

Virtual Routing Forwarding

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# Purpose

The purpose of this lab was to learn how to separate network traffic using VRF.

# Background Information

VRF or virtual routing and forwarding is an IP-based computer network technology than enables multiple virtual routers on one physical router. VRF works on the layer 3 of the OSI model.

# Lab Summary

In this lab we setup OSPF, ISIS, designed an IPv4 addressing scheme, and configured 2 VRF’s (Russia and Ukraine).

# Lab Commands

* Router(config)# ip vrf Ukraine

This command is used to add a VRF instance to the router

* Router(config)# interface gigabitethernet 0/0/0.1
* Router(config-subint)# encapsulation dot1q 1

These commands enable a sub-interface on the router

* Router(config-subint)# ip vrf forwarding Ukraine

This command binds a VRF to the sub-interface

* Router(config)# router ospf 1 vrf Ukraine

This command enables OSPF on a VRF

# Network Diagram

# Device Configurations

### R1

r1#show run

Building configuration...

Current configuration : 1847 bytes

!

! Last configuration change at 15:47:25 UTC Mon Mar 21 2022

!

version 15.5

service timestamps debug datetime msec

service timestamps log datetime msec

no platform punt-keepalive disable-kernel-core

!

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 russia

!

ip vrf ukraine

!

subscriber templating

multilink bundle-name authenticated

!

license udi pid ISR4321/K9 sn FDO214811ZM

!

spanning-tree extend system-id

!

redundancy

mode none

!

vlan internal allocation policy ascending

!

interface GigabitEthernet0/0/0

no ip address

negotiation auto

!

interface GigabitEthernet0/0/0.1

encapsulation dot1Q 1 native

ip vrf forwarding ukraine

ip address 192.168.0.1 255.255.255.0

!

interface GigabitEthernet0/0/0.2

encapsulation dot1Q 2

ip vrf forwarding russia

ip address 172.16.0.1 255.255.255.0

ip router isis

!

interface GigabitEthernet0/0/1

no ip address

shutdown

negotiation auto

!

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 ospf 1 vrf ukraine

router-id 1.1.1.1

network 192.168.0.0 0.0.0.255 area 0

!

router isis

vrf russia

net 49.0001.0000.0000.000a.00

!

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#show ip route vrf ukraine

Routing Table: ukraine

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

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

C 192.168.0.0/24 is directly connected, GigabitEthernet0/0/0.1

L 192.168.0.1/32 is directly connected, GigabitEthernet0/0/0.1

O 192.168.1.0/24 [110/2] via 192.168.0.2, 3d00h, GigabitEthernet0/0/0.1

O 192.168.2.0/24 [110/3] via 192.168.0.2, 3d00h, GigabitEthernet0/0/0.1

r1#show ip route vrf russia

Routing Table: russia

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

172.16.0.0/16 is variably subnetted, 4 subnets, 2 masks

C 172.16.0.0/24 is directly connected, GigabitEthernet0/0/0.2

L 172.16.0.1/32 is directly connected, GigabitEthernet0/0/0.2

i L1 172.16.1.0/24 [115/20] via 172.16.0.2, 3d00h, GigabitEthernet0/0/0.2

i L1 172.16.2.0/24 [115/30] via 172.16.0.2, 3d00h, GigabitEthernet0/0/0.2

### R2

r2#show run

Building configuration...

Current configuration : 2143 bytes

!

! Last configuration change at 16:01:30 UTC Mon Mar 21 2022

!

version 15.5

service timestamps debug datetime msec

service timestamps log datetime msec

no platform punt-keepalive disable-kernel-core

!

