# VRF LAB

# 

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The purpose of this lab is to set up virtual routing and forwarding on 4 Cisco 4321 routers connected to one another in a linear daisy-chain topology (above). Edge routers are connected to switches each with 2 hosts, one of which is in VRF A, the other in VRF B. The goal is for the hosts in each VRF to ping each other without being able to ping hosts in the other VRF.

### Background Information

Virtual Routing and Forwarding or VRF is a feature of routers to simulate the function of multiple independent routers at once. It isn’t the same thing as virtualization (having multiple operating systems on one device) or VLANs (a layer 2-specific virtual network within a switch), rather it is having multiple routing tables operating simultaneously. VRFs were originally developed to partition the same routing domain for multiple organizations in conjunction with an MPLS backbone. “VRF-lite” refers to using Virtual Routing and Forwarding without MPLS, a technique which has become very useful in its own right, especially for applications not requiring scalability (additionally, VPNs can aid VRF-lite scalability). Original VRFs are best suited for WAN service providers whereas VRF-lite is better for enterprise and data center networks. Interestingly, while the output of the *show VRF detail* command is the same on all devices running VRF with MPLS, it is unique for every device running VRF-lite. We will make extensive use of this command in our lab, as we are configuring VRF-lite and need to check every router.

VRFS are in this regard very similar to VLANs, tagging Layer 3 traffic and separating broadcast domains in the same way VLANs do for layer 2. So, while one should use VLANs for independent Ethernet networks on the same devices, they should use VRFs for independent IP networks on the same devices. In our various recreations of this lab, we always used switches at the ends of our network, often with VLANs fed from the VRFs, testifying to the interoperability of these two concepts. VRFs are more secure than VLANs as they are not susceptible to VLAN hopping attacks.

**<** *In my local Cisco lab, VRFs were subject to perverse mockery, rhyming with and being compared to miniature dwarven blue humanoids, reminiscent of the folk of Lilliput from Gulliver’s travels. Our lab honored this trope by including pictures of the creatures in our documentation as well as pictures of a shabbily dressed “sorcerer” with a cartoonishly oafish nose. Additionally, Gabe was referred to as “Brainy Smurf” while I was referred to as “Dopey Smurf”* ***>***

The concept of a VRF can be confusing, so here’s a visual representation to simplify things:

VRF A

VRF C/Global

VRF B

Each shaded oval represents a different VRF as labeled. They are mini-routers, pristine, embedded within their parent body. The same IP addresses can be reused in each VRF as each routing table is distinct. The number of VRFs you can create depends on the capabilities (memory, processing power) of the router and, for older router IOS versions, the protocols being used. Early Cisco routers had protocols linking to different Process Data Blocks, which for instance limited OSPF instances to 30, so there could be only 30 functional VRFs on that one router. Note: VRF C is labeled “global”. Nexus devices, one of the first device families to have operational VRF, are preconfigured with a default VRF and a management VRF. Protocols configured on the Nexus are configured on the default VRF unless specified to be configured in another VRF, hence this VRF is also referred to as a “global routing table”.

The below diagram shows how VRFs link to one another:

In this diagram, the black hoop illustrates the nature of the connection between the VRFs: they can be connected with 802.1q trunks, GRE tunnels, or MPLS tags. In our labs, we mainly used 802.1q trunks in conjunction with VLANs on the switches, although I successfully implemented GRE tunnels later. The hoop also shows that while there are 3 separate links between the routers, physically speaking there is only one. Additionally, note that each virtual link only interacts with Virtual Routers within the same VRF, keeping traffic isolated and preventing customer corporations from accidentally receiving each other’s data or spying on each other. This has very important security applications: the example corporations Mr. Mason had us configure VRFs for in this lab, Apple and Google, are examples of large corporations that might use VRF-lite to segregate routing tables on shared infrastructure rather than each having to develop their own, cutting costs.

Like a normal routing table on a router, VRFs can route protocols as well as IP routes, the protocols will simply have VRF labels after their address families, for example configuring address-family ipv4 vrf “x” under EIGRP will assign networks to the VRF x. As part of this configuration however, one might have to make IPv4 prefixes globally unique with use of Route distinguishers. This is because the same IP addresses can be reused in each VRF as mentioned earlier. RDs don’t belong to a specific VRF, they are just unique routes. There are 3 types of RDs: type 0 consists of a 2-byte ASN and a 4-byte value, type 1 consists of a 4-byte IP and a 2-byte value, type 2 consists of a 4-byte ASN and a 2-byte value. All are separated by a colon. We used type 0 RDs for BGP, I had to further use them for advanced EIGRP configurations, Shared VRFs and GRE tunneling. VRF routes are typically identified in the form RD:IP, this was for example exploited in my GRE tunnel investigation by using the address-family vpnv4 command. Layer 3 Switches, not just routers, can use VRF provided route distinguishers are used. However, this may require repartitioning of the internal ternary content-addressable memory (TCAM), otherwise the “%L3TCAM-3-SIZE\_CONFLICT: VRF requires enabling extended routing” error may occur (we did not encounter this error in the regular lab as we did not enable VRF on the switches, and I did not encounter this error when I enabled VRF on an IOSv switch in GNS3).

Route distinguishers are only half of the story: you need route targets to control the import and export of routes between VRFs. The “route target export” command allows routes to be advertised to neighbors while the “route target import” command allows the router to learn about neighboring routes. Best practice is for all instances of a VRF across the network to learn about all other routes within that VRF on neighboring routers, so one can use “route-target both” to enable both at the same time.

Route targets and RDs can be very important especially when configuring a shared VRF. This special kind of VRF breaks the rule of VRFs not interacting with one another by allowing other VRFs to import its routes through route targets. The next page shows a schematic of what that would look like.

As shown, VRF A and VRF C can access VRF B but not each other. This prevents them from sharing otherwise confidential data with each other. In this diagram, both A and B are importing information from VRF B but not exporting information (that would inadvertently cause A to share with C and vice versa). It could also be done in reverse, where VRF B would be configured to import from VRF A and C. However, this is not scalable as for a lot of VRFs connected to VRF B, there would have to be an equally large number of import statements on one VRF.

