VRF lite for Dell Networking N-Series

Dell Networking Solutions Engineering
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A Dell EMC Deployment and Configuration Guide

Revisions

Date	Description	Author
February 2016	Added BGP VRF Lite Section – Version 1.1	Sambhu Kalaga, Victor Teeter
January 2015	Initial Release - Version 1.0	Victor Teeter

Contents

Executive Summary

Virtual Routing and Forwarding (VRF) allows a physical layer 3 switch or router to be partitioned into multiple Virtual Routers (VRs). VRF isolates the control and data planes in each VR so that traffic does not flow across VRs, thus allowing multiple routing tables to co-exist within one physical L3 switch/router at the same time. Route leaking VRF routes to and from the global routing table (consisting of ports that are not members of any VRF) is also supported, which allows traffic to flow outside of the VRF. Dell Networking N3xxx and N4xxx switches running firmware version 6.2 or later can take advantage of these features.

VRF Lite is VRF deployment without MPLS. There are several benefits to implementing VRF lite. The ability to configure multiple VRs in a single switch/router reduces physical equipment required, creating a sizable cost advantage. VRs also allow more efficient updates by requiring upgrades to only a single switch/router instead of several. VRs also enable customers to test configurations on the same equipment used in a proven production environment, making new additions easier to implement.

This document provides instructions for and examples of deploying VRF lite on Dell N-Series switches.

1 Introduction

Dell Networking provides customers with the most efficient use of current networking equipment at the lowest cost, while still providing today's great new technologies focused around the explosive data growth in the industry. The various application demands have driven the need for increased bandwidth, lower latency and converged infrastructure in today's networks. Dell EMC's portfolio covers all these key areas to provide the best in service and customer experience.

Today's businesses find it difficult to keep pace with the changing networking and Enterprise landscape. With limited resources, they must support a variety of devices that provide key business functions, deliver IT services that are reliable and flexible, and provide discernible cost savings.

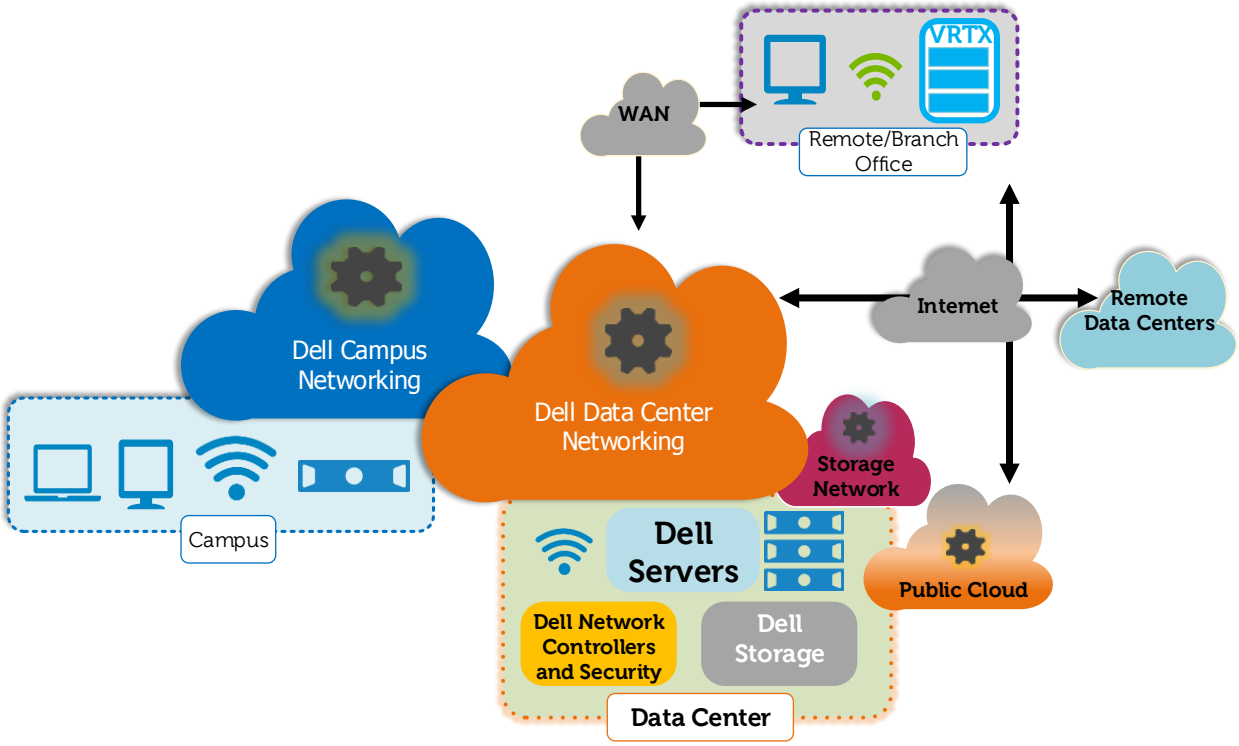

Figure 1 Networking architecture overview

This document is designed as a supplement to the *Dell N-Series User Guide* and provides easy step-by-step instructions to help users set up and configure Dell N-Series switches to use the VRF lite features. VRF lite is VRF without Multiprotocol Label Switching (MPLS) support. Each VRF instance is a separate routing table within the same layer3 switch. Each of these routing table instances are isolated from each other in a layer 3 domain, similar to how different VLANs are isolated from each other in layer 2 domain. By creating multiple VRF instances, the restrictions of multiple overlapping address spaces is no longer an issue.

Note: Each VRF domain (instance) is a separate routing table

The VRF Lite examples in this document use Dell Networking N3xxx and N4xxx switches. Any N-Series switch that supports Layer 3 routing and is running firmware **version 6.3 or later** accepts the commands in this paper for configuring VRF lite. As of this writing, the following N-Series models offer VRF lite:

N3024	N3048	N4064
N3024P	N3048P	N4032F
N3024F	N4032	N4064F

Note: N-Series switches that do not support Layer 3 routing (e.g. N2xxx) do not support VRF lite

Figure 2 illustrates the primary network topology represented throughout this guide. There are two branch offices in this example, each with two N3xxx switches that require routes to each other, but isolation from the other branch. An N4xxx 10GbE switch is located at the Main Office and is configured to use VRF to create two virtual routers.

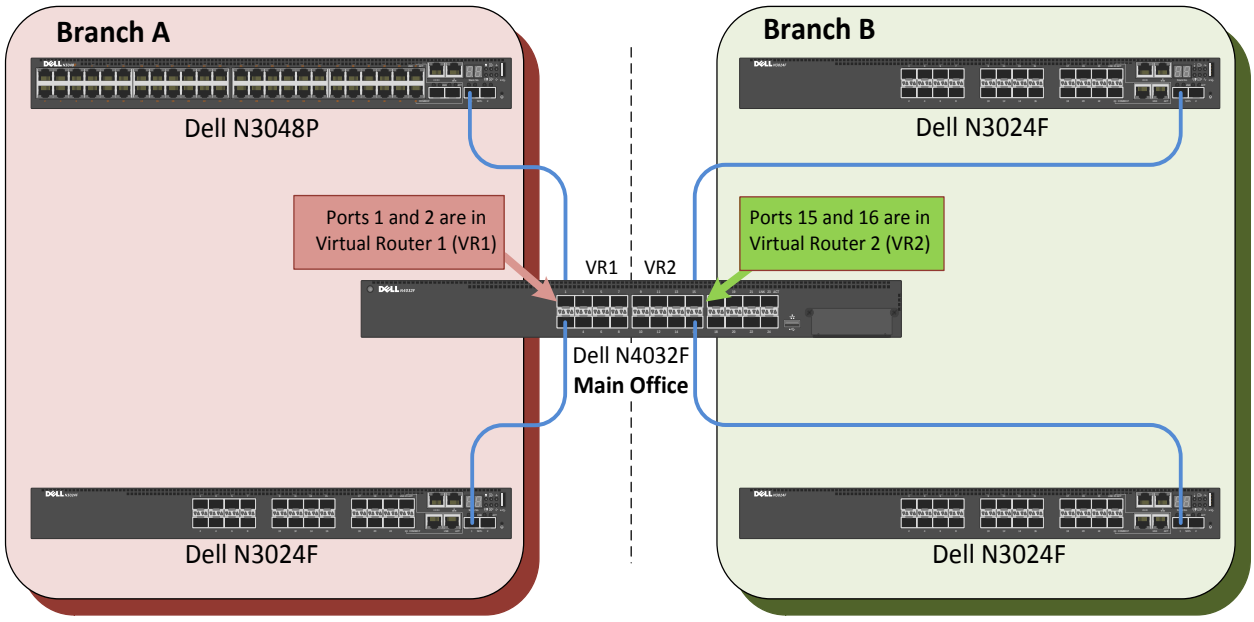

Figure 2 VRF lite Example Topology

The N4xxx switch uses two VRs to route traffic between the two switches in Branch A (using VR1), as well as between the two switches in Branch B (using VR2). Separate routing tables ensure that the two branches are only aware of their own routes.

Split a single, layer 3 switch into two or more layer 3 switches to form a multi-tenancy state. Multi-tenancy is the principle that allows a single instance of software to operate on a device that services

multiple groups, with each group sharing the software and hardware device. In the case of a layer 3 switch running VRF lite, each group has its own ports and configuration on the switch (including routing tables) allowing for isolation of data, private user management, and other reserved functionality. All VRs on the switch, however, still share the same physical components and resources within the switch including memory, firmware, power supply, etc. This contrasts with *multi-instance* designs, which use separate software and hardware on behalf of each group or tenant.

Considerations

- Global route leaking is allowed from and to VRF instances. Route leaking is not allowed between VRF instances.
- Any static or dynamic route can be leaked or distributed to the default router interfaces through static route commands.
- Since each VR has its own routing table, IP addresses can overlap among different VRF instances. Therefore, it is important to consider IP addresses when leaking routes.
- Each L3 interface can only belong to one unique VRF instance.
- Physical routers do not exchange VRF information that has only local significance.
- N4XXX switches accept a maximum of 52 VRFs, while N3XXX switches accept a maximum of 12 VRFs.
- All VRF instances share the physical switch's resources (loopbacks, routing table, ARP table entries, Mbufs), but switch administration can subdivide and reserve these resources for particular VRF instances.
- VRF lite is VRF without MPLS support.
- Any VRF instance may use any individual port.

VRF lite provides support for Border Gateway protocol (BGP) when using firmware version 6.3 or later. VRF lite provides support for other protocols such as Open Shortest Path First (OSPF), Virtual Router Redundancy Protocol (VRRP), IP Helper/DHCP Relay, IP Source Guard/DHCP Snooping, Static routing, Internet Control Message Protocol (ICMP), Route leaking, Ping, Traceroute and SNMPv2/v3 when using firmware version 6.2 or later.

2 Simple VRF Example

In this example, two branch offices that route traffic through the Main Office are directly connected. Each branch has two N3xxx switches that require routes to each other, but isolation from the other "competing" branch. The Main Office houses an N4xxx 10GbE switch configured to use VRF to create two virtual routers (VRs). Each VR isolates the traffic for its associated branch.

Each branch is unaware of the IP subnets and routing table of the other branch and can therefore overlap IP addresses without impairing to either network.

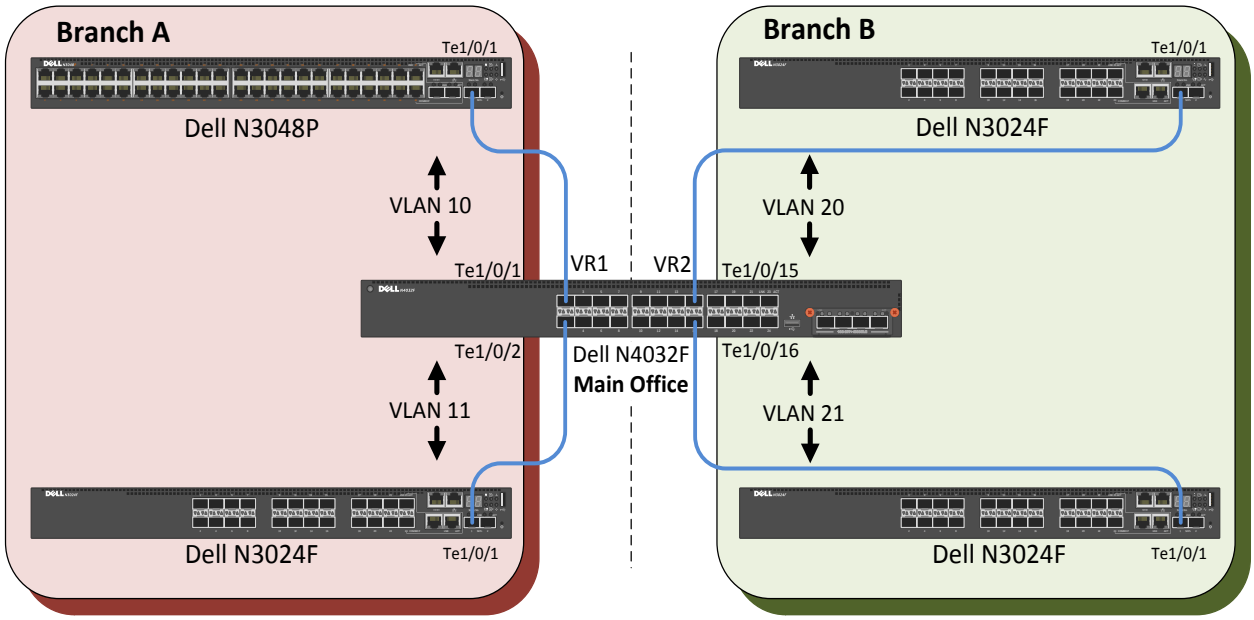

Figure 3 A Simple VRF Configuration

Enter the following CLI commands to configure an initial VRF scenario like the one shown in Figure 3. The following tables also provide explanations of each CLI command:

Note: The first five configuration files attached in the left margin of this document may be used to copy and paste directly into each switch's CLI. The files pertaining to this example are titled "Simple-VRF". Click the paperclip icon to open and close the attachment list.