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 russia

!

ip vrf ukraine

!

subscriber templating

multilink bundle-name authenticated

!

license udi pid ISR4321/K9 sn FDO214414TX

!

spanning-tree extend system-id

!

redundancy

mode none

!

vlan internal allocation policy ascending

!

interface GigabitEthernet0/0/0

no ip address

negotiation auto

!

interface GigabitEthernet0/0/0.1

encapsulation dot1Q 1 native

ip vrf forwarding ukraine

ip address 192.168.1.1 255.255.255.0

!

interface GigabitEthernet0/0/0.2

encapsulation dot1Q 2

ip vrf forwarding russia

ip address 172.16.1.1 255.255.255.0

ip router isis

!

interface GigabitEthernet0/0/1

no ip address

negotiation auto

!

interface GigabitEthernet0/0/1.1

encapsulation dot1Q 1 native

ip vrf forwarding ukraine

ip address 192.168.0.2 255.255.255.0

!

interface GigabitEthernet0/0/1.2

encapsulation dot1Q 2

ip vrf forwarding russia

ip address 172.16.0.2 255.255.255.0

ip router isis

!

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 ospf 1 vrf ukraine

router-id 2.2.2.2

network 192.168.0.0 0.0.0.255 area 0

network 192.168.1.0 0.0.0.255 area 0

!

router isis

vrf russia

net 49.0001.0000.0000.000b.00

!

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#show ip route vrf ukraine

### Routing Table: ukraine

### 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

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

### C 192.168.0.0/24 is directly connected, GigabitEthernet0/0/1.1

### L 192.168.0.2/32 is directly connected, GigabitEthernet0/0/1.1

### 192.168.1.0/24 is variably subnetted, 2 subnets, 2 masks

### C 192.168.1.0/24 is directly connected, GigabitEthernet0/0/0.1

### L 192.168.1.1/32 is directly connected, GigabitEthernet0/0/0.1

### O 192.168.2.0/24 [110/2] via 192.168.1.2, 3d00h, GigabitEthernet0/0/0.1

r2#show ip route vrf russia

Routing Table: russia

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

172.16.0.0/16 is variably subnetted, 5 subnets, 2 masks

C 172.16.0.0/24 is directly connected, GigabitEthernet0/0/1.2

L 172.16.0.2/32 is directly connected, GigabitEthernet0/0/1.2

C 172.16.1.0/24 is directly connected, GigabitEthernet0/0/0.2

L 172.16.1.1/32 is directly connected, GigabitEthernet0/0/0.2

i L1 172.16.2.0/24 [115/20] via 172.16.1.2, 3d00h, GigabitEthernet0/0/0.2

### R3

r3#show run

Building configuration...

Current configuration : 2048 bytes

!

! Last configuration change at 16:03:27 UTC Tue Mar 22 2022

!

version 15.5

service timestamps debug datetime msec

service timestamps log datetime msec

no platform punt-keepalive disable-kernel-core

!

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 russia

!

ip vrf ukraine

!

subscriber templating

multilink bundle-name authenticated

!

license udi pid ISR4321/K9 sn FDO214328EH

!

spanning-tree extend system-id

!

redundancy

mode none

!

vlan internal allocation policy ascending

!

interface GigabitEthernet0/0/0

no ip address

negotiation auto

!

interface GigabitEthernet0/0/0.1

encapsulation dot1Q 1 native

ip vrf forwarding ukraine

ip address 192.168.2.1 255.255.255.0

!

interface GigabitEthernet0/0/0.2

encapsulation dot1Q 2

ip vrf forwarding russia

ip address 172.16.2.1 255.255.255.0

ip router isis

!

interface GigabitEthernet0/0/1

no ip address

negotiation auto

!

interface GigabitEthernet0/0/1.1

encapsulation dot1Q 1 native

ip vrf forwarding ukraine

ip address 192.168.1.2 255.255.255.0

!

interface GigabitEthernet0/0/1.2

encapsulation dot1Q 2

ip vrf forwarding russia

ip address 172.16.1.2 255.255.255.0

ip router isis

!

interface Serial0/1/0

no ip address

shutdown

!

interface Serial0/1/1

no ip address

shutdown

!

interface Service-Engine0/2/0

no ip address

shutdown

!

interface GigabitEthernet0

vrf forwarding Mgmt-intf

no ip address

shutdown

negotiation auto

!

interface Vlan1

no ip address

shutdown

!

router ospf 1 vrf ukraine

router-id 3.3.3.3

network 192.168.1.0 0.0.0.255 area 0

network 192.168.2.0 0.0.0.255 area 0

!

router isis

vrf russia

net 49.0001.0000.0000.000c.00

!