#### **To Summarize, VRFs are a cool and efficient way to subdivide a network at layer 3.**

RT import B

RT both A

RT both B

### Lab Summary

We started this lab ahead of the game: I originally was exposed to VRFs by asking about and receiving documentation about them from Advanced CCNP Tyler Chung. At the time, I still needed to finish old labs and was moving on to BGP, so I dabbled with it a bit but left it for later. When I awoke from my dogmatic slumber, I proposed the idea of a VRF lab to my trusty stooge and lab partner, Gabriel Rosas. He was initially very upset that this lab was nothing more than a spin-off of VLANs but for routers, but he overcame this conviction upon reading more source material, and we completed the lab in a then-record time of 2 days, using 2 routers and 2 switches rather than 4 routers. When tasked to redo the lab with 4 routers, we simply added the additional routers between the existing topology, resulting in a beast with 4 routers AND 2 switches. The first day was mostly reading documentation and trying to derive configurations from those doc sources. The second day, I had prepared switch configurations that would integrate with the VRF network, and we successfully implemented VRFs on the routers. A week or so after that, Mr. Mason assigned it to the class, and we adapted our lab as aforementioned. Gabe was primarily responsible for the BGP VRF while I configured the EIGRP VRF. After that, we received our sign-off but I wanted to go further into shared VRFs, and features of VRF I thought might be useful for MPLS as well as security. I did this several months after the lab had been finished due to its

RT import B

RT both C

sheer difficulty: a basic shared VRF configuration is not that hard but to pair it with advanced gateway protocols, access lists, and route distribution added a lot of troubleshooting issues. As a result of this investigation, I also investigated other ways to create links between VRFs and configured VRFs using a GRE tunnel, a configuration which I’ve included here yet which I hope to further develop and spin off into its own little lab on GRE tunnels.

The fact is, because we were only simulating 2 hosts on each end with the PCs, we only needed routers and not switches but I now realize this was a better model of how an actual VRF network would work as there would be multiple hosts on each end of the network, so there would be a need of a layer 2/3 device with multiple ports.

### Lab cOmmands

The original configuration from when we used 2 routers had the VRFs named “Gab” and “Harsha”, later these were changed to “BGP” and “EIGRP”, each of which supported the routing protocols they were named after.

General Configuration

enable: done in user exec mode to trigger privileged exec mode

configure terminal: done in privileged exec mode to trigger global config mode

hostname “x”: assigns a name x to the router

ipv6 unicast-routing: enables ipv6 on the router

interface “x”: opens an interface of name x

ip address <address> <mask>: configures an IP address on an interface

ipv6 address <address>: configures an ipv6 address on an interface

ipv6 address <mask> link-local: configures an ipv6 link-local address on an interface

no shutdown: turns an interface on for use

router eigrp “x”: creates an instance of ipv4 EIGRP with autonomous system number x for you to add ipv4 network statements and other commands

router bgp “x”: creates an instance of BGP with autonomous system number x for you to add network statements and other commands

address-family ipv4 vrf “x”: lets you add network statements and other commands for a certain protocol specified in the previous two commands, within specified VRF x.

network <ip> <mask>: network statement, advertises eigrp/bgp network

encapsulation dot1Q “x”: allows a router subinterface to connect to a switch vlan

switchport mode “x”: configures a trunk or access port on a switch

switchport trunk allowed vlan “x”: allows vlans to cross the trunk

switchport trunk encapsulation dot1q: tells the switch that the interface should use IEEE 802.1Q encapsulation on the frames.

switchport access vlan “x”: assigns a VLAN to an access port

ip route vrf <ip> <mask>: configures a static route within a VRF

VRF Configuration

ip vrf “x”: creates a VRF instance named x. Note that VRF names are case-sensitive.

ip vrf forwarding “x”: enables an interface/subinterface to use VRF x.

rd <ASN>:“x” – type 0 RD. Distinguishes routes from each other. ASN is the autonomous system number of the protocol being distinguished and x is a 4-byte number.

route-target import: allows the router to learn about neighboring routes

route-target export: allows routes to be advertised to neighbors

route-target both: accomplishes both rt export and import

capability vrf-lite: enables vrf-lite on OSPF

*Note that there were relatively few VRF commands listed here as most VRF commands involve modified existing commands, e.g. address-family ipv4 vrf “x”.*

Bonus Configuration

(Extra things like GRE tunnelling that weren’t explicitly part of the VRF lab)

interface Tunnel0: enables GRE tunneling on a tunnel interface

tunnel source “x”: where x is an IP address or an interface.

tunnel destination “x”: where x is a hostname or an IP address.

address-family vpnv4: an address family to support BGP ipv4 coupled with RDs. Note it was configured on the physical routing table rather than any VRF.

tunnel vrf “x”: Associates a VRF with a tunnel destination.

access-list “x” permit/deny <ip> <wildcard mask>: permits/denies a range of IPs from accessing the network with autonomous system number x**\***

route-map <name> permit “x”: redirects routes as part of PBR for autonomous system number x**\***

**\*Abandoned as config was analogous to sign-off config.**

### Network diagram

4 router Lab:

g0/0/0.10&0.20

10.0.0.254 255.255.255.128

g0/0/0.10&0.20

192.168.0.9 255.255.255.252

g0/0/0.10&0.20

192.168.0.5 255.255.255.252

g0/0/0.10&0.20

192.168.0.1 255.255.255.252

S2

S1

g0/0/1.10&1.20

10.0.0.126 255.255.255.128

g0/0/1.10&1.20

192.168.0.10 255.255.255.252

g0/0/1.10&1.20

192.168.0.6 255.255.255.252

g0/0/1.10&1.20

192.168.0.2 255.255.255.252

Shared VRF (IOSvL215 switches in GNS3, original config was 3 routers with 2 switches at the ends):

S3

S1

S2

GRE tunneling w/ VRFs (R1 and R3 are tunnel endpoints):

*I will try to replace this topology with something nicer for a possible GRE lab report.*

### Configurations

2 router lab not included (concepts covered are evident in 4 router lab)

4 router lab (EIGRP & BGP, Mr. Mason signoff):