N4032F (Main Office)	Description of Commands
	Configure VR1 (Branch A) VR

configure
  vlan 10-11
  exit
	< create two VLANs for VR1

interface Te1/0/1
  switchport access vlan 10
  interface Te1/0/2
  switchport access vlan 11
  exit
	< assign each VLAN to an interface for VR1

ip vrf brancha
  ip routing
  exit
	< create VR1 (brancha) and enable routing

interface vlan 10
  ip address 192.168.10.1 /24
  ip vrf forwarding brancha
 	
interface vlan 11
  ip address 192.168.11.1 /24
  ip vrf forwarding brancha
  exit
exit
	< assign an IP address to the first VR1 interface
	< put the VLAN interface into VR1 (brancha)
	< assign an IP address to the 2nd VR1 interface
	< put the VLAN interface into VR1 (brancha)

	Configure VR2 (Branch B) VR

configure
  vlan 20-21
  exit
	< create two VLANs for VR2

interface Te1/0/15
  switchport access vlan 20
interface Te1/0/16
  switchport access vlan 21
  exit
	< assign each VLAN to an interface on VR2

ip vrf branchb
  ip routing
  exit
	< create VR2 (branchb) and enable routing

interface vlan 20
  ip address 192.168.20.1 /24
  ip vrf forwarding branchb
 	
interface vlan 21
  ip address 192.168.21.1 /24
  ip vrf forwarding branchb
  exit
	< assign an IP address to the first VR2 interface
	< put the VLAN interface into VR2 (branchb)
	< assign an IP address to the 2nd VR2 interface
	< put the VLAN interface into VR2 (branchb)

ip routing exit	< enable routing globally across the physical switch

Add a VLAN to each switch in Branch A and connect to the router.

Branch A (Top Switch)	Description of Commands
	Configure the N3048P (Top Switch) for Branch A

`configure`
`  vlan 10`
`  exit`
	< create a VLAN for Branch A

`interface vlan 10` `  ip address 192.168.10.2 /24`	< assign an IP address to the VLAN

`interface Te1/0/1`
`  switchport access vlan 10`
`  exit`
	< assign an untagged port to the VLAN

`ip default-gateway 192.168.10.1` `exit`	< set the default gateway to the IP address of the Main Office interface
`ping 192.168.10.1`	< ping the Main Office to verify connectivity

The commands in the following table , entered from the N4032F (Main Office) switch, also test connectivity.

- Use this command to ping the brancha top switch: **`ping vrf brancha 192.168.10.2`**
- Use this command to show VRF VLAN information: **`show ip route vrf brancha`**

Branch A (Bottom Switch)	Description of Commands
	Configure the N3024F (Bottom Switch) for Branch A

`configure`
`  vlan 11`
`  exit`
	< create another VLAN for Branch A

`interface vlan 11` `  ip address 192.168.11.2 /24`	< assign an IP address to the VLAN

`interface Te1/0/1`
`  switchport access vlan 11`
`  exit`
	< assign an untagged port to the VLAN

`ip default-gateway 192.168.11.1` `exit`	< set the default gateway to the IP address of the Main Office

`ping 192.168.11.1`
 	
`ping 192.168.10.2`
	< ping the Main Office to verify connectivity
	< ping the top Branch A switch to verify end-to-end connectivity

The commands from the following table, entered from the N4032F (Main Office) switch, also test connectivity.

- Use this command to ping the brancha bottom switch: **`ping vrf brancha 192.168.11.2`**
- Use this command to show VRF VLAN information: **`show ip route vrf brancha`**

Add a VLAN to each switch in Branch B and connect to the router.

Branch B (Top Switch)	Description of Commands
	Configure the N3024F (Top Switch) for Branch B

`configure`
`  vlan 20`
`  exit`
	< create a VLAN for Branch B

`interface vlan 20` `  ip address 192.168.20.2 /24`	< assign an IP address to the VLAN

`interface Te1/0/1`
`  switchport access vlan 20`
`  exit`
	< assign an untagged port to the VLAN

`ip default-gateway 192.168.20.1` `exit`	< set the default gateway to the IP address of the Main Office
`ping 192.168.20.1`	< ping the Main Office switch to verify connectivity

The commands from the following table, entered from the N4032F (Main Office) switch, also test connectivity.

- Use this command to ping the branchb top switch: **`ping vrf branchb 192.168.20.2`**
- Use this command to show VRF VLAN information: **`show ip route vrf  branchb`**

Branch B (Bottom Switch)	Description of Commands
	Configure the N3024F (Bottom Switch) for Branch B

`configure`
`  vlan 21`
`  exit`
	< create another VLAN for Branch B

`interface vlan 21` `  ip address 192.168.21.2 /24`	< assign an IP address to the VLAN

`interface Te1/0/1`
`  switchport access vlan 21`
`  exit`
	< assign an untagged port to the VLAN

`ip default-gateway 192.168.21.1` `exit`	< set the default gateway to the IP address of the Main Office
`ping 192.168.21.1`	< ping the Main Office to verify connectivity
`ping 192.168.20.2`	< ping the top Branch B switch to verify end-to-end connectivity

The following commands, entered from the N4032F (Main Office) switch, also test connectivity.

- Use this command to ping the branchb bottom switch: **`ping vrf branchb 192.168.21.2`**
- Use this command to show VRF VLAN information: **`show ip route vrf branchb`**

Note: Remember to save the configuration after verifying proper behavior.

3 BGP on VRF lite

BGP is a large-scale routing protocol used to communicate routing information between autonomous systems (ASs), which are well-defined, separately administered network domains. In this example, there is a main office and a branch office, each of which is a separately administered network domain at a different location and connected by customer-edge, layer 3, N4048 switch using BGP as external gateway protocol to the provider edge router. Each office has three departments (CEO, finance and IT), separately connected using multiple layer 3, N3048 switches to the N4048 switch using OSPF as internal gateway protocol. The same departments at different offices have to exchange routes with each other, but not with the other departments. That is, the Main Office finance department has to exchange routes with the Branch Office finance department and the Main Office IT department exchanges routes with the Branch Office IT department. Only like-departments exchange routes between main and branch offices. However, CEO Office has to exchange routes with Finance and IT departments, without IT and Finance exchanging routes with each other.

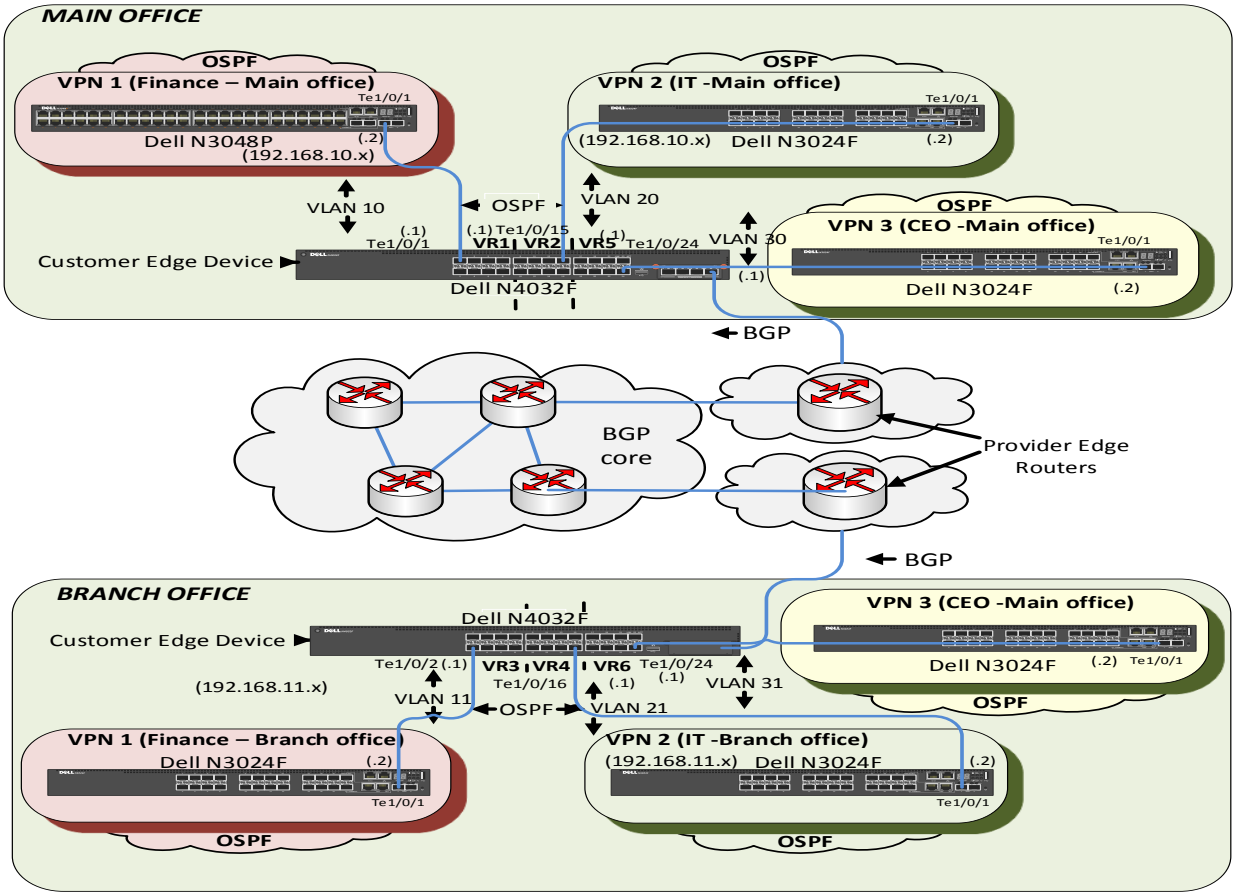

Figure 4 BGP on VRF lite

In this example, N4032 layer 3 switches achieve route exchanges within same department across different offices by configuring BGP with different VR domains. Create six VRs (VR1, VR2, VR3, VR4, VR5 and VR6) across the two layer 3 switches as shown in Figure 5. VR1 and VR3 share routing information between themselves. Likewise, VR2 and VR4, VR5 and VR6 share their routing information.

Note: To simplify this in-lab validation, we have directly connected two customer-edge devices and enabled BGP VRF lite. Provider-edge routers (that is, ISP) configuration is not in the scope of this document. Provider-edge routers must support BGP VRF lite.

Each branch is unaware of the IP subnets and routing table of the other branch and can therefore can overlap IP addresses without impairing either network. A route distinguisher keeps track of these overlapping IP routes belonging to different branches. As the name implies, a route distinguisher distinguishes one set of routes (one VRF) from another. The route distinguisher is a unique number prepended to each route within a VRF to identify it as belonging to that particular VRF or branch. The route distinguisher is carried with traffic along its route via Multiprotocol BGP (MP-BGP) when exchanging VPN routes with other PE routers. For simplicity and route target validation, this example is designed to have non-overlapping IP addresses.

While route distinguishers maintain uniqueness among identical routes in different VRFs, route targets share routes among different VRFs. Route targets applied to VRFs import and export routes among VRFs. The CEO office applies route targets to its VRFs (VR5,VR6) to import routes from both the Finance (VR1,VR2) and IT departments (VR3,VR4).

The following tables include CLI configurations for Branch Office, Main Office, Main Office Finance, Main Office IT, Main Office CEO, Branch Office Finance, Branch Office IT and Branch Office CEO. The following table also provides explanations of each CLI command.

OSPF inter-area routes are sent through IXIA to the following switches Finance branch (70.10.x.x), IT branch (50.10.x.x) and CEO branch (40.10.x.x) connected to the Main Office and Finance branch (60.10.x.x) switch connected to the Branch Office for validating this example. The show commands for IP routes on the switches follow the configuration tables.

Note: Use the six configuration files attached in the left margin of this document to copy and paste directly into each switch's CLI. The files pertaining to this example are titled "BGP". Click the paperclip icon to open and close the attachment list. This method requires allowing 60 seconds after pasting the final configuration before pinging across the network. Execute the show commands after the 60 seconds delay.

