network statements were only applicable to the VRF it was configured for. After confirming that there were 2 separate routing tables for each of the VRFs, using the `show ip route vrf [name] command`, I tested pings from S1 to S3, and S1 to S2/S4.

Lab Commands

`R1(config)#ip vrf [vrf name]`

This command creates a VRF for the given name, and enters VRF configuration mode.

```
R1(config)#interface [port name].[number]
R1(config-if)#encapsulation dot1q [number]
```

This command creates a sub-interface with the IEEE 802.1q encapsulation.

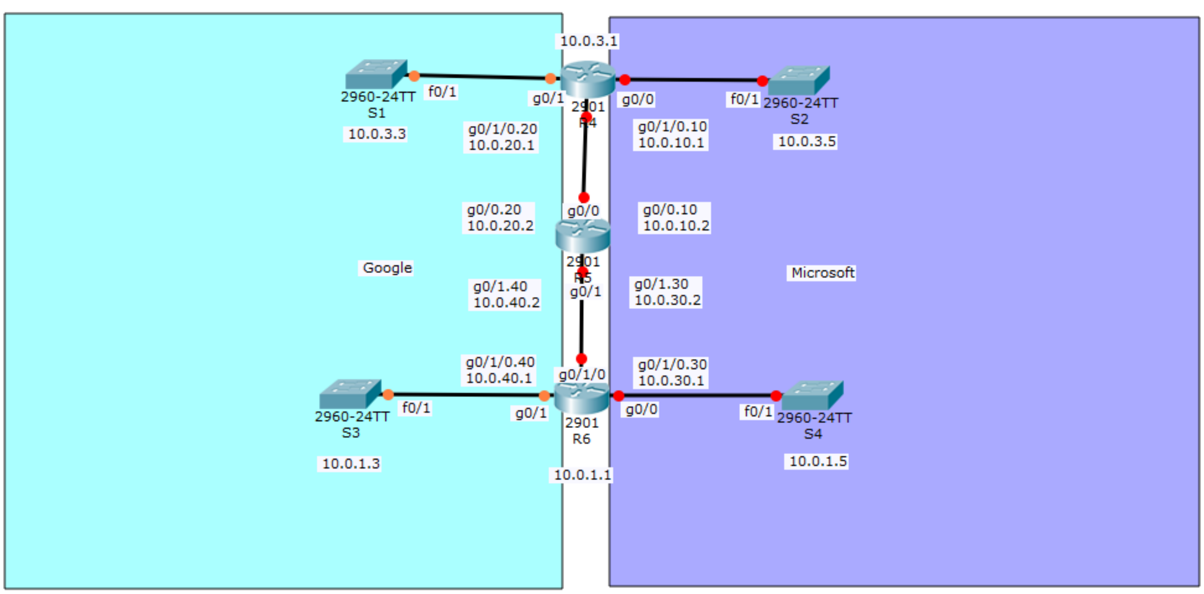
`R1(config-if)#ip vrf forwarding [vrf name]`

This command associates the given VRF with the interface.

`R1(config)#router ospf [process id] vrf [vrf name]`

This command enables OSPF routing and enters router configuration mode. The process id portion identifies the OSPF process and the vrf keyword and vrf-name argument is used to identify a VRF.

Lab Diagram



Configurations

R4 show run:

```
R4#sh run
Building configuration...
Current configuration : 2265 bytes
Last configuration change at
16:28:59 UTC Wed May 24 2017
version 15.2
service timestamps debug datetime
msec
service timestamps log datetime
msec
no service password-encryption
hostname R4
ip vrf Google
description Google
ip vrf Microsoft
description Microsoft
no ip domain lookup
vtp domain CCNP
vtp mode transparent
interface GigabitEthernet0/0
ip vrf forwarding Microsoft
ip address 10.0.3.1 255.255.255.0
duplex auto
speed auto
interface GigabitEthernet0/1
ip vrf forwarding Google
ip address 10.0.3.1 255.255.255.0
duplex auto
speed auto
interface GigabitEthernet0/1/0
no ip address
duplex auto
speed auto
interface GigabitEthernet0/1/0.10
encapsulation dot1Q 10
ip vrf forwarding Microsoft
ip address 10.0.10.1 255.255.255.0
interface GigabitEthernet0/1/0.20
encapsulation dot1Q 20
ip vrf forwarding Google
ip address 10.0.20.1 255.255.255.0
router ospf 1 vrf Microsoft
router-id 4.4.4.1
network 10.0.3.0 0.0.0.255 area 0
network 10.0.4.0 0.0.0.255 area 0
network 10.0.10.0 0.0.0.255 area 0
router ospf 2 vrf Google
router-id 4.4.4.2
network 10.0.3.0 0.0.0.255 area 0
network 10.0.4.0 0.0.0.255 area 0
network 10.0.20.0 0.0.0.255 area 0
no ip http server
no ip http secure-server
line con 0
line vty 0 4
login
transport input all
scheduler allocate 20000 1000
End
```