**S1#sh run**

service timestamps debug uptime

service timestamps log uptime

no service password-encryption

hostname S1

boot-start-marker

boot-end-marker

no aaa new-model

system mtu routing 1500

vtp domain CCNP

vtp mode transparent

crypto pki trustpoint TP-self-signed-1928519808

enrollment selfsigned

subject-name cn=IOS-Self-Signed-Certificate-1928519808

revocation-check none

rsakeypair TP-self-signed-1928519808

spanning-tree mode pvst

spanning-tree extend system-id

vlan internal allocation policy ascending

vlan 2

name forleft

vlan 3

name forright

vlan 10

name voice

vlan 20

name data

vlan 30

name Expedia

vlan 40

name forty

vlan 100

vlan 996

name CUSTOMER\_NATIVE

interface FastEthernet1/0/1

switchport trunk encapsulation dot1q

switchport mode trunk

interface FastEthernet1/0/2

description Gab

switchport access vlan 10

switchport mode access

interface FastEthernet1/0/3

description Harsha

switchport access vlan 20

switchport mode access

interface FastEthernet1/0/4

interface FastEthernet1/0/5

interface FastEthernet1/0/6

interface FastEthernet1/0/7

interface FastEthernet1/0/8

interface FastEthernet1/0/9

interface FastEthernet1/0/10

interface FastEthernet1/0/11

interface FastEthernet1/0/12

interface FastEthernet1/0/13

interface FastEthernet1/0/14

interface FastEthernet1/0/15

interface FastEthernet1/0/16

interface FastEthernet1/0/17

interface FastEthernet1/0/18

interface FastEthernet1/0/19

interface FastEthernet1/0/20

interface FastEthernet1/0/21

interface FastEthernet1/0/22

interface FastEthernet1/0/23

interface FastEthernet1/0/24

interface GigabitEthernet1/0/1

interface GigabitEthernet1/0/2

interface GigabitEthernet1/1/1

speed auto 1000

interface GigabitEthernet1/1/2

speed auto 1000

interface Vlan1

no ip address

shutdown

ip http server

ip http secure-server

logging esm config

line con 0

line vty 0 4

login

line vty 5 15

login

end

**S2#sh run**

service timestamps debug datetime msec

service timestamps log datetime msec

no service password-encryption

hostname S2

boot-start-marker

boot-end-marker

no aaa new-model

system mtu routing 1500

vtp domain CCNP

vtp mode transparent

spanning-tree mode pvst

spanning-tree extend system-id

vlan internal allocation policy ascending

vlan 2

name forleft

vlan 3

name forright

vlan 4

vlan 10

name voice

vlan 20

name data

vlan 30

name Expedia

vlan 100

vlan 996

name CUSTOMER\_NATIVE

interface FastEthernet1/0/1

switchport trunk encapsulation dot1q

switchport trunk allowed vlan 10,20

switchport mode trunk

interface FastEthernet1/0/2

description Gab

switchport mode access

switchport access vlan 10

interface FastEthernet1/0/3

description Harsha

switchport mode access

switchport access vlan 20

interface FastEthernet1/0/4

interface FastEthernet1/0/5

interface FastEthernet1/0/6

interface FastEthernet1/0/7

interface FastEthernet1/0/8

interface FastEthernet1/0/9

interface FastEthernet1/0/10

interface FastEthernet1/0/11

interface FastEthernet1/0/12

interface FastEthernet1/0/13

interface FastEthernet1/0/14

interface FastEthernet1/0/15

interface FastEthernet1/0/16

interface FastEthernet1/0/17

interface FastEthernet1/0/18

interface FastEthernet1/0/19

interface FastEthernet1/0/20

interface FastEthernet1/0/21

interface FastEthernet1/0/22

interface FastEthernet1/0/23

interface FastEthernet1/0/24

interface GigabitEthernet1/0/1

interface GigabitEthernet1/0/2

interface GigabitEthernet1/1/1

speed auto 1000

interface GigabitEthernet1/1/2

speed auto 1000

interface Vlan1

no ip address

shutdown

ip http server

ip http secure-server

logging esm config

line con 0

line vty 0 4

login

line vty 5 15

login

end

**R1#sh run**

hostname R1

boot-start-marker

boot-end-marker

vrf definition Mgmt-intf

address-family ipv4

exit-address-family

address-family ipv6

exit-address-family

no aaa new-model

ip vrf BGP

rd 10:1

ip vrf EIGRP

subscriber templating

multilink bundle-name authenticated

license udi pid ISR4321/K9 sn FDO214421CF

spanning-tree extend system-id

redundancy

mode none

vlan internal allocation policy ascending

interface GigabitEthernet0/0/0

no ip address

negotiation auto

interface GigabitEthernet0/0/0.10

encapsulation dot1Q 10

ip vrf forwarding BGP

ip address 192.168.0.1 255.255.255.252

interface GigabitEthernet0/0/0.20

encapsulation dot1Q 20

ip vrf forwarding EIGRP

ip address 192.168.0.1 255.255.255.252

interface GigabitEthernet0/0/1

no ip address

negotiation auto

interface GigabitEthernet0/0/1.10

encapsulation dot1Q 10

ip vrf forwarding BGP

ip address 10.0.0.126 255.255.255.128

interface GigabitEthernet0/0/1.20

encapsulation dot1Q 20

ip vrf forwarding EIGRP

ip address 10.0.0.126 255.255.255.128

interface Serial0/1/0

no ip address

interface Serial0/1/1

no ip address

interface GigabitEthernet0

vrf forwarding Mgmt-intf

no ip address

negotiation auto

interface Vlan1

no ip address

router eigrp 20

address-family ipv4 vrf EIGRP

network 10.0.0.0

network 192.168.0.0

neighbor 192.168.0.2 GigabitEthernet0/0/0.20

autonomous-system 20

eigrp router-id 1.1.1.1

exit-address-family

router bgp 10

bgp router-id 1.1.1.1

bgp log-neighbor-changes

address-family ipv4 vrf BGP

network 10.0.0.0 mask 255.255.255.128

neighbor 192.168.0.2 remote-as 20

neighbor 192.168.0.2 activate

exit-address-family

ip forward-protocol nd

no ip http server

no ip http secure-server

ip tftp source-interface GigabitEthernet0

control-plane

line con 0

stopbits 1

line aux 0

stopbits 1

line vty 0 4

login

end

**R2#sh run**

hostname R2

boot-start-marker

boot-end-marker

vrf definition Mgmt-intf

address-family ipv4

exit-address-family

address-family ipv6

exit-address-family

no aaa new-model

ip vrf BGP

rd 10:1

ip vrf EIGRP

subscriber templating

multilink bundle-name authenticated

license udi pid ISR4321/K9 sn FDO211216BL