N4032F (Main Office Switch Configurations)	Description of Commands
	Configure VR1 (Finance - brancha) VR

configure
  vlan 10,12
  exit
	< create two VLANs for VR1

interface Te1/0/1 switchport access vlan 10	< assign a VLAN to an interface for VR1

interface Te1/0/3
  switchport mode trunk
  switchport trunk allowed vlan 12
  exit
	< configure the interface in trunk mode
	< assign VLAN to an interface going to provider edge routers in trunk mode

ip vrf brancha
  rd 100:1000
  route-target export 100:1000
  exit
	< create VR1 (brancha) and enable routing
	< create route distinguisher
	< export routes from brancha

interface vlan 10
  ip vrf forwarding brancha
  ip address 192.168.10.1 /24
  ip ospf area 0
	< put the VLAN interface into VR1 (brancha)
	< assign an IP address
	< configure the VLAN in OSPF area

interface vlan 12
  ip vrf forwarding brancha
  ip address 192.168.12.1 /24
  exit
	< put the VLAN interface into VR1 (brancha)
	< assign an IP address

ip routing	< enable IP routing

router ospf vrf "brancha"
  router-id 7.7.7.7.1
  redistribute bgp subnets
  exit
	< specify OSPF for brancha
	< enable OSPF router-id
	< redistribute BGP subnets in ospf

router bgp 100
  bgp router-id 192.24.24.3
  address-family ipv4 vrf brancha
 	
  neighbor 192.168.12.2 remote-as 200
  redistribute connected
  redistribute ospf
  exit
  exit
	< specify BGP for brancha
	< enable BGP router-id
	< enable address family ipv vrf-family ipv4 vrf brancha
	< enable neighbor with remote-as
	
	< enable redistribute-connected
	< enable redistribute-OSPF
	< exit
	< exit

Configure VR2 (IT - branchb) VR

```
configure
  vlan 20,22
  exit

interface Te1/0/2
  switchport access vlan 20

interface Te1/0/3
  switchport trunk allowed vlan add
22
  exit

ip vrf branchb
  rd 100:2000
  route-target export 100:2000
  exit

interface vlan 20
  ip vrf forwarding branchb
  ip address 192.168.20.1 /24
  ip ospf area 0


interface vlan 22
  ip vrf forwarding branchb
  ip address 192.168.12.1 /24
  exit

router ospf vrf branchb
  router-id 8.8.8.1
  redistribute bgp subnets
  exit


router bgp 100
  address-family ipv4 vrf branchb

  neighbor 192.168.12.2 remote-as 200
  redistribute connected
  redistribute ospf
  exit
exit
```

< create two VLANs for VR2

< assign a VLAN to an interface for VR2

< assign VLAN 22 to an interface going to provider edge routers in trunk mode

< create VR2 (branchb) and enable routing
< create a route distinguisher
< export routes from branchb

< put the VLAN interface into VR2 (branchb)
< assign an IP address
< configure the VLAN OSPF area

< put the VLAN interface into VR2 (branchb)
< assign an IP address

< specify OSPF for *branchb*
< provide a router ID
< select route redistribution source protocol

< specify BGP for branchb
< enable address family ipv vrf-family ipv4 vrf branchb
< enable neighbor remote-as
< enable redistribute-connected
< enable redistribute-OSPF

	Configure VR5 (CEO - branchc) VR

configure
  vlan 30,32
  exit
	< create two VLANs for VR3

interface Te1/0/4 switchport access vlan 30	< assign a VLAN to an interface for VR2

interface Te1/0/3
  switchport trunk allowed vlan add 32
  exit
	< assign VLAN 22 to an interface going to provider edge routers in trunk mode

ip vrf branchc
  rd 100:3000
  route-target import 100:1000
  route-target import 100:2000
  exit
	< create VR5 (branchc) and enable routing
	< create a route distinguisher
	< import routes from brancha
	< import routes from branchb

interface vlan 30
  ip vrf forwarding branchc
  ip address 192.168.30.1 /24
  ip ospf area 0
	< put the VLAN interface into VR2 (branchc)
	< assign an IP address
	< configure the VLAN OSPF area

interface vlan 32
  ip vrf forwarding branchc
  ip address 192.168.12.1 /24
  exit
	< put the VLAN interface into VR2 (branchc)
	< assign an IP address

router ospf vrf branchc
  router-id 9.9.9.1
  redistribute bgp subnets
  exit
	< specify OSPF for *branchc*
	< provide a router ID
	< select route redistribution source protocol

router bgp 100
  address-family ipv4 vrf branchc
 	
  neighbor 192.168.12.2 remote-as 200
  redistribute connected
  redistribute ospf
  exit
exit
	< specify BGP for branchc
	< enable address family ipv vrf-family ipv4 vrf branchc
	< enable neighbor remote-as
	< enable redistribute-connected
	< enable redistribute-OSPF

IP routes for brancha (Finance VRF instance) on the Main Office switch:

Note:
Inter-area routes (70.10.x.x) are distributed through IXIA into Main Office finance switch
Inter-area routes (60.10.x.x) are distributed through IXIA into Branch Office finance switch.

```
N4048_R192U24_MO#show ip route vrf brancha

Route Codes: R - RIP Derived, O - OSPF Derived, C - Connected, K - Kernel S - Static
       B - BGP Derived, E - Externally Derived, IA - OSPF Inter Area
       E1 - OSPF External Type 1, E2 - OSPF External Type 2
       N1 - OSPF NSSA External Type 1, N2 - OSPF NSSA External Type 2
       S U - Unnumbered Peer, L - Leaked Route

 * Indicates the best (lowest metric) route for the subnet.

No default gateway is configured.
C      *7.7.7.1/32 [0/0] directly connected,   loopback 0
B      *11.11.11.1/32 [20/0] via 192.168.12.2,   00h:27m:58s,  Vl12
B      *60.1.1.0/24 [20/0] via 192.168.12.2,   00h:27m:34s,  Vl12
B      *60.10.1.0/24 [20/0] via 192.168.12.2,   00h:27m:34s,  Vl12
B      *60.10.2.0/24 [20/0] via 192.168.12.2,   00h:27m:34s,  Vl12
B      *60.10.3.0/24 [20/0] via 192.168.12.2,   00h:27m:34s,  Vl12
B      *60.10.4.0/24 [20/0] via 192.168.12.2,   00h:27m:34s,  Vl12
B      *60.10.5.0/24 [20/0] via 192.168.12.2,   00h:27m:34s,  Vl12
O      *70.1.1.0/24 [110/20] via 192.168.10.2,   00h:29m:59s,  Vl10
O IA   *70.10.1.0/24 [110/20] via 192.168.10.2,   00h:29m:59s,  Vl10
O IA   *70.10.2.0/24 [110/20] via 192.168.10.2,   00h:29m:59s,  Vl10
O IA   *70.10.3.0/24 [110/20] via 192.168.10.2,   00h:29m:59s,  Vl10
O IA   *70.10.4.0/24 [110/20] via 192.168.10.2,   00h:29m:59s,  Vl10
O IA   *70.10.5.0/24 [110/20] via 192.168.10.2,   00h:29m:59s,  Vl10
C      *192.168.10.0/24 [0/0] directly connected,   Vl10
B      *192.168.11.0/24 [20/0] via 192.168.12.2,   00h:27m:34s,  Vl12
C      *192.168.12.0/24 [0/0] directly connected,   Vl12
```

IP routes for branchb (IT VRF instance) on the Main Office switch:

Note:
Inter-area routes (50.10.x.x) are distributed through IXIA into Main Office IT switch

```
N4048_R192U24_MO#show ip route vrf branchb

Route Codes: R - RIP Derived, O - OSPF Derived, C - Connected, K - Kernel S - Static
      B - BGP Derived, E - Externally Derived, IA - OSPF Inter Area
      E1 - OSPF External Type 1, E2 - OSPF External Type 2
      N1 - OSPF NSSA External Type 1, N2 - OSPF NSSA External Type 2
      S U - Unnumbered Peer, L - Leaked Route

 * Indicates the best (lowest metric) route for the subnet.

No default gateway is configured.
C      *8.8.8.1/32 [0/0] directly connected,   loopback 1
B      *12.12.12.1/32 [20/0] via 192.168.12.2,   00h:30m:25s,  Vl22
O      *50.1.1.0/24 [110/20] via 192.168.20.2,   00h:20m:15s,  Vl20
O IA   *50.10.0.0/24 [110/20] via 192.168.20.2,   00h:20m:15s,  Vl20
O IA   *50.10.1.0/24 [110/20] via 192.168.20.2,   00h:20m:15s,  Vl20
O IA   *50.10.2.0/24 [110/20] via 192.168.20.2,   00h:20m:15s,  Vl20
O IA   *50.10.3.0/24 [110/20] via 192.168.20.2,   00h:20m:15s,  Vl20
O IA   *50.10.4.0/24 [110/20] via 192.168.20.2,   00h:20m:15s,  Vl20
C      *192.168.12.0/24 [0/0] directly connected,   Vl22
C      *192.168.20.0/24 [0/0] directly connected,   Vl20
B      *192.168.21.0/24 [20/0] via 192.168.12.2,   00h:17m:13s,  Vl22
```

IP routes for branchc (CEO VRF instance) on the Main Office switch:

Note: Inter-ospf area routes and Leaked routes are seen in VRF branchc instance

```
N4048_R192U24_MO#show ip route vrf branchc

Route Codes: R - RIP Derived, O - OSPF Derived, C - Connected, K - Kernel S - Static
      B - BGP Derived, E - Externally Derived, IA - OSPF Inter Area
      E1 - OSPF External Type 1, E2 - OSPF External Type 2
      N1 - OSPF NSSA External Type 1, N2 - OSPF NSSA External Type 2
      S U - Unnumbered Peer, L - Leaked Route

 * Indicates the best (lowest metric) route for the subnet.

No default gateway is configured.
B L    *7.7.7.1/32 [200/0] via 26d:10h:26m,  loopback 0
B L    *8.8.8.1/32 [200/0] via 26d:10h:26m,  loopback 1
```

```
C      *9.9.9.1/32 [0/0] directly connected,   loopback 2
B      *11.11.11.1/32 [20/0] via 192.168.12.2,   00h:31m:27s,  Vl32
B      *12.12.12.1/32 [20/0] via 192.168.12.2,   00h:31m:27s,  Vl32
B      *13.13.13.1/32 [20/0] via 192.168.12.2,   00h:31m:27s,  Vl32
O      *40.1.1.0/24 [110/20] via 192.168.30.2,   00h:30m:41s,  Vl30
O IA   *40.10.0.0/24 [110/20] via 192.168.30.2,   00h:30m:41s,  Vl30
O IA   *40.10.1.0/24 [110/20] via 192.168.30.2,   00h:30m:41s,  Vl30
O IA   *40.10.2.0/24 [110/20] via 192.168.30.2,   00h:30m:41s,  Vl30
O IA   *40.10.3.0/24 [110/20] via 192.168.30.2,   00h:30m:41s,  Vl30
O IA   *40.10.4.0/24 [110/20] via 192.168.30.2,   00h:30m:41s,  Vl30
B L    *50.1.1.0/24 [200/0] via 192.168.20.2,   00h:21m:13s,  Vl20
B L    *50.10.0.0/24 [200/0] via 192.168.20.2,   00h:21m:13s,  Vl20
B L    *50.10.1.0/24 [200/0] via 192.168.20.2,   00h:21m:13s,  Vl20
B L    *50.10.2.0/24 [200/0] via 192.168.20.2,   00h:21m:13s,  Vl20
B L    *50.10.3.0/24 [200/0] via 192.168.20.2,   00h:21m:13s,  Vl20
B L    *50.10.4.0/24 [200/0] via 192.168.20.2,   00h:21m:13s,  Vl20
B      *60.1.1.0/24 [20/0] via 192.168.12.2,   00h:30m:54s,  Vl32
B      *60.10.1.0/24 [20/0] via 192.168.12.2,   00h:30m:54s,  Vl32
B      *60.10.2.0/24 [20/0] via 192.168.12.2,   00h:30m:54s,  Vl32
B      *60.10.3.0/24 [20/0] via 192.168.12.2,   00h:30m:54s,  Vl32
B      *60.10.4.0/24 [20/0] via 192.168.12.2,   00h:30m:54s,  Vl32
B      *60.10.5.0/24 [20/0] via 192.168.12.2,   00h:30m:54s,  Vl32
B L    *70.1.1.0/24 [200/0] via 192.168.10.2,   00h:33m:17s,  Vl10
B L    *70.10.1.0/24 [200/0] via 192.168.10.2,   00h:33m:17s,  Vl10
B L    *70.10.2.0/24 [200/0] via 192.168.10.2,   00h:33m:17s,  Vl10
B L    *70.10.3.0/24 [200/0] via 192.168.10.2,   00h:33m:17s,  Vl10
B L    *70.10.4.0/24 [200/0] via 192.168.10.2,   00h:33m:17s,  Vl10
B L    *70.10.5.0/24 [200/0] via 192.168.10.2,   00h:33m:17s,  Vl10
B L    *192.168.10.0/24 [200/0] via 21d:01h:17m,  Vl10
C      *192.168.12.0/24 [0/0] directly connected,   Vl32
B L     192.168.12.0/24 [200/0] via 00h:31m:27s,  Vl12
B L    *192.168.20.0/24 [200/0] via 00h:23m:04s,  Vl20
B L    *192.168.21.0/24 [200/0] via 192.168.12.2,   00h:18m:13s,  Vl22
C      *192.168.30.0/24 [0/0] directly connected,   Vl30
B      *192.168.31.0/24 [20/0] via 192.168.12.2,   00h:31m:27s,  Vl32
```

CLI commands in the following table configure the BGP VRF Lite on the Dell N4032F (Branch Office) switch. The following table also provides explanations of each CLI command.

N4032F (Branch Office Switch Configurations)	Description of Commands
	Configure VR3 (Finance - brancha) VR

`configure`
`  vlan 11,12`
`  exit`
	< create two VLANs for VR3

`interface Te1/0/1`
`  switchport access vlan 11`
`  exit`
	< assign a VLAN to an interface

`interface Te1/0/3`
`  switchport mode trunk`
`  switchport trunk allowed vlan 12`
`  exit`
	< configure the interface in trunk mode
	< assign VLAN to an interface going to provider edge routers in trunk mode

`ip vrf brancha`
`  rd 200:1000`
`  route-target export 200:1000`
`  exit`
	< create VR3 (brancha) and enable routing
	< create a route distinguisher
	< export routes from brancha

`interface vlan 11`
`    ip vrf forwarding brancha`
`    ip address 192.168.11.2 /24`
`    ip ospf area 0`
	< assign VLAN interface to VR3 (brancha)
	< assign an IP address
	< configure the VLAN in OSPF area

`interface vlan 12`
`  ip vrf forwarding brancha`
`  ip address 192.168.12.2 /24`
`  ip ospf area 0`
`  exit`
	< put the VLAN interface into VR3 (brancha)
	< assign an IP address
	< configure the VLAN in OSPF area

`ip routing`	< enable routing globally across physical switch

`router ospf vrf "brancha"`
`  router-id 11.11.11.1`
`  redistribute bgp subnets`
`  exit`
	< specify OSPF for *brancha*
	< provide a router ID
	< select route redistribution source protocol

`router bgp 200`
`  bgp router-id 192.23.2.2`
`  address-family ipv4 vrf brancha`
 	
`    neighbor 192.168.12.1 remote-as 100`
`    redistribute connected`
`    redistribute ospf`
`    exit`
`  exit`
	< specify BGP for brancha
	< enable bgp router-id
	< enable address family ipv vrf-family ipv4 vrf brancha
	< enable neighbor remote-as
	< enable redistribute-connected
	< enable redistribute-OSPF