R5 show run:

```
R5(config)#do sh run
Building configuration...
version 15.2
service timestamps debug datetime
msec
service timestamps log datetime
msec
no service password-encryption
hostname R5
no aaa new-model
memory-size iomem 10
ip vrf Google
description Google
ip vrf Microsoft
description Microsoft
no ip domain lookup
no ipv6 cef
interface GigabitEthernet0/0
no ip address
ip broadcast-address 0.0.0.0
duplex auto
speed auto
interface GigabitEthernet0/0.10
encapsulation dot1Q 10
ip vrf forwarding Microsoft
ip address 10.0.10.2 255.255.255.0
ip broadcast-address 10.0.10.0
interface GigabitEthernet0/0.20
encapsulation dot1Q 20
```

```
ip vrf forwarding Google
ip address 10.0.20.2 255.255.255.0
ip broadcast-address 10.0.20.0
interface GigabitEthernet0/1
no ip address
ip broadcast-address 0.0.0.0
duplex auto
speed auto
interface GigabitEthernet0/1.30
encapsulation dot1Q 30
ip vrf forwarding Microsoft
ip address 10.0.30.2 255.255.255.0
ip broadcast-address 10.0.30.0
interface GigabitEthernet0/1.40
encapsulation dot1Q 40
ip vrf forwarding Google
ip address 10.0.40.2 255.255.255.0
ip broadcast-address 10.0.40.0
router ospf 1 vrf Microsoft
router-id 5.5.5.1
network 10.0.10.0 0.0.0.255 area 0
network 10.0.30.0 0.0.0.255 area 0
router ospf 2 vrf Google
router-id 5.5.5.2
network 10.0.20.0 0.0.0.255 area 0
network 10.0.40.0 0.0.0.255 area 0
line con 0
line vty 0 4
login
transport input all
scheduler allocate 20000 1000
end
```

R6 show run:

```
R6(config)#do sh run
Building configuration...
Current configuration : 2241 bytes
version 15.2
hostname R6
ip vrf Google
description Google
ip vrf Microsoft
description Microsoft
no ip domain lookup
no ipv6 cef
interface GigabitEthernet0/0
ip vrf forwarding Microsoft
ip address 10.0.1.1 255.255.255.0
duplex auto
speed auto
interface GigabitEthernet0/1
ip vrf forwarding Google
ip address 10.0.1.1 255.255.255.0
duplex auto
speed auto
interface GigabitEthernet0/1/0
no ip address
duplex auto
speed auto
interface GigabitEthernet0/1/0.30
encapsulation dot1Q 30
ip vrf forwarding Microsoft
ip address 10.0.30.1 255.255.255.0
interface GigabitEthernet0/1/0.40
encapsulation dot1Q 40
ip vrf forwarding Google
ip address 10.0.40.1 255.255.255.0
router ospf 1 vrf Microsoft
router-id 6.6.6.1
network 10.0.1.0 0.0.0.255 area 0
network 10.0.2.0 0.0.0.255 area 0
network 10.0.30.0 0.0.0.255 area 0
router ospf 2 vrf Google
router-id 6.6.6.2
network 10.0.1.0 0.0.0.255 area 0
network 10.0.2.0 0.0.0.255 area 0
network 10.0.40.0 0.0.0.255 area 0
line con 0
line vty 0 4
login
transport input all
scheduler allocate 20000 1000
end
```

R4#sh ip route vrf Microsoft

```
Routing Table: Microsoft
Codes: L - local, C - connected, S - static, R - RIP, M - mobile, B - BGP
      D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
      N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
      E1 - OSPF external type 1, E2 - OSPF external type 2
      i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2
      ia - IS-IS inter area, * - candidate default, U - per-user static route
      o - ODR, P - periodic downloaded static route, H - NHRP, l - LISP
      + - replicated route, % - next hop override
Gateway of last resort is not set
     10.0.0.0/8 is variably subnetted, 6 subnets, 2 masks
O        10.0.1.0/24 [110/3] via 10.0.10.2, 00:16:20, GigabitEthernet0/1/0.10
C        10.0.3.0/24 is directly connected, GigabitEthernet0/0
L        10.0.3.1/32 is directly connected, GigabitEthernet0/0
C        10.0.10.0/24 is directly connected, GigabitEthernet0/1/0.10
L        10.0.10.1/32 is directly connected, GigabitEthernet0/1/0.10
O        10.0.30.0/24 [110/2] via 10.0.10.2, 00:16:20,
GigabitEthernet0/1/0.10
```