spanning-tree extend system-id

redundancy

mode none

vlan internal allocation policy ascending

interface GigabitEthernet0/0/0

no ip address

negotiation auto

interface GigabitEthernet0/0/0.10

encapsulation dot1Q 10

ip vrf forwarding BGP

ip address 192.168.0.5 255.255.255.252

interface GigabitEthernet0/0/0.20

encapsulation dot1Q 20

ip vrf forwarding EIGRP

ip address 192.168.0.5 255.255.255.252

interface GigabitEthernet0/0/1

no ip address

negotiation auto

interface GigabitEthernet0/0/1.10

encapsulation dot1Q 10

ip vrf forwarding BGP

ip address 192.168.0.2 255.255.255.252

interface GigabitEthernet0/0/1.20

encapsulation dot1Q 20

ip vrf forwarding EIGRP

ip address 192.168.0.2 255.255.255.252

interface Serial0/1/0

no ip address

interface Serial0/1/1

no ip address

interface GigabitEthernet0

vrf forwarding Mgmt-intf

no ip address

negotiation auto

interface Vlan1

no ip address

router eigrp 20

address-family ipv4 vrf EIGRP

network 192.168.0.0 0.0.0.3

network 192.168.0.4 0.0.0.3

neighbor 192.168.0.6 GigabitEthernet0/0/0.20

neighbor 192.168.0.1 GigabitEthernet0/0/1.20

autonomous-system 20

eigrp router-id 2.2.2.2

exit-address-family

router bgp 20

bgp router-id 2.2.2.2

bgp log-neighbor-changes

address-family ipv4 vrf BGP

neighbor 192.168.0.1 remote-as 10

neighbor 192.168.0.1 activate

neighbor 192.168.0.6 remote-as 30

neighbor 192.168.0.6 activate

exit-address-family

ip forward-protocol nd

no ip http server

no ip http secure-server

ip tftp source-interface GigabitEthernet0

control-plane

line con 0

stopbits 1

line aux 0

stopbits 1

line vty 0 4

login

end

**R3#sh run**

hostname R3

boot-start-marker

boot-end-marker

vrf definition Mgmt-intf

address-family ipv4

exit-address-family

address-family ipv6

exit-address-family

no aaa new-model

ip vrf BGP

rd 10:1

ip vrf EIGRP

rd 20:1

route-target export 20:1

route-target import 20:1

subscriber templating

vtp domain cisco

vtp mode transparent

multilink bundle-name authenticated

license udi pid ISR4321/K9 sn FDO214420G7

spanning-tree extend system-id

redundancy

mode none

vlan internal allocation policy ascending

interface GigabitEthernet0/0/0

no ip address

negotiation auto

interface GigabitEthernet0/0/0.10

encapsulation dot1Q 10

ip vrf forwarding BGP

ip address 192.168.0.9 255.255.255.252

interface GigabitEthernet0/0/0.20

encapsulation dot1Q 20

ip vrf forwarding EIGRP

ip address 192.168.0.9 255.255.255.252

interface GigabitEthernet0/0/1

no ip address

negotiation auto

interface GigabitEthernet0/0/1.10

encapsulation dot1Q 10

ip vrf forwarding BGP

ip address 192.168.0.6 255.255.255.252

interface GigabitEthernet0/0/1.20

encapsulation dot1Q 20

ip vrf forwarding EIGRP

ip address 192.168.0.6 255.255.255.252

interface Serial0/1/0

no ip address

shutdown

interface Serial0/1/1

no ip address

shutdown

interface GigabitEthernet0

vrf forwarding Mgmt-intf

no ip address

shutdown

negotiation auto

interface Vlan1

no ip address

shutdown

router eigrp 20

address-family ipv4 vrf EIGRP

network 192.168.0.4 0.0.0.3

network 192.168.0.8 0.0.0.3

neighbor 192.168.0.10 GigabitEthernet0/0/0.20

neighbor 192.168.0.5 GigabitEthernet0/0/1.20

autonomous-system 20

eigrp router-id 3.3.3.3

exit-address-family

router bgp 30

bgp router-id 3.3.3.3

bgp log-neighbor-changes

address-family ipv4 vrf BGP

neighbor 192.168.0.5 remote-as 20

neighbor 192.168.0.5 activate

neighbor 192.168.0.10 remote-as 40

neighbor 192.168.0.10 activate

exit-address-family

ip forward-protocol nd

no ip http server

no ip http secure-server

ip tftp source-interface GigabitEthernet0

control-plane

line con 0

stopbits 1

line aux 0

stopbits 1

line vty 0 4

login

end

**R4#sh run**

hostname R4

boot-start-marker

boot-end-marker

vrf definition Mgmt-intf

address-family ipv4

exit-address-family

address-family ipv6

exit-address-family

no aaa new-model

ip vrf BGP

rd 10:1

ip vrf EIGRP

subscriber templating

vtp domain cisco

vtp mode transparent

multilink bundle-name authenticated

license udi pid ISR4321/K9 sn FDO21442B21

spanning-tree extend system-id

redundancy

mode none

vlan internal allocation policy ascending

interface GigabitEthernet0/0/0

no ip address

negotiation auto

interface GigabitEthernet0/0/0.10

encapsulation dot1Q 10

ip vrf forwarding BGP

ip address 10.0.0.254 255.255.255.128

interface GigabitEthernet0/0/0.20

encapsulation dot1Q 20

ip vrf forwarding EIGRP

ip address 10.0.0.254 255.255.255.128

interface GigabitEthernet0/0/1

no ip address

negotiation auto

interface GigabitEthernet0/0/1.10

encapsulation dot1Q 10

ip vrf forwarding BGP

ip address 192.168.0.10 255.255.255.252

interface GigabitEthernet0/0/1.20

encapsulation dot1Q 20

ip vrf forwarding EIGRP

ip address 192.168.0.10 255.255.255.252

interface Serial0/1/0

no ip address

shutdown

interface Serial0/1/1

no ip address

shutdown

interface GigabitEthernet0/2/0

no ip address

shutdown

negotiation auto

interface GigabitEthernet0/2/1

no ip address

shutdown

negotiation auto

interface GigabitEthernet0

vrf forwarding Mgmt-intf

no ip address

shutdown

negotiation auto

interface Vlan1

no ip address

shutdown

router eigrp 20

address-family ipv4 vrf EIGRP

network 192.168.0.8 0.0.0.3

neighbor 192.168.0.9 GigabitEthernet0/0/1.20

autonomous-system 20

eigrp router-id 4.4.4.4

exit-address-family

router bgp 40

bgp router-id 4.4.4.4

bgp log-neighbor-changes

address-family ipv4 vrf BGP

network 10.0.0.128 mask 255.255.255.128

neighbor 192.168.0.9 remote-as 30

neighbor 192.168.0.9 activate

exit-address-family

ip forward-protocol nd

no ip http server

no ip http secure-server

ip tftp source-interface GigabitEthernet0

control-plane

line con 0

stopbits 1

line aux 0

stopbits 1

line vty 0 4

login

end

**R1#sh ip route vrf BGP**

Routing Table: BGP

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