	Configure VR4 (IT - branchb) VR

configure
  vlan 21,22
  exit
	< create two VLANs for VR4

interface Te1/0/2 switchport access vlan 21	< put the interface to the other Main Office switch into VLAN 22

interface Te1/0/3
  switchport mode trunk allowed vlan add 22
  exit
	< assign VLAN to an interface going to provider edge routers in trunk mode

ip vrf branchb
  rd 200:2000
  route-target export 200:2000
  exit
	< create VR4 (branchb) and enable routing
	< create a route distinguisher
	< export routes from branchb

interface vlan 21
  ip vrf forwarding branchb
  ip address 192.168.21.2 /24
  ip ospf area 0
	< put the VLAN interface into VR4 (branchb)
	< assign an IP address
	< configure the VLAN in OSPF area

interface vlan 22
  ip vrf forwarding branchb
  ip address 192.168.12.2 /24
  exit
	< put the VLAN interface into VR2 (branchb)
	< assign an IP address

ip routing	< enable routing globally across the physical switch

router ospf vrf branchb
  router-id 12.12.12.1
  redistribute bgp subnets
  exit
	< specify OSPF for branchb
	< provide a router ID
	< select route redistribution source protocol

router bgp 200
  address-family ipv4 vrf branchb
 	
  neighbor 192.168.12.1 remote-as 100
  redistribute connected
  redistribute ospf
  exit
  exit
	< specify BGP for branchb
	< enable address family ipv vrf-family ipv4 vrf branchb
	< enable neighbor remote-as
	< enable redistribute-connected
	< enable redistribute-OSPF

	Configure VR6 (CEO - branchc) VR

`configure`
`  vlan 31,32`
`  exit`
	< create two VLANs for VR6

`interface Te1/0/4` `  switchport access vlan 31`	< put the interface to the other Main Office switch into VLAN 31

`interface Te1/0/3`
`  switchport mode trunk allowed vlan add 22`
`  exit`
	< assign VLAN to an interface going to provider edge routers in trunk mode

`ip vrf branchc`
`  rd 200:3000`
`  route-target import 200:1000`
`  route-target import 200:2000`
`  exit`
	< create VR6 (branchc) and enable routing
	< create a route distinguisher
	< import routes from brancha
	< import routes from branchb

`interface vlan 31`
`  ip vrf forwarding branchc`
`  ip address 192.168.31.2 /24`
`  ip ospf area 0`
`  exit`
	< put the VLAN interface into VR4 (branchb)
	< assign an IP address
	< configure the VLAN in OSPF area

`interface vlan 32`
`    ip vrf forwarding branchc`
`    ip address 192.168.12.2 /24`
`    exit`
	< put the VLAN interface into VR2 (branchb)
	< assign an IP address

`ip routing`	< enable routing globally across the physical switch

`router ospf vrf branchc`
`  router-id 13.13.13.1`
`  redistribute bgp subnets`
`  exit`
	< specify OSPF for branchc
	< provide a router ID
	< select route redistribution source protocol

`router bgp 200`
`  address-family ipv4 vrf branchc`
`    neighbor 192.168.12.1 remote-as 100`
`    redistribute connected`
`    redistribute ospf`
`    exit`
`  exit`
	< specify BGP for branchc
	< enable address family ipv vrf-family ipv4 vrf branchb
	< enable neighbor remote-as
	< enable redistribute-connected
	< enable redistribute-OSPF

`exit`	

IP routes for brancha (Finance VRF instance) on the Branch Office switch:

Note:
Inter-area routes (70.10.x.x) are distributed through IXIA into Main Office finance switch
Inter-area routes (60.10.x.x) are distributed through IXIA into Branch Office finance switch.

```
N4000_R192U23_BO#show ip route vrf brancha

Route Codes: R - RIP Derived, O - OSPF Derived, C - Connected, K - Kernel S - Static
       B - BGP Derived, E - Externally Derived, IA - OSPF Inter Area
       E1 - OSPF External Type 1, E2 - OSPF External Type 2
       N1 - OSPF NSSA External Type 1, N2 - OSPF NSSA External Type 2
       S U - Unnumbered Peer, L - Leaked Route

 * Indicates the best (lowest metric) route for the subnet.

No default gateway is configured.
B      *7.7.7.1/32 [20/0] via 192.168.12.1,   00h:39m:20s,  Vl12
C      *11.11.11.1/32 [0/0] directly connected,   loopback 0
O      *60.1.1.0/24 [110/20] via 192.168.11.1,   00h:39m:25s,  Vl11
O IA   *60.10.1.0/24 [110/20] via 192.168.11.1,   00h:39m:25s,  Vl11
O IA   *60.10.2.0/24 [110/20] via 192.168.11.1,   00h:39m:25s,  Vl11
O IA   *60.10.3.0/24 [110/20] via 192.168.11.1,   00h:39m:25s,  Vl11
O IA   *60.10.4.0/24 [110/20] via 192.168.11.1,   00h:39m:25s,  Vl11
O IA   *60.10.5.0/24 [110/20] via 192.168.11.1,   00h:39m:25s,  Vl11
B      *70.1.1.0/24 [20/0] via 192.168.12.1,   00h:39m:20s,  Vl12
B      *70.10.1.0/24 [20/0] via 192.168.12.1,   00h:39m:20s,  Vl12
B      *70.10.2.0/24 [20/0] via 192.168.12.1,   00h:39m:20s,  Vl12
B      *70.10.3.0/24 [20/0] via 192.168.12.1,   00h:39m:20s,  Vl12
B      *70.10.4.0/24 [20/0] via 192.168.12.1,   00h:39m:20s,  Vl12
B      *70.10.5.0/24 [20/0] via 192.168.12.1,   00h:39m:20s,  Vl12
B      *192.168.10.0/24 [20/0] via 192.168.12.1,   00h:39m:20s,  Vl12
C      *192.168.11.0/24 [0/0] directly connected,   Vl11
C      *192.168.12.0/24 [0/0] directly connected,   Vl12
```

IP routes for branchb (IT VRF instance) on the Branch Office switch:

Note: Only Inter-ospf area routes which are redistributed through BGP are seen in VRF branchb instance.

```
N4000_R192U23_BO#show ip route vrf branchb

Route Codes: R - RIP Derived, O - OSPF Derived, C - Connected, K - Kernel S - Static
      B - BGP Derived, E - Externally Derived, IA - OSPF Inter Area
      E1 - OSPF External Type 1, E2 - OSPF External Type 2
      N1 - OSPF NSSA External Type 1, N2 - OSPF NSSA External Type 2
      S U - Unnumbered Peer, L - Leaked Route

 * Indicates the best (lowest metric) route for the subnet.

No default gateway is configured.
B      *8.8.8.1/32 [20/0] via 192.168.12.1,   00h:40m:27s,  Vl22
C      *12.12.12.1/32 [0/0] directly connected,   loopback 1
B      *50.1.1.0/24 [20/0] via 192.168.12.1,   00h:30m:14s,  Vl22
B      *50.10.0.0/24 [20/0] via 192.168.12.1,   00h:30m:14s,  Vl22
B      *50.10.1.0/24 [20/0] via 192.168.12.1,   00h:30m:14s,  Vl22
B      *50.10.2.0/24 [20/0] via 192.168.12.1,   00h:30m:14s,  Vl22
B      *50.10.3.0/24 [20/0] via 192.168.12.1,   00h:30m:14s,  Vl22
B      *50.10.4.0/24 [20/0] via 192.168.12.1,   00h:30m:14s,  Vl22
C      *192.168.12.0/24 [0/0] directly connected,   Vl22
B      *192.168.20.0/24 [20/0] via 192.168.12.1,   00h:30m:47s,  Vl22
C      *192.168.21.0/24 [0/0] directly connected,   Vl21
```

IP routes for branchc (CEO VRF instance) on the Branch Office switch:

Note: Inter-ospf area routes and Leaked routes are seen in VRF branchc instance

```
N4000_R192U23_BO#show ip route vrf branchc

Route Codes: R - RIP Derived, O - OSPF Derived, C - Connected, K - Kernel S - Static
      B - BGP Derived, E - Externally Derived, IA - OSPF Inter Area
      E1 - OSPF External Type 1, E2 - OSPF External Type 2
      N1 - OSPF NSSA External Type 1, N2 - OSPF NSSA External Type 2
      S U - Unnumbered Peer, L - Leaked Route

 * Indicates the best (lowest metric) route for the subnet.

No default gateway is configured.
B      *7.7.7.1/32 [20/0] via 192.168.12.1,   00h:40m:59s,  Vl32
B L    *8.8.8.1/32 [200/0] via 192.168.12.1,   00h:40m:59s,  Vl22
B      *9.9.9.1/32 [20/0] via 192.168.12.1,   00h:40m:59s,  Vl32
```

```
B L    *11.11.11.1/32 [200/0] via 26d:10h:35m,  loopback 0
B L    *12.12.12.1/32 [200/0] via 26d:10h:35m,  loopback 1
C      *13.13.13.1/32 [0/0] directly connected,   loopback 2
B      *40.1.1.0/24 [20/0] via 192.168.12.1,   00h:40m:05s,  Vl32
B      *40.10.0.0/24 [20/0] via 192.168.12.1,   00h:40m:05s,  Vl32
B      *40.10.1.0/24 [20/0] via 192.168.12.1,   00h:40m:05s,  Vl32
B      *40.10.2.0/24 [20/0] via 192.168.12.1,   00h:40m:05s,  Vl32
B      *40.10.3.0/24 [20/0] via 192.168.12.1,   00h:40m:05s,  Vl32
B      *40.10.4.0/24 [20/0] via 192.168.12.1,   00h:40m:05s,  Vl32
B L    *50.1.1.0/24 [200/0] via 192.168.12.1,   00h:30m:48s,  Vl22
B L    *50.10.0.0/24 [200/0] via 192.168.12.1,   00h:30m:48s,  Vl22
B L    *50.10.1.0/24 [200/0] via 192.168.12.1,   00h:30m:48s,  Vl22
B L    *50.10.2.0/24 [200/0] via 192.168.12.1,   00h:30m:48s,  Vl22
B L    *50.10.3.0/24 [200/0] via 192.168.12.1,   00h:30m:48s,  Vl22
B L    *50.10.4.0/24 [200/0] via 192.168.12.1,   00h:30m:48s,  Vl22
B L    *60.1.1.0/24 [200/0] via 192.168.11.1,   00h:40m:55s,  Vl11
B L    *60.10.1.0/24 [200/0] via 192.168.11.1,   00h:40m:55s,  Vl11
B L    *60.10.2.0/24 [200/0] via 192.168.11.1,   00h:40m:55s,  Vl11
B L    *60.10.3.0/24 [200/0] via 192.168.11.1,   00h:40m:55s,  Vl11
B L    *60.10.4.0/24 [200/0] via 192.168.11.1,   00h:40m:55s,  Vl11
B L    *60.10.5.0/24 [200/0] via 192.168.11.1,   00h:40m:55s,  Vl11
B      *70.1.1.0/24 [20/0] via 192.168.12.1,   00h:40m:59s,  Vl32
B      *70.10.1.0/24 [20/0] via 192.168.12.1,   00h:40m:59s,  Vl32
B      *70.10.2.0/24 [20/0] via 192.168.12.1,   00h:40m:59s,  Vl32
B      *70.10.3.0/24 [20/0] via 192.168.12.1,   00h:40m:59s,  Vl32
B      *70.10.4.0/24 [20/0] via 192.168.12.1,   00h:40m:59s,  Vl32
B      *70.10.5.0/24 [20/0] via 192.168.12.1,   00h:40m:59s,  Vl32
B L    *192.168.10.0/24 [200/0] via 192.168.12.1,   00h:40m:59s,  Vl22
C      *192.168.12.0/24 [0/0] directly connected,   Vl32
B L    *192.168.20.0/24 [200/0] via 192.168.12.1,   00h:32m:39s,  Vl22
B L    *192.168.21.0/24 [200/0] via 00h:27m:51s,  Vl21
B      *192.168.30.0/24 [20/0] via 192.168.12.1,   00h:40m:59s,  Vl32
C      *192.168.31.0/24 [0/0] directly connected,   Vl31
```

Use the CLI commands in the following table to add a VLAN to Main office Finance switch and connect to the Main Office using OSPF:

Main Office Finance Switch	Description of Commands
	Configure the N3048 for Main Office Finance department

`configure`
`vlan 10`
`exit`
	< create a VLAN

`interface vlan 10`
`  ip address 192.168.10.2 /24`
`  ip ospf area 0`
`  exit`
	< assign an IP address to the VLAN
	< configure the VLAN in OSPF area

`interface Gi1/0/47`
`  switchport access vlan 10`
`  exit`
	< assign an untagged port to the VLAN

`router ospf`
`  router-id 3.3.3.1`
`  exit`
	< enable default OSPF
	< provide a router ID

`ip routing`	< enable global ip routing
`exit`	< ping the Main Office switch to verify connectivity
`ping 192.168.10.1`	

IP routes for the Main Office finance switch:

Note:
Inter-area routes (70.10.x.x) are distributed through IXIA into Main Office finance switch
Inter-area routes (60.10.x.x) are distributed through IXIA into Branch Office finance switch.

```
N3048_R193U24_MOA#show ip route

Route Codes: R - RIP Derived, O - OSPF Derived, C - Connected, K - Kernel S - Static
      B - BGP Derived, E - Externally Derived, IA - OSPF Inter Area
      E1 - OSPF External Type 1, E2 - OSPF External Type 2
      N1 - OSPF NSSA External Type 1, N2 - OSPF NSSA External Type 2
      S U - Unnumbered Peer, L - Leaked Route

 * Indicates the best (lowest metric) route for the subnet.

No default gateway is configured.
C      *3.3.3.1/32 [0/0] directly connected,   loopback 0
O E2   *11.11.11.1/32 [110/1] via 192.168.10.1,   00h:42m:54s,  Vl10
O E2   *60.1.1.0/24 [110/1] via 192.168.10.1,   00h:42m:30s,  Vl10
O E2   *60.10.1.0/24 [110/1] via 192.168.10.1,   00h:42m:30s,  Vl10
O E2   *60.10.2.0/24 [110/1] via 192.168.10.1,   00h:42m:30s,  Vl10
O E2   *60.10.3.0/24 [110/1] via 192.168.10.1,   00h:42m:30s,  Vl10
O E2   *60.10.4.0/24 [110/1] via 192.168.10.1,   00h:42m:30s,  Vl10
O E2   *60.10.5.0/24 [110/1] via 192.168.10.1,   00h:42m:30s,  Vl10
C      *70.1.1.0/24 [0/0] directly connected,   Vl70
O IA   *70.10.1.0/24 [110/10] via 70.1.1.2,   21d:00h:38m,  Vl70
O IA   *70.10.2.0/24 [110/10] via 70.1.1.2,   21d:00h:38m,  Vl70
O IA   *70.10.3.0/24 [110/10] via 70.1.1.2,   21d:00h:38m,  Vl70
O IA   *70.10.4.0/24 [110/10] via 70.1.1.2,   21d:00h:38m,  Vl70
O IA   *70.10.5.0/24 [110/10] via 70.1.1.2,   21d:00h:38m,  Vl70
C      *192.168.10.0/24 [0/0] directly connected,   Vl10
O E2   *192.168.11.0/24 [110/1] via 192.168.10.1,   00h:42m:30s,  Vl10
```

Use the CLI commands in the following table to add a VLAN to Branch Office finance switch and connect to the Branch Office using OSPF:

Branch Office Finance Switch	Description of Commands
	Configure the N3048 for Branch Office Finance department

`configure`
`  vlan 11`
`  exit`
	< create a VLAN

`interface vlan 11`
`  ip address 192.168.11.1 /24`
`  ip ospf area 0`
	< assign an IP address to the VLAN
	< configure the VLAN in OSPF area

`interface Gi1/0/47`
`  switchport access vlan 11`
`  exit`
	< assign an untagged port to the VLAN

`router ospf`
`  router-id 2.2.2.1`
`  exit`
	< enable default OSPF
	< provide a router ID

`ip routing`	< enable global ip routing
`ping 192.168.11.2`	< ping the Branch Office to verify connectivity
`ping 192.168.10.2`	< ping the Main office Finance switch to verify end-to-end connectivity
`traceroute 192.168.11.2`	< trace the route to see all hops

If the preceding ping commands fail, check each configuration. Refer to the Troubleshooting section for additional assistance.