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#show ip route vrf ukraine

Routing Table: ukraine

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

O 192.168.0.0/24 [110/2] via 192.168.1.1, 3d00h, GigabitEthernet0/0/1.1

192.168.1.0/24 is variably subnetted, 2 subnets, 2 masks

C 192.168.1.0/24 is directly connected, GigabitEthernet0/0/1.1

L 192.168.1.2/32 is directly connected, GigabitEthernet0/0/1.1

192.168.2.0/24 is variably subnetted, 2 subnets, 2 masks

C 192.168.2.0/24 is directly connected, GigabitEthernet0/0/0.1

L 192.168.2.1/32 is directly connected, GigabitEthernet0/0/0.1

r3#show ip route vrf russia

Routing Table: russia

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

172.16.0.0/16 is variably subnetted, 5 subnets, 2 masks

i L1 172.16.0.0/24 [115/20] via 172.16.1.1, 3d00h, GigabitEthernet0/0/1.2

C 172.16.1.0/24 is directly connected, GigabitEthernet0/0/1.2

L 172.16.1.2/32 is directly connected, GigabitEthernet0/0/1.2

C 172.16.2.0/24 is directly connected, GigabitEthernet0/0/0.2

L 172.16.2.1/32 is directly connected, GigabitEthernet0/0/0.2

### R4

r4#show run

Building configuration...

Current configuration : 1868 bytes

!

! Last configuration change at 15:52:17 UTC Tue Mar 22 2022

!

version 15.5

service timestamps debug datetime msec

service timestamps log datetime msec

no platform punt-keepalive disable-kernel-core

!

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 russia

!

ip vrf ukraine

!

subscriber templating

vtp mode transparent

multilink bundle-name authenticated

!

license udi pid ISR4321/K9 sn FDO210907U3

!

spanning-tree extend system-id

!

redundancy

mode none

!

vlan internal allocation policy ascending

!

interface GigabitEthernet0/0/0

no ip address

shutdown

negotiation auto

!

interface GigabitEthernet0/0/1

no ip address

negotiation auto

!

interface GigabitEthernet0/0/1.1

encapsulation dot1Q 1 native

ip vrf forwarding ukraine

ip address 192.168.2.2 255.255.255.0

!

interface GigabitEthernet0/0/1.2

encapsulation dot1Q 2

ip vrf forwarding russia

ip address 172.16.2.2 255.255.255.0

ip router isis

!

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 ospf 1 vrf ukraine

router-id 4.4.4.4

network 192.168.2.0 0.0.0.255 area 0

!

router isis

vrf russia

net 49.0001.0000.0000.000d.00

!

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#show ip route vrf ukraine

Routing Table: ukraine

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

O 192.168.0.0/24 [110/3] via 192.168.2.1, 3d00h, GigabitEthernet0/0/1.1

O 192.168.1.0/24 [110/2] via 192.168.2.1, 3d00h, GigabitEthernet0/0/1.1

192.168.2.0/24 is variably subnetted, 2 subnets, 2 masks

C 192.168.2.0/24 is directly connected, GigabitEthernet0/0/1.1

L 192.168.2.2/32 is directly connected, GigabitEthernet0/0/1.1

r4#show ip route vrf russia

Routing Table: russia

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

172.16.0.0/16 is variably subnetted, 4 subnets, 2 masks

i L1 172.16.0.0/24 [115/30] via 172.16.2.1, 3d00h, GigabitEthernet0/0/1.2

i L1 172.16.1.0/24 [115/20] via 172.16.2.1, 3d00h, GigabitEthernet0/0/1.2

C 172.16.2.0/24 is directly connected, GigabitEthernet0/0/1.2

L 172.16.2.2/32 is directly connected, GigabitEthernet0/0/1.2

# Problems

In this lab we encountered some difficulty configuring sub-interfaces, this was because we forgot to pass the encapsulation dot1q command.

# Conclusion

In summary, we configured OSPF, ISIS, sub-interfaces, and 2 networks separated by VRF.