a - application route

+ - replicated route, % - next hop override, p - overrides from PfR

Gateway of last resort is not set

10.0.0.0/8 is variably subnetted, 3 subnets, 2 masks

C 10.0.0.0/25 is directly connected, GigabitEthernet0/0/1.10

L 10.0.0.126/32 is directly connected, GigabitEthernet0/0/1.10

B 10.0.0.128/25 [20/0] via 192.168.0.2, 00:04:20

192.168.0.0/24 is variably subnetted, 2 subnets, 2 masks

C 192.168.0.0/30 is directly connected, GigabitEthernet0/0/0.10

L 192.168.0.1/32 is directly connected, GigabitEthernet0/0/0.10

**R1#sh ip route vrf EIGRP**

Routing Table: EIGRP

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

a - application route

+ - replicated route, % - next hop override, p - overrides from PfR

Gateway of last resort is not set

10.0.0.0/8 is variably subnetted, 3 subnets, 2 masks

C 10.0.0.0/25 is directly connected, GigabitEthernet0/0/1.20

L 10.0.0.126/32 is directly connected, GigabitEthernet0/0/1.20

D 10.0.0.128/25

[90/28928] via 192.168.0.2, 00:02:15, GigabitEthernet0/0/0.20

192.168.0.0/24 is variably subnetted, 4 subnets, 2 masks

C 192.168.0.0/30 is directly connected, GigabitEthernet0/0/0.20

L 192.168.0.1/32 is directly connected, GigabitEthernet0/0/0.20

D 192.168.0.4/30

[90/3072] via 192.168.0.2, 00:16:21, GigabitEthernet0/0/0.20

D 192.168.0.8/30

[90/3328] via 192.168.0.2, 00:16:17, GigabitEthernet0/0/0.20

**R2#sh ip route vrf BGP**

Routing Table: BGP

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

a - application route

+ - replicated route, % - next hop override, p - overrides from PfR

Gateway of last resort is not set

10.0.0.0/25 is subnetted, 2 subnets

B 10.0.0.0 [20/0] via 192.168.0.1, 00:08:48

B 10.0.0.128 [20/0] via 192.168.0.6, 00:08:05

192.168.0.0/24 is variably subnetted, 4 subnets, 2 masks

C 192.168.0.0/30 is directly connected, GigabitEthernet0/0/1.10

L 192.168.0.2/32 is directly connected, GigabitEthernet0/0/1.10

C 192.168.0.4/30 is directly connected, GigabitEthernet0/0/0.10

L 192.168.0.5/32 is directly connected, GigabitEthernet0/0/0.10

**R2#sh ip route vrf EIGRP**

Routing Table: EIGRP

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

a - application route

+ - replicated route, % - next hop override, p - overrides from PfR

Gateway of last resort is not set

10.0.0.0/25 is subnetted, 2 subnets

D 10.0.0.0

[90/28416] via 192.168.0.1, 00:15:51, GigabitEthernet0/0/1.20

D 10.0.0.128

[90/28672] via 192.168.0.6, 00:00:42, GigabitEthernet0/0/0.20

192.168.0.0/24 is variably subnetted, 5 subnets, 2 masks

C 192.168.0.0/30 is directly connected, GigabitEthernet0/0/1.20

L 192.168.0.2/32 is directly connected, GigabitEthernet0/0/1.20

C 192.168.0.4/30 is directly connected, GigabitEthernet0/0/0.20

L 192.168.0.5/32 is directly connected, GigabitEthernet0/0/0.20

D 192.168.0.8/30

[90/3072] via 192.168.0.6, 00:14:43, GigabitEthernet0/0/0.20

**R3#sh ip route vrf BGP**

Routing Table: BGP

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

a - application route

+ - replicated route, % - next hop override, p - overrides from PfR

Gateway of last resort is not set

10.0.0.0/25 is subnetted, 2 subnets

B 10.0.0.0 [20/0] via 192.168.0.5, 00:09:32

B 10.0.0.128 [20/0] via 192.168.0.10, 00:09:32

192.168.0.0/24 is variably subnetted, 4 subnets, 2 masks

C 192.168.0.4/30 is directly connected, GigabitEthernet0/0/1.10

L 192.168.0.6/32 is directly connected, GigabitEthernet0/0/1.10

C 192.168.0.8/30 is directly connected, GigabitEthernet0/0/0.10

L 192.168.0.9/32 is directly connected, GigabitEthernet0/0/0.10

**R3#sh ip route vrf EIGRP**

Routing Table: EIGRP

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

a - application route

+ - replicated route, % - next hop override, p - overrides from PfR

Gateway of last resort is not set

10.0.0.0/25 is subnetted, 2 subnets

D 10.0.0.0

[90/28672] via 192.168.0.5, 00:17:31, GigabitEthernet0/0/1.20

D 10.0.0.128

[90/28416] via 192.168.0.10, 00:03:29, GigabitEthernet0/0/0.20

192.168.0.0/24 is variably subnetted, 5 subnets, 2 masks

D 192.168.0.0/30

[90/3072] via 192.168.0.5, 00:17:31, GigabitEthernet0/0/1.20

C 192.168.0.4/30 is directly connected, GigabitEthernet0/0/1.20

L 192.168.0.6/32 is directly connected, GigabitEthernet0/0/1.20

C 192.168.0.8/30 is directly connected, GigabitEthernet0/0/0.20

L 192.168.0.9/32 is directly connected, GigabitEthernet0/0/0.20

**R4#sh ip route vrf BGP**

Routing Table: BGP

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

a - application route

+ - replicated route, % - next hop override, p - overrides from PfR

Gateway of last resort is not set

10.0.0.0/8 is variably subnetted, 3 subnets, 2 masks

B 10.0.0.0/25 [20/0] via 192.168.0.9, 00:17:24

C 10.0.0.128/25 is directly connected, GigabitEthernet0/0/0.10

L 10.0.0.254/32 is directly connected, GigabitEthernet0/0/0.10

192.168.0.0/24 is variably subnetted, 2 subnets, 2 masks

C 192.168.0.8/30 is directly connected, GigabitEthernet0/0/1.10

L 192.168.0.10/32 is directly connected, GigabitEthernet0/0/1.10

**R4#sh ip route vrf EIGRP**

Routing Table: EIGRP

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

a - application route

+ - replicated route, % - next hop override, p - overrides from PfR

Gateway of last resort is not set

10.0.0.0/8 is variably subnetted, 3 subnets, 2 masks

D 10.0.0.0/25

[90/28928] via 192.168.0.9, 00:18:22, GigabitEthernet0/0/1.20

C 10.0.0.128/25 is directly connected, GigabitEthernet0/0/0.20

L 10.0.0.254/32 is directly connected, GigabitEthernet0/0/0.20

192.168.0.0/24 is variably subnetted, 4 subnets, 2 masks

D 192.168.0.0/30

[90/3328] via 192.168.0.9, 00:18:22, GigabitEthernet0/0/1.20

D 192.168.0.4/30

[90/3072] via 192.168.0.9, 00:18:26, GigabitEthernet0/0/1.20

C 192.168.0.8/30 is directly connected, GigabitEthernet0/0/1.20

L 192.168.0.10/32 is directly connected, GigabitEthernet0/0/1.20