IP routes for the Branch Office finance switch:

Note:
Inter-area routes (70.10.x.x) are distributed through IXIA into Main Office finance switch
Inter-area routes (60.10.x.x) are distributed through IXIA into Branch Office finance switch.

```
N3048_R193U22_BOA#show ip route

Route Codes: R - RIP Derived, O - OSPF Derived, C - Connected, K - Kernel S - Static
      B - BGP Derived, E - Externally Derived, IA - OSPF Inter Area
      E1 - OSPF External Type 1, E2 - OSPF External Type 2
      N1 - OSPF NSSA External Type 1, N2 - OSPF NSSA External Type 2
      S U - Unnumbered Peer, L - Leaked Route

 * Indicates the best (lowest metric) route for the subnet.

No default gateway is configured.
C      *2.2.2.1/32 [0/0] directly connected,   loopback 0
O E2   *7.7.7.1/32 [110/1] via 192.168.11.2,   00h:48m:33s,  Vl11
C      *60.1.1.0/24 [0/0] directly connected,   Vl60
O IA   *60.10.1.0/24 [110/10] via 60.1.1.2,   15h:31m:09s,  Vl60
O IA   *60.10.2.0/24 [110/10] via 60.1.1.2,   15h:31m:00s,  Vl60
O IA   *60.10.3.0/24 [110/10] via 60.1.1.2,   15h:31m:00s,  Vl60
O IA   *60.10.4.0/24 [110/10] via 60.1.1.2,   15h:31m:00s,  Vl60
O IA   *60.10.5.0/24 [110/10] via 60.1.1.2,   15h:31m:00s,  Vl60
O E2   *70.1.1.0/24 [110/1] via 192.168.11.2,   00h:47m:42s,  Vl11
O E2   *70.10.1.0/24 [110/1] via 192.168.11.2,   00h:47m:42s,  Vl11
O E2   *70.10.2.0/24 [110/1] via 192.168.11.2,   00h:47m:42s,  Vl11
O E2   *70.10.3.0/24 [110/1] via 192.168.11.2,   00h:47m:42s,  Vl11
O E2   *70.10.4.0/24 [110/1] via 192.168.11.2,   00h:47m:42s,  Vl11
O E2   *70.10.5.0/24 [110/1] via 192.168.11.2,   00h:47m:37s,  Vl11
O E2   *192.168.10.0/24 [110/1] via 192.168.11.2,   00h:48m:33s,  Vl11
C      *192.168.11.0/24 [0/0] directly connected,   Vl11
```

Use the CLI commands in the following table to add a VLAN to Main Office IT switch and connect to the Main Office using OSPF:

Main Office IT switch	Description of Commands
	Configure the N3048 for Main Office IT department
`configure`	
`  vlan 20`	< create a VLAN for Branch B
`  exit`	
`interface vlan 20`	< assign an IP address to the VLAN
`  ip address 192.168.20.2 /24`	< configure the VLAN in OSPF area
`  ip ospf area 0`	
`  exit`	
	< assign an untagged port to the VLAN
`interface Gi1/0/47`	
`  switchport access vlan 20`	
`  exit`	
	< enable default OSPF
`router ospf`	< provide a router ID
`  router-id 4.4.4.1`	
`  exit`	
	<enable global ip routing
`ip routing`	
	< ping the Main Office switch to verify connectivity
`ping 192.168.20.1`	

IP routes for the Main Office IT switch:

Note: Inter-area routes (50.10.x.x) are distributed through IXIA into Main Office IT switch

```
N3024_R193U25_MOB#show ip route

Route Codes: R - RIP Derived, O - OSPF Derived, C - Connected, K - Kernel S - Static
      B - BGP Derived, E - Externally Derived, IA - OSPF Inter Area
      E1 - OSPF External Type 1, E2 - OSPF External Type 2
      N1 - OSPF NSSA External Type 1, N2 - OSPF NSSA External Type 2
      S U - Unnumbered Peer, L - Leaked Route

 * Indicates the best (lowest metric) route for the subnet.

No default gateway is configured.
C      *4.4.4.1/32 [0/0] directly connected,   loopback 0
O E2   *12.12.12.1/32 [110/1] via 192.168.20.1,   00h:45m:47s,  Vl20
C      *50.1.1.0/24 [0/0] directly connected,   Vl50
O IA   *50.10.0.0/24 [110/10] via 50.1.1.2,   16h:03m:07s,  Vl50
O IA   *50.10.1.0/24 [110/10] via 50.1.1.2,   16h:02m:58s,  Vl50
O IA   *50.10.2.0/24 [110/10] via 50.1.1.2,   16h:02m:58s,  Vl50
O IA   *50.10.3.0/24 [110/10] via 50.1.1.2,   16h:02m:58s,  Vl50
O IA   *50.10.4.0/24 [110/10] via 50.1.1.2,   16h:02m:58s,  Vl50
C      *192.168.20.0/24 [0/0] directly connected,   Vl20
O E2   *192.168.21.0/24 [110/1] via 192.168.20.1,   00h:42m:45s,  Vl20
```

Use the CLI commands in the following table to add a VLAN to Branch Office IT switch and connect to the Branch Office using OSPF:

Branch Office IT switch	Description of Commands
	Configure the N3048 for Branch Office IT department

`configure`
`  vlan 21`
`  exit`
	< create another VLAN for Branch B

`interface vlan 21` `  ip address 192.168.21.1 /24`	< assign an IP address to the VLAN

`interface Gi1/0/47`
`  switchport access vlan 21`
`  exit`
	< assign an untagged port to the VLAN

`router ospf`
`  router-id 1.1.1.1`
`  exit`
	< enable default OSPF
	< provide a router ID

`ping 192.168.11.2`	< ping the Main Office to verify connectivity
`ping 192.168.10.2`	< ping the top Branch B switch to verify end-to-end connectivity
`traceroute 192.168.21.2`	< trace the route to see all hops

If the preceding ping commands fail, check each configuration. Refer to the Troubleshooting section for additional assistance.

IP routes for the Branch Office IT switch:

Note: Inter-area routes (50.10.x.x) are distributed through IXIA into Main Office IT switch are received as E2 routes in Branch Office IT switch redistributed through BGP into OSPF area.

```
N3048_R193U23_BOB#show ip route

Route Codes: R - RIP Derived, O - OSPF Derived, C - Connected, K - Kernel S - Static
      B - BGP Derived, E - Externally Derived, IA - OSPF Inter Area
      E1 - OSPF External Type 1, E2 - OSPF External Type 2
      N1 - OSPF NSSA External Type 1, N2 - OSPF NSSA External Type 2
      S U - Unnumbered Peer, L - Leaked Route

 * Indicates the best (lowest metric) route for the subnet.

No default gateway is configured.
C      *1.1.1.1/32 [0/0] directly connected,   loopback 0
O E2   *8.8.8.1/32 [110/1] via 192.168.21.2,   00h:44m:54s,  Vl21
O E2   *50.1.1.0/24 [110/1] via 192.168.21.2,   00h:44m:54s,  Vl21
O E2   *50.10.0.0/24 [110/1] via 192.168.21.2,   00h:44m:54s,  Vl21
O E2   *50.10.1.0/24 [110/1] via 192.168.21.2,   00h:44m:54s,  Vl21
O E2   *50.10.2.0/24 [110/1] via 192.168.21.2,   00h:44m:54s,  Vl21
O E2   *50.10.3.0/24 [110/1] via 192.168.21.2,   00h:44m:54s,  Vl21
O E2   *50.10.4.0/24 [110/1] via 192.168.21.2,   00h:44m:54s,  Vl21
O E2   *192.168.20.0/24 [110/1] via 192.168.21.2,   00h:44m:54s,  Vl21
C      *192.168.21.0/24 [0/0] directly connected,   Vl21
```

Use the CLI commands in the following table to add a VLAN to Main Office CEO switch and connect to the Main Office using OSPF:

Main Office CEO switch	Description of Commands
	Configure the N3048 for Main Office CEO department
`configure`	
`  vlan 30`	< create a VLAN for Branch B
`  exit`	
`interface vlan 30`	< assign an IP address to the VLAN
`  ip address 192.168.30.2 /24`	< configure the VLAN in OSPF area
`  ip ospf area 0`	
`  exit`	
`interface Gi1/0/47`	< assign an untagged port to the VLAN
`  switchport access vlan 20`	
`  exit`	
`router ospf`	< enable default OSPF
`  router-id 5.5.5.1`	< provide a router ID
`  exit`	
`ip routing`	< enable global ip routing
`ping 192.168.30.1`	< ping the Main Office switch to verify connectivity

IP routes for the Main Office CEO switch:

NOTE: Inter-area routes (50.10.x.x) are distributed through IXIA into Main Office CEO switch. There are also routes redistributed by BGP from brancha and branchb.

8164_R193U34_MOCEO#show ip route

Route Codes: R - RIP Derived, O - OSPF Derived, C - Connected, K - Kernel S - Static
B - BGP Derived, E - Externally Derived, IA - OSPF Inter Area
E1 - OSPF External Type 1, E2 - OSPF External Type 2
N1 - OSPF NSSA External Type 1, N2 - OSPF NSSA External Type 2
S U - Unnumbered Peer, L - Leaked Route

* Indicates the best (lowest metric) route for the subnet.

No default gateway is configured.
C *5.5.5.1/32 [0/0] directly connected, loopback 0
O E2 *7.7.7.1/32 [110/1] via 192.168.30.1, 03h:01m:34s, Vl30
O E2 *8.8.8.1/32 [110/1] via 192.168.30.1, 03h:01m:34s, Vl30
O E2 *11.11.11.1/32 [110/1] via 192.168.30.1, 03h:01m:34s, Vl30

```
O E2   *12.12.12.1/32 [110/1] via 192.168.30.1,   03h:01m:34s,  Vl30
O E2   *13.13.13.1/32 [110/1] via 192.168.30.1,   03h:01m:34s,  Vl30
C      *40.1.1.0/24 [0/0] directly connected,   Vl40
O IA   *40.10.0.0/24 [110/10] via 40.1.1.2,   03h:01m:34s,  Vl40
O IA   *40.10.1.0/24 [110/10] via 40.1.1.2,   03h:01m:34s,  Vl40
O IA   *40.10.2.0/24 [110/10] via 40.1.1.2,   03h:01m:34s,  Vl40
O IA   *40.10.3.0/24 [110/10] via 40.1.1.2,   03h:01m:34s,  Vl40
O IA   *40.10.4.0/24 [110/10] via 40.1.1.2,   03h:01m:34s,  Vl40
O E2   *50.1.1.0/24 [110/1] via 192.168.30.1,   02h:52m:06s,  Vl30
O E2   *50.10.0.0/24 [110/1] via 192.168.30.1,   02h:52m:06s,  Vl30
O E2   *50.10.1.0/24 [110/1] via 192.168.30.1,   02h:52m:06s,  Vl30
O E2   *50.10.2.0/24 [110/1] via 192.168.30.1,   02h:52m:01s,  Vl30
O E2   *50.10.3.0/24 [110/1] via 192.168.30.1,   02h:52m:01s,  Vl30
O E2   *50.10.4.0/24 [110/1] via 192.168.30.1,   02h:52m:01s,  Vl30
O E2   *60.1.1.0/24 [110/1] via 192.168.30.1,   03h:01m:34s,  Vl30
O E2   *60.10.1.0/24 [110/1] via 192.168.30.1,   03h:01m:34s,  Vl30
O E2   *60.10.2.0/24 [110/1] via 192.168.30.1,   03h:01m:34s,  Vl30
O E2   *60.10.3.0/24 [110/1] via 192.168.30.1,   03h:01m:34s,  Vl30
O E2   *60.10.4.0/24 [110/1] via 192.168.30.1,   03h:01m:34s,  Vl30
O E2   *60.10.5.0/24 [110/1] via 192.168.30.1,   03h:01m:34s,  Vl30
O E2   *70.1.1.0/24 [110/1] via 192.168.30.1,   03h:01m:34s,  Vl30
O E2   *70.10.1.0/24 [110/1] via 192.168.30.1,   03h:01m:34s,  Vl30
O E2   *70.10.2.0/24 [110/1] via 192.168.30.1,   03h:01m:34s,  Vl30
O E2   *70.10.3.0/24 [110/1] via 192.168.30.1,   03h:01m:34s,  Vl30
O E2   *70.10.4.0/24 [110/1] via 192.168.30.1,   03h:01m:34s,  Vl30
O E2   *70.10.5.0/24 [110/1] via 192.168.30.1,   03h:01m:34s,  Vl30
O E2   *192.168.10.0/24 [110/1] via 192.168.30.1,   03h:01m:34s,  Vl30
O E2   *192.168.20.0/24 [110/1] via 192.168.30.1,   02h:53m:58s,  Vl30
O E2   *192.168.21.0/24 [110/1] via 192.168.30.1,   02h:49m:06s,  Vl30
C      *192.168.30.0/24 [0/0] directly connected,   Vl30
O E2   *192.168.31.0/24 [110/1] via 192.168.30.1,   03h:01m:34s,  Vl30
```

Use the CLI commands in the following table to add a VLAN to Branch Office CEO switch and connect to the Branch Office using OSPF:

Branch Office CEO switch	Description of Commands
	Configure the N3048 for Branch Office CEO department

`configure`
`  vlan 31`
`  exit`
	< create another VLAN for Branch B

`interface vlan 31` `  ip address 192.168.31.1 /24`	< assign an IP address to the VLAN

`interface Gi1/0/47`
`  switchport access vlan 31`
`  exit`
	< assign an untagged port to the VLAN

`router ospf`
`  router-id 6.6.6.1`
`  exit`
	< enable default OSPF
	< provide a router ID

`ping 192.168.11.2`	< ping the Main Office to verify connectivity
`ping 192.168.10.2`	< ping the top Branch B switch to verify end-to-end connectivity
`traceroute 192.168.31.2`	< trace the route to see all hops

If the preceding ping commands fail, check each configuration. Refer to the Troubleshooting section for additional assistance.