R4#sh ip route vrf Google

```
Routing Table: Google
Codes: L - local, C - connected, S - static, R - RIP, M - mobile, B - BGP
      D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
      N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
      E1 - OSPF external type 1, E2 - OSPF external type 2
      i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2
      ia - IS-IS inter area, * - candidate default, U - per-user static route
      o - ODR, P - periodic downloaded static route, H - NHRP, l - LISP
      + - replicated route, % - next hop override
Gateway of last resort is not set

     10.0.0.0/8 is variably subnetted, 6 subnets, 2 masks
O        10.0.1.0/24 [110/3] via 10.0.20.2, 00:07:27, GigabitEthernet0/1/0.20
C        10.0.3.0/24 is directly connected, GigabitEthernet0/1
L        10.0.3.1/32 is directly connected, GigabitEthernet0/1
C        10.0.20.0/24 is directly connected, GigabitEthernet0/1/0.20
L        10.0.20.1/32 is directly connected, GigabitEthernet0/1/0.20
O        10.0.40.0/24 [110/2] via 10.0.20.2, 00:07:27,
GigabitEthernet0/1/0.20
```

R4#sh ip ospf neigh

```
 Neighbor ID     Pri   State           Dead Time   Address         Interface
5.5.5.2           1   FULL/BDR        00:00:36    10.0.20.2       GigabitEthe
rnet0/1/0.20
5.5.5.1           1   FULL/BDR        00:00:37    10.0.10.2       GigabitEthe
rnet0/1/0.10
```

R4#sh vrf Microsoft

```
 Name                             Default RD          Protocols   Interfaces
 Microsoft                        <not set>           ipv4        Gi0/0
                                                                  Gi0/1/0.10
```

R4#sh vrf Google

```
 Name                             Default RD          Protocols   Interfaces
 Google                           <not set>           ipv4        Gi0/1
                                                                  Gi0/1/0.20
```

R5#sh ip route vrf Microsoft

```
 Routing Table: Microsoft
Codes: L - local, C - connected, S - static, R - RIP, M - mobile, B - BGP
      D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
      N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
      E1 - OSPF external type 1, E2 - OSPF external type 2
      i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2
      ia - IS-IS inter area, * - candidate default, U - per-user static route
      o - ODR, P - periodic downloaded static route, H - NHRP, l - LISP
      + - replicated route, % - next hop override
Gateway of last resort is not set

     10.0.0.0/8 is variably subnetted, 6 subnets, 2 masks
O       10.0.1.0/24 [110/2] via 10.0.30.1, 00:18:30, GigabitEthernet0/1.30
O       10.0.3.0/24 [110/2] via 10.0.10.1, 00:18:35, GigabitEthernet0/0.10
C       10.0.10.0/24 is directly connected, GigabitEthernet0/0.10
L       10.0.10.2/32 is directly connected, GigabitEthernet0/0.10
C       10.0.30.0/24 is directly connected, GigabitEthernet0/1.30
L       10.0.30.2/32 is directly connected, GigabitEthernet0/1.30
```

R5#sh ip route vrf Google

```
Routing Table: Google
Codes: L - local, C - connected, S - static, R - RIP, M - mobile, B - BGP
      D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
      N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
      E1 - OSPF external type 1, E2 - OSPF external type 2
      i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2
      ia - IS-IS inter area, * - candidate default, U - per-user static route
      o - ODR, P - periodic downloaded static route, H - NHRP, l - LISP
      + - replicated route, % - next hop override
Gateway of last resort is not set

     10.0.0.0/8 is variably subnetted, 6 subnets, 2 masks
O       10.0.1.0/24 [110/2] via 10.0.40.1, 00:09:44, GigabitEthernet0/1.40
O       10.0.3.0/24 [110/2] via 10.0.20.1, 00:18:45, GigabitEthernet0/0.20
C       10.0.20.0/24 is directly connected, GigabitEthernet0/0.20
L       10.0.20.2/32 is directly connected, GigabitEthernet0/0.20
C       10.0.40.0/24 is directly connected, GigabitEthernet0/1.40
L       10.0.40.2/32 is directly connected, GigabitEthernet0/1.40
```

R5#sh ip ospf neigh

```
Neighbor ID     Pri   State           Dead Time   Address         Interface
6.6.6.2           1   FULL/DR         00:00:37    10.0.40.1       GigabitEthe
rnet0/1.40
4.4.4.2           1   FULL/DR         00:00:34    10.0.20.1       GigabitEthe
rnet0/0.20
6.6.6.1           1   FULL/DR         00:00:31    10.0.30.1       GigabitEthe
rnet0/1.30
4.4.4.1           1   FULL/DR         00:00:32    10.0.10.1       GigabitEthe
rnet0/0.10.
```