**R1#sh vrf detail**

VRF BGP (VRF Id = 2); default RD 10:1; default VPNID <not set>

Old CLI format, supports IPv4 only

Flags: 0xC

Interfaces:

Gi0/0/0.10 Gi0/0/1.10

Address family ipv4 unicast (Table ID = 0x2):

Flags: 0x0

No Export VPN route-target communities

No Import VPN route-target communities

No import route-map

No global export route-map

No export route-map

VRF label distribution protocol: not configured

VRF label allocation mode: per-prefix

Address family ipv6 unicast not active

Address family ipv4 multicast not active

VRF EIGRP (VRF Id = 3); default RD <not set>; default VPNID <not set>

Old CLI format, supports IPv4 only

Flags: 0x8

Interfaces:

Gi0/0/0.20 Gi0/0/1.20

Address family ipv4 unicast (Table ID = 0x3):

Flags: 0x0

No Export VPN route-target communities

No Import VPN route-target communities

No import route-map

No global export route-map

No export route-map

VRF label distribution protocol: not configured

VRF label allocation mode: per-prefix

Address family ipv6 unicast not active

Address family ipv4 multicast not active

VRF Mgmt-intf (VRF Id = 1); default RD <not set>; default VPNID <not set>

New CLI format, supports multiple address-families

Flags: 0x1808

Interfaces:

Gi0

Address family ipv4 unicast (Table ID = 0x1):

Flags: 0x0

No Export VPN route-target communities

No Import VPN route-target communities

No import route-map

No global export route-map

No export route-map

VRF label distribution protocol: not configured

VRF label allocation mode: per-prefix

Address family ipv6 unicast (Table ID = 0x1E000001):

Flags: 0x0

No Export VPN route-target communities

No Import VPN route-target communities

No import route-map

No global export route-map

No export route-map

VRF label distribution protocol: not configured

VRF label allocation mode: per-prefix

Address family ipv4 multicast not active

**R2#sh vrf detail**

VRF BGP (VRF Id = 2); default RD 10:1; default VPNID <not set>

Old CLI format, supports IPv4 only

Flags: 0xC

Interfaces:

Gi0/0/0.10 Gi0/0/1.10

Address family ipv4 unicast (Table ID = 0x2):

Flags: 0x0

No Export VPN route-target communities

No Import VPN route-target communities

No import route-map

No global export route-map

No export route-map

VRF label distribution protocol: not configured

VRF label allocation mode: per-prefix

Address family ipv6 unicast not active

Address family ipv4 multicast not active

VRF EIGRP (VRF Id = 3); default RD <not set>; default VPNID <not set>

Old CLI format, supports IPv4 only

Flags: 0x8

Interfaces:

Gi0/0/0.20 Gi0/0/1.20

Address family ipv4 unicast (Table ID = 0x3):

Flags: 0x0

No Export VPN route-target communities

No Import VPN route-target communities

No import route-map

No global export route-map

No export route-map

VRF label distribution protocol: not configured

VRF label allocation mode: per-prefix

Address family ipv6 unicast not active

Address family ipv4 multicast not active

VRF Mgmt-intf (VRF Id = 1); default RD <not set>; default VPNID <not set>

New CLI format, supports multiple address-families

Flags: 0x1808

Interfaces:

Gi0

Address family ipv4 unicast (Table ID = 0x1):

Flags: 0x0

No Export VPN route-target communities

No Import VPN route-target communities

No import route-map

No global export route-map

No export route-map

VRF label distribution protocol: not configured

VRF label allocation mode: per-prefix

Address family ipv6 unicast (Table ID = 0x1E000001):

Flags: 0x0

No Export VPN route-target communities

No Import VPN route-target communities

No import route-map

No global export route-map

No export route-map

VRF label distribution protocol: not configured

VRF label allocation mode: per-prefix

Address family ipv4 multicast not active

Shared VRF:

*Show runs only due to GNS3 error*

hostname S1ip routingno ip domain-lookupip vrf Blue rd 65000:3ip vrf Green rd 65000:2 route-target export 65000:2 route-target import 65000:99ip vrf Red rd 65000:1 route-target export 65000:1 route-target import 65000:99ip vrf Shared rd 65000:99 route-target export 65000:99 route-target import 65000:1 route-target import 65000:2spanning-tree mode pvstspanning-tree extend system-idvlan internal allocation policy ascendinginterface Loopback0 ip address 192.0.2.1 255.255.255.255interface Loopback99

description VOIP Services

ip vrf forwarding Shared

ip address 192.168.99.1 255.255.255.0

interface g0/0

switchport mode dynamic desirable

interface g0/1

switchport mode dynamic desirable

interface g0/2 no switchport ip vrf forwarding Red ip address 172.16.1.2 255.255.255.252interface g0/3 no switchport ip vrf forwarding Green ip address 172.17.1.2 255.255.255.252interface g1/0 no switchport ip vrf forwarding Blue ip address 172.18.1.2 255.255.255.252

interface g1/1

switchport trunk encapsulation dot1q

switchport mode trunk

interface g1/2

switchport trunk encapsulation dot1q

switchport mode trunk

interface Vlan2 ip vrf forwarding Red ip address 172.16.0.1 255.255.255.0interface Vlan3 ip vrf forwarding Green ip address 172.17.0.1 255.255.255.0interface Vlan4 ip vrf forwarding Blue ip address 172.18.0.1 255.255.255.0router ospf 1 vrf Red log-adjacency-changes redistribute bgp 65000 subnets network 0.0.0.0 255.255.255.255 area 0router ospf 2 vrf Green log-adjacency-changes redistribute bgp 65000 subnets network 0.0.0.0 255.255.255.255 area 0router ospf 3 vrf Blue log-adjacency-changes network 0.0.0.0 255.255.255.255 area 0router bgp 65000 no synchronization bgp log-neighbor-changes no auto-summary address-family ipv4 vrf Shared redistribute connected no synchronization exit-address-family address-family ipv4 vrf Red redistribute connected redistribute ospf 1 vrf Red no synchronization exit-address-family address-family ipv4 vrf Green redistribute connected redistribute ospf 2 vrf Green no synchronization exit-address-family address-family ipv4 vrf Blue redistribute connected