IP routes for the Branch Office CEO switch:

Note: Inter-area OSPF IXIA routes injected in Main Office CEO switch are received as E2 routes in Branch Office CEO switch redistributed through BGP into OSPF area. Routes imported by BGP from brancha and branchb VRFs are also listed as E2 routes in this switch.

N4000_R193U33_BOCEO#show ip route

Route Codes: R - RIP Derived, O - OSPF Derived, C - Connected, K - Kernel S - Static
B - BGP Derived, E - Externally Derived, IA - OSPF Inter Area
E1 - OSPF External Type 1, E2 - OSPF External Type 2
N1 - OSPF NSSA External Type 1, N2 - OSPF NSSA External Type 2
S U - Unnumbered Peer, L - Leaked Route

* Indicates the best (lowest metric) route for the subnet.

```
No default gateway is configured.
C      *6.6.6.1/32 [0/0] directly connected,   loopback 0
O E2   *7.7.7.1/32 [110/1] via 192.168.31.2,   03h:04m:58s,  Vl31
O E2   *8.8.8.1/32 [110/1] via 192.168.31.2,   03h:04m:58s,  Vl31
O E2   *9.9.9.1/32 [110/1] via 192.168.31.2,   03h:04m:58s,  Vl31
O E2   *11.11.11.1/32 [110/1] via 192.168.31.2,   03h:04m:58s,  Vl31
O E2   *12.12.12.1/32 [110/1] via 192.168.31.2,   03h:04m:58s,  Vl31
O E2   *40.1.1.0/24 [110/1] via 192.168.31.2,   03h:04m:05s,  Vl31
O E2   *40.10.0.0/24 [110/1] via 192.168.31.2,   03h:04m:05s,  Vl31
O E2   *40.10.1.0/24 [110/1] via 192.168.31.2,   03h:04m:05s,  Vl31
O E2   *40.10.2.0/24 [110/1] via 192.168.31.2,   03h:04m:05s,  Vl31
O E2   *40.10.3.0/24 [110/1] via 192.168.31.2,   03h:04m:05s,  Vl31
O E2   *40.10.4.0/24 [110/1] via 192.168.31.2,   03h:04m:05s,  Vl31
O E2   *50.1.1.0/24 [110/1] via 192.168.31.2,   02h:54m:48s,  Vl31
O E2   *50.10.0.0/24 [110/1] via 192.168.31.2,   02h:54m:48s,  Vl31
O E2   *50.10.1.0/24 [110/1] via 192.168.31.2,   02h:54m:48s,  Vl31
O E2   *50.10.2.0/24 [110/1] via 192.168.31.2,   02h:54m:48s,  Vl31
O E2   *50.10.3.0/24 [110/1] via 192.168.31.2,   02h:54m:48s,  Vl31
O E2   *50.10.4.0/24 [110/1] via 192.168.31.2,   02h:54m:48s,  Vl31
O E2   *60.1.1.0/24 [110/1] via 192.168.31.2,   03h:04m:48s,  Vl31
O E2   *60.10.1.0/24 [110/1] via 192.168.31.2,   03h:04m:48s,  Vl31
O E2   *60.10.2.0/24 [110/1] via 192.168.31.2,   03h:04m:48s,  Vl31
O E2   *60.10.3.0/24 [110/1] via 192.168.31.2,   03h:04m:48s,  Vl31
O E2   *60.10.4.0/24 [110/1] via 192.168.31.2,   03h:04m:48s,  Vl31
O E2   *60.10.5.0/24 [110/1] via 192.168.31.2,   03h:04m:48s,  Vl31
O E2   *70.1.1.0/24 [110/1] via 192.168.31.2,   03h:04m:48s,  Vl31
O E2   *70.10.1.0/24 [110/1] via 192.168.31.2,   03h:04m:48s,  Vl31
O E2   *70.10.2.0/24 [110/1] via 192.168.31.2,   03h:04m:48s,  Vl31
O E2   *70.10.3.0/24 [110/1] via 192.168.31.2,   03h:04m:48s,  Vl31
O E2   *70.10.4.0/24 [110/1] via 192.168.31.2,   03h:04m:48s,  Vl31
O E2   *70.10.5.0/24 [110/1] via 192.168.31.2,   03h:04m:48s,  Vl31
O E2   *192.168.10.0/24 [110/1] via 192.168.31.2,   03h:04m:58s,  Vl31
O E2   *192.168.20.0/24 [110/1] via 192.168.31.2,   02h:56m:39s,  Vl31
O E2   *192.168.21.0/24 [110/1] via 192.168.31.2,   02h:51m:51s,  Vl31
O E2   *192.168.30.0/24 [110/1] via 192.168.31.2,   03h:04m:48s,  Vl31
C      *192.168.31.0/24 [0/0] directly connected,   Vl31
```

4 OSPF on VRF lite

If multiple layer 3 switches connect switches in a branch, configure the VRs using OSPF so each switch shares routing information with the other(s). In this example, two layer 3 switches separate each branch's two switches. Create four VRs (VR1, VR2, VR3, and VR4) across the two layer 3 switches as shown in Figure 5. VR1 and VR3 share routing information while, VR2 and VR4 share routing information.

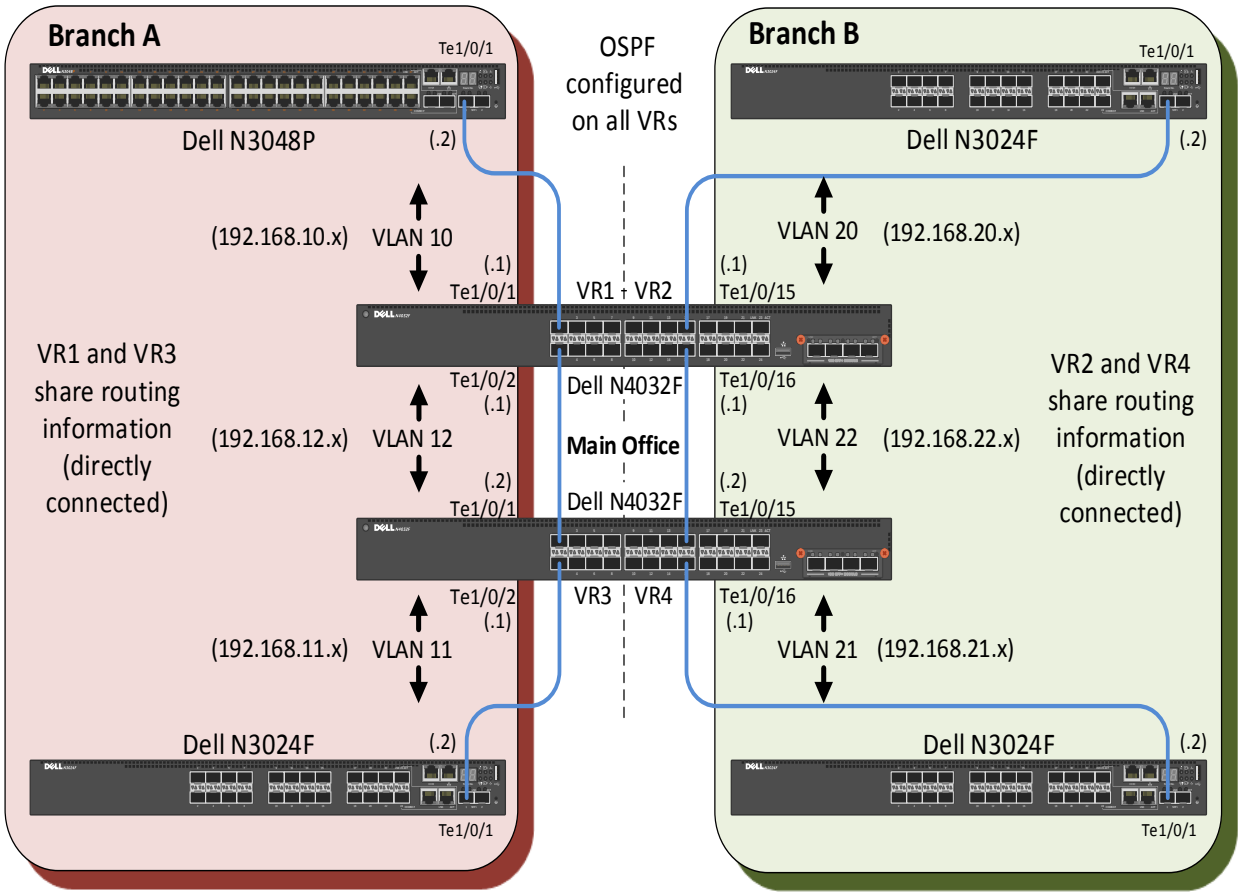

Figure 5 OSPF on VRF lite

In this example, there are two branch offices. Each branch has two N3xxx switches that require routes to each other but isolation from the other branch. This example shows two N4xxx routing switches at the Main Office configured to use VRF lite to create two VRs on each. Each VR pair isolates the traffic for its branch.

Each branch is unaware of the IP subnets and routing table of the other branch and can therefore overlap IP addresses without impairing either network. To avoid confusion in the example, this particular design does *not* overlap IP addresses.

Note: The configurations of the four branch switches do not change between the Simple VRF example (Figure 3) and the OSPF example below (Figure 5).

Use the CLI commands in the following table to configure the VRs and OSPF on the top Dell 4032F (Main Office) switch. The following table also provides explanations of each CLI command:

Note: Use the six configuration files attached in the left margin of this document to copy and paste directly into each switch's CLI. The files pertaining to this example are titled "OSPF". Click the paperclip icon to open and close the attachment list. This method requires allowing 20 seconds after pasting the final configuration before pinging across the network.

N4032F (Main Office – Top Switch)	Description of Commands
	Configure VR1 (Branch A) VR

`configure`
`  vlan 10,12`
`  exit`
	< create two VLANs for VR1

`interface Te1/0/1` `  switchport access vlan 10`	< assign a VLAN to an interface for VR1

`interface Te1/0/2`
`  switchport access vlan 12`
`  exit`
	< put the interface to the other Main Office switch into VLAN 12

`ip vrf brancha`
`  ip routing`
`  exit`
	< create VR1 (brancha) and enable routing

`interface vlan 10`
`  ip vrf forwarding brancha`
`  ip address 192.168.10.1 /24`
`  ip ospf area 0`
	< put the VLAN interface into VR1 (brancha)
	< assign an IP address
	< configure the VLAN OSPF area

`interface vlan 12`
`  ip vrf forwarding brancha`
`  ip address 192.168.12.1 /24`
`  ip ospf area 0`
`  exit`
	< put the VLAN interface into VR1 (brancha)
	< assign an IP address
	< configure the VLAN OSPF area

`exit`	***Configure VR2 (Branch B) VR***

`configure`
`  vlan 20,22`
`  exit`
	< create two VLANs for VR2

`interface Te1/0/15` `  switchport access vlan 20`	< assign a VLAN to an interface on VR2

`interface Te1/0/16`
`  switchport access vlan 22`
`  exit`
	< put the interface to the other Main Office switch into VLAN 22

`ip vrf branchb`
`  ip routing`
`  exit`
	< create VR2 (branchb) and enable routing

`interface vlan 20`
`  ip vrf forwarding branchb`
`  ip address 192.168.20.1 /24`
`  ip ospf area 0`
	< put the VLAN interface into VR2 (branchb)
	< assign an IP address
	< configure the VLAN OSPF area

`interface vlan 22`
`  ip vrf forwarding branchb`
`  ip address 192.168.22.1 /24`
`  ip ospf area 0`
`  exit`
	< put the VLAN interface into VR2 (branchb)
	< assign an IP address
	< configure the VLAN OSPF area

`ip routing`	< enable routing globally across the physical switch
	Enable OSPF on both VRFs

`router ospf vrf brancha`
`  network 192.168.0.0 255.255.255.0 area 0`
`  router-id 192.168.0.253`
`  redistribute connected`
`  enable`
`  exit`
	< specify OSPF for *brancha*
	< configure IP address and OSPF router area
	< provide a router ID
	< select route redistribution source protocol
	< enable OSPF administrative mode

`router ospf vrf branchb`
`  network 192.168.0.0 255.255.255.0 area 0`
`  router-id 192.168.0.252`
`  redistribute connected`
`  enable`
`  exit`
`exit`
	< specify OSPF for *branchb*
	< configure IP address and OSPF router area
	< provide a router ID
	< select route redistribution source protocol
	< enable OSPF administrative mode

Use the CLI commands in the following table to configure the VRs and OSPF on the top Dell 4032F (Main Office) switch. The following table also provides explanations of each CLI command.