R5#sh vrf Microsoft

```
 Name                             Default RD          Protocols   Interfaces
 Microsoft                        <not set>           ipv4        Gi0/0.10
                                                                  Gi0/1.30
```

R5#sh vrf Google

```
 Name                             Default RD          Protocols   Interfaces
 Google                           <not set>           ipv4        Gi0/0.20
                                                                  Gi0/1.40
```

R6#sh ip route vrf Microsoft

```
Routing Table: Microsoft
Codes: L - local, C - connected, S - static, R - RIP, M - mobile, B - BGP
      D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
      N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
      E1 - OSPF external type 1, E2 - OSPF external type 2
      i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2
      ia - IS-IS inter area, * - candidate default, U - per-user static route
      o - ODR, P - periodic downloaded static route, H - NHRP, l - LISP
      + - replicated route, % - next hop override
Gateway of last resort is not set

     10.0.0.0/8 is variably subnetted, 6 subnets, 2 masks
C        10.0.1.0/24 is directly connected, GigabitEthernet0/0
L        10.0.1.1/32 is directly connected, GigabitEthernet0/0
O        10.0.3.0/24 [110/3] via 10.0.30.2, 00:03:13, GigabitEthernet0/1/0.30
O        10.0.10.0/24 [110/2] via 10.0.30.2, 00:03:13,
GigabitEthernet0/1/0.30
C        10.0.30.0/24 is directly connected, GigabitEthernet0/1/0.30
L        10.0.30.1/32 is directly connected, GigabitEthernet0/1/0.30
```

R6#sh ip route vrf Google

```
Routing Table: Google
Codes: L - local, C - connected, S - static, R - RIP, M - mobile, B - BGP
      D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
      N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
      E1 - OSPF external type 1, E2 - OSPF external type 2
      i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2
      ia - IS-IS inter area, * - candidate default, U - per-user static route
      o - ODR, P - periodic downloaded static route, H - NHRP, l - LISP
      + - replicated route, % - next hop override
Gateway of last resort is not set

     10.0.0.0/8 is variably subnetted, 6 subnets, 2 masks
C        10.0.1.0/24 is directly connected, GigabitEthernet0/1
L        10.0.1.1/32 is directly connected, GigabitEthernet0/1
O        10.0.3.0/24 [110/3] via 10.0.40.2, 00:03:28, GigabitEthernet0/1/0.40
O        10.0.20.0/24 [110/2] via 10.0.40.2, 00:03:28,
GigabitEthernet0/1/0.40
C        10.0.40.0/24 is directly connected, GigabitEthernet0/1/0.40
L        10.0.40.1/32 is directly connected, GigabitEthernet0/1/0.40
```

R6#sh ip ospf neigh

```
Neighbor ID     Pri   State           Dead Time   Address         Interface
5.5.5.2           1   FULL/BDR        00:00:30    10.0.40.2       GigabitEthe
rnet0/1/0.40
5.5.5.1           1   FULL/BDR        00:00:32    10.0.30.2       GigabitEthe
rnet0/1/0.30
```

R6#sh ip vrf Microsoft

```
 Name                             Default RD          Interfaces
 Microsoft                        <not set>           Gi0/0
                                                      Gi0/1/0.30
```

R6#sh ip vrf Google

```
 Name                             Default RD          Interfaces
 Google                           <not set>           Gi0/1
                                                      Gi0/1/0.40
```

Problems

The main issue that I had was finding a strategy to route traffic through the middle router. The original design of the topology did not have VRFs on the middle router, so there was no way for packets to travel from one Provider edge router to another (R4 to R6). At first, I tried using 2 tunnels, one for each VRF, on R4 and R6, to bypass R5. However, the tunnel interface would not go up, even after I set the correct IP address, source interface, and destination address. As a result, there was no routing along all three routers. Then, I tried to use sub-interfaces. I created 2 sub-interfaces on R4 and R6, and 4 sub-interfaces on R5, separating each sub-interface by VRF with the `ip vrf forwarding` command. After adding the new networks to OSPF, I was able to ping from R4 to R6, and there was connectivity across the whole network.

Another issue I had was with the physical topology. The patch panel on my rack did not have a fully functioning console port for R6. I tried to fix the problem by crawling behind my rack and checking the console cable connection on R6, but it was securely in place. I considered using a different router, but I had already put all my cables in and I did not want to waste more time re-cabling. Then, I realized that the routers had individual console ports, so I tried using a console cable to connect to the physical console port on the router, which worked.

Conclusion

Through this lab, I learned the capabilities of Virtual Routing and Forwarding. There are many useful applications for VRF in the workforce, especially for Internet Service Providers and the government. I now understand that sub-interfaces are effective for routing traffic through backbone router, and that tunnels are better to be used with ROAST. Being able to configure VRFs is a very valuable skill to have.