redistribute ospf 3 vrf Blue

no synchronization

exit-address-family

hostname S2ip routingno ip domain-lookupip vrf Green rd 65000:2ip vrf Red rd 65000:1spanning-tree mode pvstspanning-tree extend system-idvlan internal allocation policy ascendinginterface g0/0 switchport mode dynamic desirableinterface g0/1 switchport mode dynamic desirable

interface g0/2

switchport trunk encapsulation dot1q

switchport mode trunk

interface Vlan2 ip vrf forwarding Red ip address 172.16.0.2 255.255.255.0interface Vlan3 ip vrf forwarding Green ip address 172.17.0.2 255.255.255.0interface Vlan11 ip vrf forwarding Red ip address 172.16.2.1 255.255.255.0interface Vlan12 ip vrf forwarding Green ip address 172.17.2.1 255.255.255.0router ospf 1 vrf Red log-adjacency-changes passive-interface Vlan11 network 0.0.0.0 255.255.255.255 area 0router ospf 2 vrf Green log-adjacency-changes passive-interface Vlan12 network 0.0.0.0 255.255.255.255 area 0

hostname S3

ip routing

no ip domain-lookup

ip vrf Blue

rd 65000:3

ip vrf Red

rd 65000:1

spanning-tree mode pvst

spanning-tree extend system-id

vlan internal allocation policy ascending

interface g0/0

switchport mode dynamic desirable

interface g0/0

switchport mode dynamic desirable

interface g0/2

switchport trunk encapsulation dot1q

switchport mode trunk

interface Vlan2

ip vrf forwarding Red

ip address 172.16.0.3 255.255.255.0

interface Vlan4

ip vrf forwarding Blue

ip address 172.18.0.3 255.255.255.0

interface Vlan21

ip vrf forwarding Red

ip address 172.16.3.1 255.255.255.0

interface Vlan22

ip vrf forwarding Blue

ip address 172.18.3.1 255.255.255.0

router ospf 1 vrf Red

log-adjacency-changes

passive-interface Vlan21

network 0.0.0.0 255.255.255.255 area 0

router ospf 3 vrf Blue

log-adjacency-changes

passive-interface Vlan22

network 0.0.0.0 255.255.255.255 area 0

GRE tunnels w/ VRFs:

*R2, R5, and R6 were omitted from this list b/c they had only IPs. Access lists permitting GRE can optionally be configured on R2.*

R1#sh run

no ip domain lookup

ip cef

interface Tunnel0

ip address 200.200.200.1 255.255.255.0

tunnel source fa0/0

tunnel destination 20.20.20.3

interface fa0/0

description Connection to R2-CE router

ip address 10.10.10.1 255.255.255.0

ip access-group 100 in

ip access-group 100 out

ip classless

ip route 0.0.0.0 0.0.0.0 Tunnel0

ip route 20.20.20.3 255.255.255.255 10.10.10.2

no ip http server

access-list 100 permit gre host 10.10.10.1 host 20.20.20.3

access-list 100 permit gre host 20.20.20.3 host 10.10.10.1

end

R1#sh ip rout

Codes: 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

Gateway of last resort is 0.0.0.0 to network 0.0.0.0

C 200.200.200.0/24 is directly connected, Tunnel0

20.0.0.0/32 is subnetted, 1 subnets

S 20.20.20.3 [1/0] via 10.10.10.2

10.0.0.0/24 is subnetted, 1 subnets

C 10.10.10.0 is directly connected, FastEthernet0/0

S\* 0.0.0.0/0 is directly connected, Tunnel0

R1#sho int Tunnel0

Tunnel0 is up, line protocol is up

Hardware is Tunnel

Internet address is 200.200.200.1/24

MTU 1514 bytes, BW 9 Kbit/sec, DLY 500000 usec,

reliability 255/255, txload 1/255, rxload 1/255

Encapsulation TUNNEL, loopback not set

Keepalive not set

Tunnel source 10.10.10.1 (FastEthernet0/0), destination 20.20.20.3

Tunnel protocol/transport GRE/IP

Key disabled, sequencing disabled

Checksumming of packets disabled

Tunnel TTL 255

Fast tunneling enabled

Tunnel transmit bandwidth 8000 (kbps)

Tunnel receive bandwidth 8000 (kbps)

Last input never, output never, output hang never

Last clearing of "show interface" counters never

Input queue: 0/75/0/0 (size/max/drops/flushes); Total output drops: 0

Queueing strategy: fifo

Output queue: 0/0 (size/max)