N4032F (Main Office – Bottom Switch)	Description of Commands
	Configure VR3 (Branch A) VR

`configure`
`  vlan 11,12`
`  exit`
	< create two VLANs for VR1

`interface Te1/0/1`
`  switchport access vlan 12`
`  exit`
	< put the interface to the other Main Office switch into VLAN 12

`interface Te1/0/2`
`  switchport access vlan 11`
`  exit`
	< assign this VLAN to an interface for VR1

`ip vrf brancha`
`  ip routing`
`  exit`
	< create VR1 (brancha) and enable routing

`interface vlan 11`
`    ip vrf forwarding brancha`
`    ip address 192.168.11.1 /24`
`    ip ospf area 0`
	< put the VLAN interface into VR1 (brancha)
	< assign an IP address
	< configure the VLAN OSPF area

`interface vlan 12`
`  ip vrf forwarding brancha`
`  ip address 192.168.12.2 /24`
`  ip ospf area 0`
`  exit`
	< put the VLAN interface into VR1 (brancha)
	< assign an IP address
	< configure the VLAN OSPF area

`exit`	
	Configure VR4 (Branch B) VR

`configure`
`  vlan 21,22`
`  exit`
	< create two VLANs for VR2

`interface Te1/0/15` `  switchport access vlan 22`	< put the interface to the other Main Office switch into VLAN 22

`interface Te1/0/16`
`  switchport access vlan 21`
`  exit`
	< assign this VLAN to an interface on VR2

`ip vrf branchb`
`  ip routing`
`  exit`
	< create VR2 (branchb) and enable routing

interface vlan 21
  ip vrf forwarding branchb
  ip address 192.168.21.1 /24
  ip ospf area 0
 	
interface vlan 22
  ip vrf forwarding branchb
  ip address 192.168.22.2 /24
  ip ospf area 0
  exit
 	
ip routing
	< put the VLAN interface into VR2 (branchb)
	< assign an IP address
	< configure the VLAN OSPF area
	
	< put the VLAN interface into VR2 (branchb)
	< assign an IP address
	< configure the VLAN OSPF area
	
	< enable routing globally across the physical switch

router ospf vrf brancha
  network 192.168.0.0 255.255.255.0 area 0
  router-id 192.168.0.251
  redistribute connected
  enable
  exit
 	
router ospf vrf branchb
  network 192.168.0.0 255.255.255.0 area 0
  router-id 192.168.0.250
  redistribute connected
  enable
 	
  exit
exit
	Enable OSPF on both VRFs
	
	< specify OSPF for *brancha*
	< configure IP address and OSPF router area
	< provide a router ID
	< optionally, use route redistribute command to enable OSPF on all interfaces in the VRF
	< enable OSPF administrative mode
	
	< specify OSPF for *branchb*
	< configure IP address and OSPF router area
	< provide a router ID
	< optionally, use route redistribute command to enable OSPF on all interfaces in the VRF
	< enable OSPF administrative mode

The VR names **brancha** and **branchb** used above can be different from one physical switch to the next. This example uses the same names on both N4032F switches to avoid confusion.

Use the CLI commands in the following tables to add a VLAN to each switch in Branch A and connect to the router. The following tables also provide explanations of each CLI command:

Note: The configurations of the following four branch switches do not change between the Simple VRF example topology shown in Figure 3 and the OSPF example topology shown in Figure 5. The same four configurations work in both scenarios.

Branch A (Top Switch)	Description of Commands
	Configure the N3048P (Top Switch) for Branch A

`configure`
`vlan 10`
`exit`
	< create a VLAN for Branch A

`interface vlan 10` `ip address 192.168.10.2 /24`	< assign an IP address to the VLAN

`interface Te1/0/1`
`switchport access vlan 10`
`exit`
	< assign an untagged port to the VLAN

`ip default-gateway 192.168.10.1` `exit`	< set the default gateway to the IP address of the Main Office interface
`ping 192.168.10.1`	< ping the top Main Office switch to verify connectivity

Branch A (Bottom Switch)	Description of Commands
	Configure the N3024F (Bottom Switch) for Branch A

`configure`
`  vlan 11`
`  exit`
	< create another VLAN for Branch A

`interface vlan 11` `  ip address 192.168.11.2 /24`	< assign an IP address to the VLAN

`interface Te1/0/1`
`  switchport access vlan 11`
`  exit`
	< assign an untagged port to the VLAN

`ip default-gateway 192.168.11.1` `exit`	< set the default gateway to the IP address of the Main Office
`ping 192.168.11.1`	< ping the Main Office to verify connectivity
`ping 192.168.10.2`	< ping the top Branch A switch to verify end-to-end connectivity
`traceroute 192.168.10.2`	< trace the route to see all hops

If the preceding ping commands fail, check each configuration. Refer to the Troubleshooting section for additional assistance.

Use the CLI commands in the following tables to add a VLAN to each switch in Branch B and connect to the router. The following tables also provide explanations of each CLI command:

Branch B (Top Switch)	Description of Commands
	Configure the N3024F (Top Switch) for Branch B

`configure`
`  vlan 20`
`  exit`
	< create a VLAN for Branch B

`interface vlan 20` `  ip address 192.168.20.2 /24`	< assign an IP address to the VLAN

`interface Te1/0/1`
`  switchport access vlan 20`
`  exit`
	< assign an untagged port to the VLAN

`ip default-gateway 192.168.20.1` `exit`	< set the default gateway to the IP address of the Main Office
`ping 192.168.20.1`	< ping the Main Office switch to verify connectivity

Branch B (Bottom Switch)	Description of Commands
	Configure the N3024F (Bottom Switch) for Branch B

`configure`
`  vlan 21`
`  exit`
	< create another VLAN for Branch B

`interface vlan 21` `  ip address 192.168.21.2 /24`	< assign an IP address to the VLAN

`interface Te1/0/1`
`  switchport access vlan 21`
`  exit`
	< assign an untagged port to the VLAN

`ip default-gateway 192.168.21.1` `exit`	< set the default gateway to the IP address of the Main Office
`ping 192.168.21.1`	< ping the Main Office to verify connectivity
`ping 192.168.20.2`	< ping the top Branch B switch to verify end-to-end connectivity
`traceroute 192.168.20.2`	< trace the route to see all hops

If the preceding ping commands fail, check each configuration. Refer to the Troubleshooting section for additional assistance.

5 VRF VRRP Configuration

When a default gateway router (Layer 3 switch) fails, all traffic directed toward it is lost until the failure is corrected. Virtual Router Redundancy Protocol (VRRP) circumvents the failing router by providing a scheme to dynamically elect a backup router, which helps minimize network down time. VRFs support VRRP as shown in Figure 6. VRFs enable the configuration of several VRRP instances on two physical switches.

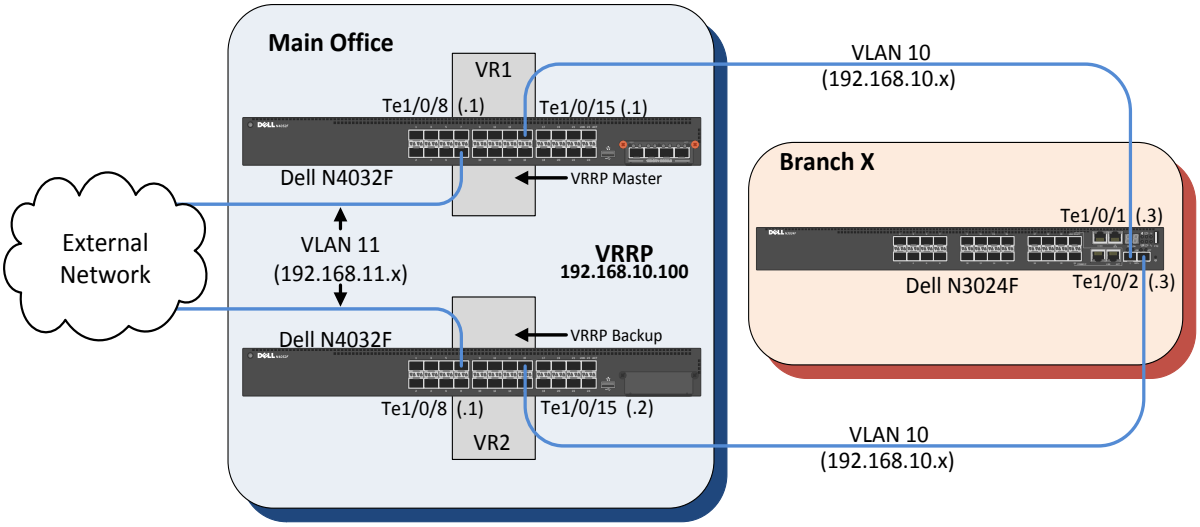

Figure 6 VRRP on VRF lite

In this example, a switch in Branch X uses redundant routers at the Main Office to connect to an external network. If the master router at the Main Office goes offline, the backup router takes over. A “priority” command distinguishes between the Master and Backup roles. Use the following CLI commands to configure the master router (top) in the topology. The following table also provides explanations of each CLI command:

Configuring the VRF VRRP Master

Note: Use the three configuration files attached in the left margin of this document to copy and paste directly into each switch's CLI. The files pertaining to this example are titled "VRRP". Click the paperclip icon to open and close the attachment list.

N4032F (Main Office – Top Switch)	Description of Commands

`configure`
`  vlan 10,11`
`  exit`
	< create two VLANs

`ip vrf branchx`
`  ip routing`
`  exit`
	< create VR1 (branchx)
	< enabled routing in VRF

`ip routing` `ip vrrp`	< enable IP routing globally < enable VRRP globally

`interface vlan 10`
`  ip vrf forwarding branchx`
`  ip address 192.168.10.1 255.255.255.0`
`  vrrp 1`
`  vrrp 1 mode`
`  vrrp 1 ip 192.168.10.100`
`  vrrp 1 priority 5`
`  vrrp 1 accept-mode`
`  exit`
	< configure VLAN interface
	< make VRF member
	< add IP address
	< create VRRP instance using VRID 1
	< set VRRP address
	< set VRRP priority high to be master VR
	< set to accept pings

`interface Te1/0/15`
`  switchport access vlan 10`
`exit`
	< configure physical interface
	< add VLAN membership

`interface vlan 11`
`  ip vrf forwarding branchx`
`  ip address 192.168.11.1 255.255.255.0`
	< create a VLAN for the external network
	< put the VLAN interface into the VR
	< assign an IP address to the interface

`interface Te1/0/8`
`  switchport access vlan 11`
`  exit`
`exit`
	< assign a port to the VLAN

Configuring the VRF VRRP Backup

Use the commands in the following table to configure the second router (bottom) in the VRRP topology. The following table also provides explanations of each CLI command:

N4032F (Main Office – Bottom Switch)	Description of Commands

`configure`
`  vlan 10,11`
`  exit`
	< create VLAN

`ip vrf branchx`
`  ip routing`
`  exit`
	< create VR2 (branchx)*
	< enabled routing in VRF

`ip routing` `ip vrrp`	< enable IP routing globally < enable VRRP globally

`interface vlan 10`
`  ip vrf forwarding branchx`
`  ip address 192.168.10.2 255.255.255.0`
`  vrrp 1`
`  vrrp 1 mode`
`  vrrp 1 ip 192.168.10.100`
`  vrrp 1 priority 2`
`  vrrp 1 accept-mode`
`  exit`
	< configure VLAN interface
	< make it a VRF member
	< add IP address
	< create VRRP instance using VRID 1 (same as on the peer switch)
	< set VRRP address (same as peer switch)
	< set VRRP priority lower to be Backup VR**
	< set to accept pings

`interface Te1/0/15`
`  switchport access vlan 10`
`exit`
	< configure physical interface
	< add VLAN membership

`interface vlan 11`
`  ip vrf forwarding branchx`
`  ip address 192.168.11.1 255.255.255.0`
	< create a vlan for the external network
	< put the VLAN interface into the VR
	< assign an IP address to the interface

`interface Te1/0/8`
`  switchport access vlan 11`
`  exit`
`exit`
	< assign a port to the VLAN

Notes:

1. The VRs on the top and bottom switches can use the same or different names. Only the local switch knows this name, which is not shared with the peer VRRP switch.
2. The VRRP priority determines which VR is the master router. Traffic initially routes through this VR only.

Configuring Connecting Switches

Switches connected to the two VRRP switches for routing redundancy are unaware of the VRRP and contain no VRRP configuration themselves. They must however have two non-LAG connections, one to each of the VRRP peer switches, to take advantage of the VRRP feature.

Use the commands in the following table to configure the Branch X switch as shown in VRRP topology. The following table also provides explanations of each CLI command:

Branch X	Description of Commands

`configure`
`  vlan 10`
`  exit`
	< create a VLAN for Branch B

`interface vlan 10` `  ip address 192.168.10.3 /24`	< assign an IP address to the VLAN

`interface Te1/0/1`
`  switchport access vlan 10`
`  exit`
	< assign first untagged port to the VLAN

`interface Te1/0/2`
`  switchport access vlan 10`
`  exit`
	< assign second untagged port to the VLAN

`ip default-gateway 192.168.10.100` `exit`	< set the default gateway to the IP address of the Main Office VRRP address
`ping 192.168.10.100`	< ping the Main Office switch to verify connectivity

Validating VRRP Failover

Use the following commands to validate the VRRP configuration and failover functionality. It is best practice to save that the configurations of all switches in this example before proceeding.

From the Branch X switch, create a continuous ping to the VRRP IP address using the following command:

```
ping 192.168.10.100 repeat 100

Reply From 192.168.10.100: icmp_seq = 0. time= 1217 usec.
Reply From 192.168.10.100: icmp_seq = 1. time= 2117 usec.
Reply From 192.168.10.100: icmp_seq = 1. time= 1778 usec.
```

If the 100 pings conclude before completing these tests, simply reenter the ping command.