5 minute input rate 0 bits/sec, 0 packets/sec

5 minute output rate 0 bits/sec, 0 packets/sec

0 packets input, 0 bytes, 0 no buffer

Received 0 broadcasts, 0 runts, 0 giants, 0 throttles

0 input errors, 0 CRC, 0 frame, 0 overrun, 0 ignored, 0 abort

0 packets output, 0 bytes, 0 underruns

0 output errors, 0 collisions, 0 interface resets

0 unknown protocol drops

0 output buffer failures, 0 output buffers swapped out

R3#sh run

no ip domain lookup

ip vrf blue

rd 1:1

route-target export 311:311

route-target import 411:411

ip vrf green

rd 2:2

route-target export 322:322

route-target import 422:422

ip cef

interface Tunnel0

ip vrf forwarding green

ip address 200.200.200.3 255.255.255.0

tunnel source fa0/0

tunnel destination 10.10.10.1

tunnel vrf blue

interface fa0/0

ip vrf forwarding blue

ip address 20.20.20.3 255.255.255.0

interface fa0/1

ip address 30.30.30.3 255.255.255.0

tag-switching ip

router bgp 1

no bgp default ipv4-unicast

bgp log-neighbor-changes

neighbor 30.30.30.4 remote-as 1

address-family vpnv4

neighbor 30.30.30.4 activate

neighbor 30.30.30.4 send-community extended

exit-address-family

address-family ipv4 vrf green

redistribute connected

no auto-summary

no synchronization

exit-address-family

address-family ipv4 vrf blue

redistribute connected

no auto-summary

no synchronization

exit-address-family

ip classless

ip route vrf blue 10.10.10.1 255.255.255.255 20.20.20.2

no ip http server

end

R3#sho ip rout

Codes: 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

Gateway of last resort is not set

30.0.0.0/24 is subnetted, 1 subnets

C 30.30.30.0 is directly connected, FastEthernet0/1

R3#sho ip rout vrf blue

Routing Table: blue

Codes: 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

Gateway of last resort is not set

20.0.0.0/24 is subnetted, 1 subnets

C 20.20.20.0 is directly connected, FastEthernet0/0

40.0.0.0/24 is subnetted, 1 subnets

B 40.40.40.0 [200/0] via 30.30.30.4, 01:09:59

10.0.0.0/32 is subnetted, 1 subnets

S 10.10.10.1 [1/0] via 20.20.20.2

R3#sho ip rout vrf green

Routing Table: green

Codes: 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

Gateway of last resort is not set

C 200.200.200.0/24 is directly connected, Tunnel0

100.0.0.0/24 is subnetted, 1 subnets

B 100.100.100.0 [200/0] via 30.30.30.4, 01:10:21

R3#sho int Tunnel0

Tunnel0 is up, line protocol is up

Hardware is Tunnel

Internet address is 200.200.200.3/24

MTU 1514 bytes, BW 9 Kbit/sec, DLY 500000 usec,

reliability 255/255, txload 1/255, rxload 1/255

Encapsulation TUNNEL, loopback not set

Keepalive not set

Tunnel source 20.20.20.3 (FastEthernet0/0), destination 10.10.10.1

Tunnel protocol/transport GRE/IP

Key disabled, sequencing disabled

Checksumming of packets disabled

Tunnel TTL 255

Fast tunneling enabled

Tunnel transmit bandwidth 8000 (kbps)

Tunnel receive bandwidth 8000 (kbps)

Last input never, output never, output hang never

Last clearing of "show interface" counters never

Input queue: 0/75/0/0 (size/max/drops/flushes); Total output drops: 1

Queueing strategy: fifo

Output queue: 0/0 (size/max)

5 minute input rate 0 bits/sec, 0 packets/sec

5 minute output rate 0 bits/sec, 0 packets/sec

7 packets input, 1036 bytes, 0 no buffer

Received 0 broadcasts, 0 runts, 0 giants, 0 throttles

0 input errors, 0 CRC, 0 frame, 0 overrun, 0 ignored, 0 abort

8 packets output, 992 bytes, 0 underruns

0 output errors, 0 collisions, 0 interface resets

0 unknown protocol drops

0 output buffer failures, 0 output buffers swapped out

R4#sh run

no ip domain lookup

ip vrf blue

rd 1:1

route-target export 411:411

route-target import 311:311

ip vrf green

rd 2:2

route-target export 422:422

route-target import 322:322

ip cef

interface fa0/0

ip address 30.30.30.4 255.255.255.0

tag-switching ip

interface fa0/1

ip vrf forwarding green

ip address 100.100.100.4 255.255.255.0

interface fa1/0

ip vrf forwarding blue

ip address 40.40.40.4 255.255.255.0

router bgp 1

no bgp default ipv4-unicast

bgp log-neighbor-changes

neighbor 30.30.30.3 remote-as 1

address-family vpnv4

neighbor 30.30.30.3 activate

neighbor 30.30.30.3 send-community extended

exit-address-family

address-family ipv4 vrf green

redistribute connected

no auto-summary

no synchronization

exit-address-family

address-family ipv4 vrf blue

redistribute connected

no auto-summary

no synchronization

exit-address-family

ip classless

end

R4#sho ip rout

Codes: 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

Gateway of last resort is not set

30.0.0.0/24 is subnetted, 1 subnets

C 30.30.30.0 is directly connected, FastEthernet0/0

R4#sho ip rout vrf blue

Routing Table: blue

Codes: 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

Gateway of last resort is not set

20.0.0.0/24 is subnetted, 1 subnets

B 20.20.20.0 [200/0] via 30.30.30.3, 01:12:22

40.0.0.0/24 is subnetted, 1 subnets

C 40.40.40.0 is directly connected, FastEthernet1/0

R4#sho ip rout vrf green

Routing Table: green

Codes: 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

Gateway of last resort is not set

B 200.200.200.0/24 [200/0] via 30.30.30.3, 01:12:28

100.0.0.0/24 is subnetted, 1 subnets

C 100.100.100.0 is directly connected, FastEthernet0/1

### Problems

Initially, the concept of VRF was hard to wrap our heads around. Once we got that mental block out of our heads, we finished the lab very quickly with no issue.

For when Mr. Mason asked us to redo the lab with 4 routers, I convinced Gabe we should implement BGP rather than OSPF within one of the VRFs. I had some initial trouble with the EIGRP network and neighbor statements as we were using an IP addressing scheme unfamiliar to me. Gabe on the other hand had considerably few issues configuring the BGP VRF, or so he reports. However, when he tried to configure BGP network and neighbor statements, he received the error log message “VRF BGP does not have an RD configured”. Luckily, I had read about this issue and advised him to use route designators, a concept he picked up rather quickly.

The major issue with the GNS3 endeavor was that my documentation was from 2009, and while the text remained the images had all disappeared, so. I worked my way around this issue

The first configuration issue with the advanced shared VRF topology from GNS3 was that the switches were on link autonegotiation by default (which is normal), but the 7200 routers were on half-duplex. I couldn’t change the 7200’s interfaces to accept autonegotiation, so I tried configure the switch interfaces to set a slower interface speed. This also did not work, so I replaced the 7200s with CSR1000vs, which mimicked routers from our physical Newport Cisco Lab better. In the time I took to acquire the CSR1000v, I ported the same configurations to the physical ISR4321s in the Newport Cisco Lab but enjoyed limited success: my IP addressing scheme was poorly realized. Returning to GNS3, I realized that further redesign of the lab would just be repeating the old 4 router lab we got the signoff for, so I abandoned the BGP idea to pursue configuring shared VRFs with route-targets.

The configurations for configuring GRE tunnels were heavily influenced by the official Cisco configs, which are known to have lots of errors, but this time there was remarkably little issue. I recorded several significant differences in the routing tables for the two configs, but this did not seem to affect connectivity or cause any other problems.

### Conclusion

Due to its capacities to split groups of hosts and data (and admittedly, my poor understanding of access lists), VRF has become my most re-visited lab. Perhaps after all this muck with subinterfaces and vpnv4 I will be better at IP addressing for other labs.