While the ping is running and receiving ICMP replies, enter the following commands into the Master (Main Office – top switch) to stop ping replies.

Note: This command does not stop any traffic other than ping replies.

```
config
     interface vlan 10
     no vrrp 1 accept-mode
```

The ping replies should stop immediately and scrolling of the CLI should pause. This shows that VLAN 10 traffic is only going through the top switch of the Main Office. If there were VLAN 10 traffic also going through the bottom switch of the Main Office, the ping replies would continue to scroll as they were received from that switch.

Reloading the Master (using the **`reload`** command) causes the Backup VRRP switch to become active and the ping from Branch X to resume.

```
copy running-config startup-config
reload
```

Ping replies start again on the Branch X CLI session. This time the backup VRRP switch replies.

While still pinging, enter the **`no vrrp 1 accept-mode`** command to the Backup so that once again, the ping replies and scrolling stops.

Once the Master completely reloads, it resumes as the Master VRRP switch and resumes sending replies to Branch X.

Note: After running this test, be sure to double-check that both Main offices switches have the *accept-mode* turned on to enable subsequent pinging.

Finally, test the routing portion of the example by pinging VLAN 11 from Branch X. Branch X is not a member of VLAN 11, but can reach it through the routing switches in the VRRP. Use the command **`ping 192.168.11.1`** to verify connectivity to the next hop.

6 Route Leaking

Administrators can leak any static or dynamic route within a VRF to the default router using static route commands. When there are multiple VRFs on a switch, one or more are often required to leak routes. Route leaking usually involves an entire VRF subnet, but can be individual IP addresses if necessary. Route leaking can leak routes from a VRF to the default router and vice versa, but not from one VRF to another. Since the IP addresses used on each VRF in a physical switch may overlap, it is important not to leak the same subnet or range of addresses from two separate VRFs to the default router. Doing so would cause duplicate IP addresses on the network.

Borrowing the Simple VRF Example and corresponding configurations starting on page 8, notice the Main Office switch configurations include two VRs configured on the Main Office switch. Branch A (VR1) consists of two VLANs, 10 and 11. VLAN 10 is the Marketing department VLAN, which now requires access to the internet and must therefore leak its subnet to the default router connected to the internet. For bi-directional traffic, the default router must also leak a subnet (VLAN 30) to VR1.

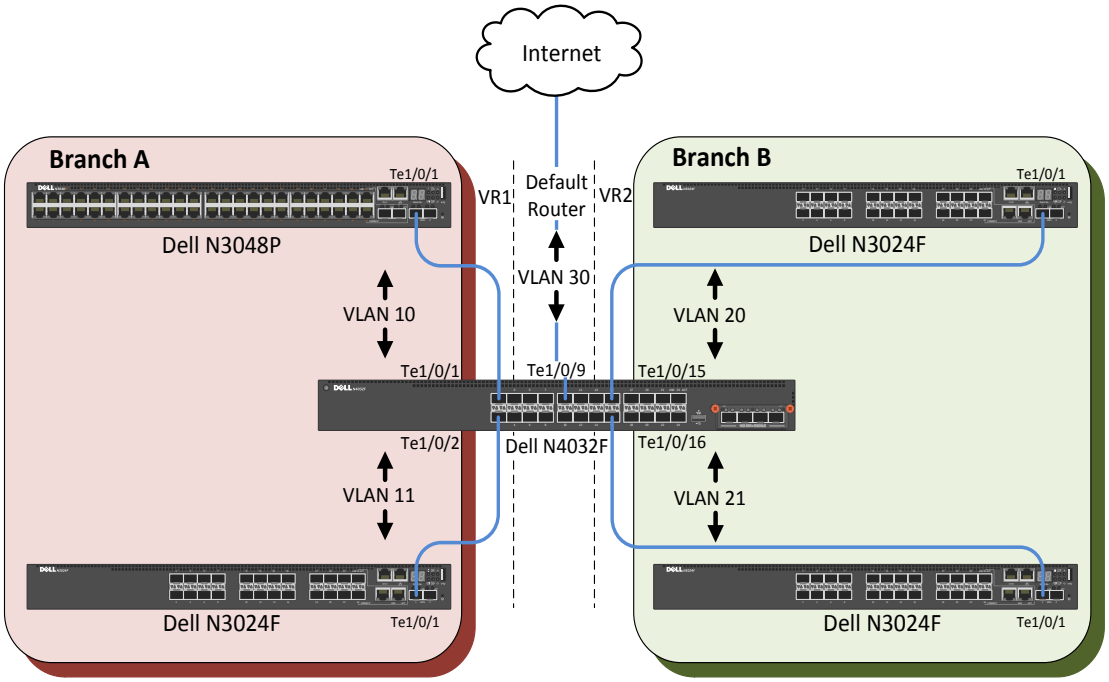

Figure 7 Route Leaking

To illustrate this example, the Default Router configuration on the Dell N4032F (Main Office) switch must add VLAN 30. Use the following commands on the switch to create the VLAN:

```
config
     vlan 30
     exit
interface vlan 30
     ip address 192.168.30.1 /24
     exit
interface tengigabitethernet 1/0/9
     switchport access vlan 30
     exit
```

Before adding the first route leak, show the current routes of VR1 (brancha) using the following command from the Main Office switch:

```
show ip route vrf brancha

   C      *192.168.10.0/24 [0/1] directly connected,   Vl10
   C      *192.168.11.0/24 [0/1] directly connected,   Vl11
```

Use the following commands to apply a default route to the brancha VRF table:

```
ip route vrf brancha 192.168.30.0 /24 vlan 30
```

Verify that the brancha VRF table now includes the default route:

```
show ip route vrf brancha

   C      *192.168.10.0/24 [0/1] directly connected,   Vl10
   C      *192.168.11.0/24 [0/1] directly connected,   Vl11
   L      *192.168.30.0/24 [1/0] via 0.0.0.0,   Vl30
```

Before adding the other route leak, show the current route of the Default Router using the following command from the Main Office switch:

```
show ip route

   C      *192.168.30.0/24 [0/1] directly connected,   Vl30
```

Use the following commands to add a brancha VRF route to the default routing table:

```
ip route 192.168.10.0 /24 vlan 10
```

Verify the default route has been added to the brancha VRF table:

```
show ip route
   L      *192.168.10.0/24 [1/0] via 0.0.0.0,   Vl10
   C      *192.168.30.0/24 [0/1] directly connected,   Vl30
```

To validate the configurations, ping VLAN 30 from the Branch A top switch. (A successful ping test validates the configuration.) The Branch A bottom switch on VLAN 11 should fail the ping.

Note: The VLAN 30 interface must be up for a successful ping. Be sure a cable is plugged into the port and that the port is up when pinging.

7 Reserving Routes

The number of routes is limited on each physical switch and all VRFs on that switch much share those routes. The number of routes a VRF uses is not reserved by default and is distributed on a first come, first serve basis, posing a risk that some VRFs may run out of routes. For this reason, routes may be reserved to one or more VRFs so other VRFs cannot use them. The commands below limit route distribution used in cases where vital VRFs with potentially large routing tables run the risk of running out of routes. When a VRF reaches the max limit, OSPF enters stub router mode, which denies static routing.

Users can configure a warning message when a VRF reaches a specified percentage of routes. Example commands below configure a limitation and warning from the Main Office switch. Use the show command to view the current configuration.

Use the following command to reserve routes for a particular VR and configure a warning after distributing 80 percent (for this example) of that maximum number of routes:

```
ip vrf brancha
maximum routes 1000
maximum routes warn 80
```

Use the following command to display the reserved routes for a particular VR:

```
show ip vrf brancha
   VRF Identifier..................... 2
   Description.......................
   Maximum Routes..................... 1000
   Threshold.......................... 80%
   Warning-only....................... TRUE
```

8 Troubleshooting

This section provides tips on how to help alleviate problems often encountered when configuring the network.

Note: If cutting and pasting the configurations provided in this document, successful pinging across the network can sometimes take up to 20 seconds after pasting the final configuration.

Intermittent ping responses

If using out-of-band (OOB) ports to manage switches, and only a few pings are getting responses between the top and bottom switches of the same branch (Branch A or Branch B), check to see if the management subnet has a default gateway set. Data traffic may be getting confused when default gateways are set. Remove the default gateway and retry pinging.

If the configuration requires a management default gateway, a shutdown/no shutdown of the Main Office ports that connect to the branches allows use of the OOB ports. Then retry pinging between the top and bottom branch switches.

Pinging issues immediately after pasting a configuration

If the configurations were copied and pasted into the corresponding switch CLI, allow up to 20 seconds after pasting the final configuration before pinging across the network.

Branch A Connectivity Issues

Run the following commands from the N4032F (Main Office) switches to test proper setup and connectivity to either of the Branch A switches. Use these commands when the test ping from the Branch A switch fails. See the *N-Series User Guide* and *CLI Guide* for more information on how to use each of these commands.

- To ping the brancha top switch enter: **`ping vrf brancha 192.168.10.2`**
- To trace the route to the top switch enter: **`traceroute vrf brancha 192.168.10.2`**
- To ping the brancha bottom switch enter: **`ping vrf brancha 192.168.11.2`**
- To trace the route to the bottom switch enter: **`traceroute vrf brancha 192.168.11.2`**
- To show VRF VLAN information enter: **`show ip route vrf brancha`**
- To show VRF interfaces and states enter: **`show ip vrf interfaces`**
- To show OSPF neighbors enter: **`show ip ospf neighbor vrf brancha`**

Branch B Connectivity Issues

Run the following commands from the N4032F (Main Office) switches to test proper setup and connectivity to either of the Branch B switches. Use these commands when the test ping from the Branch B switch fails. See the *N-Series User Guide* and *CLI Guide* for more information on how to use each of these commands.

- To ping the branchb top switch enter: **`ping vrf branchb 192.168.20.2`**
- To trace the route to the top switch enter: **`traceroute vrf branchb 192.168.20.2`**
- To ping the branchb bottom switch enter: **`ping vrf branchb 192.168.21.2`**
- To trace the route to the bottom switch enter: **`traceroute vrf branchb 192.168.21.2`**
- To show VRF VLAN information enter: **`show ip route vrf  branchb`**
- To show VRF interfaces and states enter: **`show ip vrf interfaces`**
- To show OSPF neighbors enter: **`show ip ospf neighbor vrf branchb`**

A Additional Resources

Support.dell.com focuses on meeting your needs with proven services and support.

DellTechCenter.com is an IT Community where you can connect with Dell EMC customers and Dell EMC employees to share knowledge, best practices, and information about Dell EMC products and installations.

Referenced or recommended Dell EMC publications:

- Dell Networking Support
  - http://www.dell.com/support
- Dell TechCenter (community forums and blogs for Dell EMC customers)
  - http://delltechcenter.com
- Dell Networking Whitepapers
  - http://en.community.dell.com/techcenter/networking/p/guides
- Dell Networking N3xxx User Guides and Firmware downloads
  - http://www.dell.com/support/home/us/en/19/product-support/product/networking-n3000-series/drivers
- Dell Networking N4xxx User Guides and Firmware downloads
  - http://www.dell.com/support/home/us/en/19/product-support/product/networking-n4000-series/drivers

B Versions

This document was compiled using the following components and versions.

Component	Firmware Version
Dell Networking N3xxx series, N4xxx series	6.3.0.0 firmware

C Glossary of Terms

Access Layer: The access layer is the layer of the network used by end users and end user devices to connect to the network.

Bandwidth: Bandwidth specifies the amount of data that can be transmitted in a fixed amount of time. Typically expressed in bits per second or multiples of bits per second (bits/s, kbits/s, Mbit/s, Gbit/s).

BGP: Border gateway protocol is a standardized exterior gateway routing protocol designed to exchange routing information between different host gateways, the internet or autonomous systems.

CLI (Command Line Interface): Text-based telnet, secure shell (SSH), or serial type interface that is used for issuing commands to a device.

DHCP (Dynamic Host Configuration Protocol): A network management protocol used to dynamically assign network settings to devices connected to a network.

LLDP (Link Layer Discovery Protocol): LLDP is a vendor neutral protocol used to obtain and share information about neighboring equipment.

MAC Address (Media Access Control address): A MAC address is a hardware specific address that uniquely identifies each node of a network. MAC addresses are assigned typically by the vendors of network interface controllers (NIC) and are stored in the hardware.

MPLS: Multiprotocol label switching is a scalable, protocol-independent transport based on label switching.

Multi-instance: A design that uses separate software and hardware for each customer, group or tenant. This contrasts with multi-tenancy designs.

Multi-tenancy: The principle that allows a single instance of software to operate on a device that services multiple groups, with each group sharing the software and hardware device. In the case of a layer 3 switch running VRF lite, each group has its own ports and configuration on the switch, allowing for isolation of data, private user management, and other reserved functionality. This contrasts with multi-instance designs.

OSPF: Open shortest path first is a standardized interior gateway routing protocol and is based on link state routing algorithm (Dijkstra's algorithm) for finding the shortest path between nodes within an autonomous system.

Route Leaking: Allows a VRF instance to pass traffic to and from a default router on the same physical switch.

VLAN (Virtual local area network, or Virtual LAN): VLANs are logical subgroups that are partitioned off a physical network in order to create separate broadcast domains.

VR: A virtual router that is created on a layer 3 switch or router that supports VRF lite. Multiple virtual routers can be created on the device and each VR has its own routing table.

VRF (Virtual Routing and Forwarding): Allows a physical layer 3 switch/router to be partitioned into multiple Virtual Routers (VRs). The control and data plane are isolated in each VR so that traffic does not flow across VRs, thus allowing multiple routing tables to co-exist within the same physical L3 switch/router at the same time.

VRID: The number given to identify all virtual routers that belong to the same VRRP group. It is assigned at the VLAN interface configuration CLI.

VRF lite: The implementation of VRF without MPLS support.

VRRP: Virtual Router Redundancy Protocol. This protocol provides participating hosts one or more backup routes on the network in case a route fails.

Support and Feedback

Contacting Technical Support

Support Contact Information	Web: http://Support.Dell.com/ Telephone: USA: 1-800-945-3355

Feedback for this document

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