ZebOS-XP®
Network Platform

Version 1.4
Extended Performance

Virtual Routing
Configuration Guide

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Preface

This guide describes how to configure Virtual Routing (VR) and Virtual Router Forwarding (VRF) in ZebOS-XP.

Audience

This guide is intended for network administrators and other engineering professionals who configure VR and VRF.

Conventions

Table P-1 shows the conventions used in this guide.

Table P-1: Conventions

Convention	Description
Italics	Emphasized terms; titles of books
Note:	Special instructions, suggestions, or warnings
`monospaced type`	Code elements such as commands, functions, parameters, files, and directories

Contents

This document contains these chapters and appendices:

- Chapter 1, *VR/VRF Configuration in Different Modes*
- Chapter 2, *OSPF Configuration*
- Chapter 3, *RIP Configuration*
- Chapter 4, *BGP Configuration*
- Chapter 5, *SVI Configuration*
- Chapter 6, *IGMP Configuration*
- Chapter 7, *PIM Configuration*
- Chapter 8, *VRRP configuration*

Related Documents

Use this guide with the *Virtual Routing Command Reference* for details about the commands used in the configurations.

Note: All ZebOS-XP technical manuals are available to licensed customers at http://www.ipinfusion.com/support/document_list.

Chapter Organization

The chapters in this guide are organized into these major sections:

- An overview that explains a configuration in words
- Topology with a diagram that shows the devices and connections used in the configuration
- Configuration steps in a table for each device where the left-hand side shows the commands you enter and the right-hand side explains the actions that the commands perform
- Validation which shows commands and their output that verify the configuration

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CHAPTER 1 VR/VRF Configuration in Different Modes

VR logically subdivides a physical router into multiple virtual routers, allowing each virtual router to execute separate instances of the routing protocol. Each virtual router can be independently monitored and managed by the user. Inside a virtual router, the VRF logically subdivides the routing tables into multiple VRFs. Each VR can have multiple VRFs supporting multiple routing tables (RIBs) co-existing within the same router at same time.

Topology

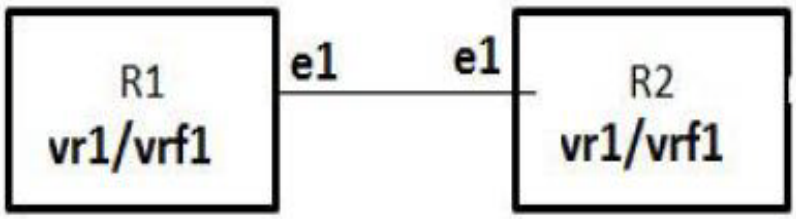

Figure 1-1: Device topology

Default VR/Default VRF

`#con t`	Enter the router configuration mode
`(config)#int eth1`	Switch to int eth1
`(config-if)#ip address 3.3.3.2/24`	Configure the ip address **`3.3.3.2`** to eth1
`(config-if)#exit`	Exit interface mode.

Adding a Static Route

`#con t`	Enter the router configuration mode
`(config)#ip route  20.20.20.0/24 eth1`	Add static route with eth1 as exit interface

Non-Default VR/Non-Default VRF

`#con t`	Enter configuration mode.
`(config)#virtual-router VR1`	Create a virtual router VR1.
`(config-vr)#load ospf`	Load the ospf module
`(config)#exit`	Exit configure mode.
`(config)#int eth1`	Enter interface mode

(config-if)#virtual-router forwarding VR1	Associate eth1 to VR1.
(config-if)#exit	Exit interface mode.
(config)#ip vrf vrf1	Create vrf1
(config)#exit	Exit configure mode.
(config)#int eth1	Enter interface mode
(config-if)#virtual-router forwarding VRF1	Associate eth1 to VRF1.
(config-if)#ip address 20.20.20.2/24	Configure the IP address to eth1
(config)#exit	Exit configure mode.

Adding a Static Route

#con t	Enter the router configuration mode
(config)# ip route vrf vrf1 20.20.20.0/24 eth1	Add static route in vrf1 with eth1 as exit interface

Non-Default VR/Default VRF

#con t	Enter configuration mode.
(config)#virtual-router VR1	Create a virtual router VR1.
(config-vr)#load ospf	Load the OSPF module
(config-vr)#load rip	Load the RIP module in VR1.
(config)#exit	Exit configure mode.
(config)#int eth1	Enter interface mode
(config-if)#virtual-router forwarding VR1	Associate eth1 to VR1.
(config)#exit	Exit configure mode.
(config)#exit	Exit configure mode.
(config)#login virtual-router VR1	Create a virtual router VR1.
(config)#>en	Enter privileged exec mode
#con t	Enter configuration mode.
(config)#interface eth1	Switch to interface eth1
(config-if)#ip address 3.3.3.2/24	Configure the IP address 3.3.3.2 to eth1
(config-if)#exit	Exit interface mode.

Adding a Static Route

#con t	Enter the router configuration mode
(config)#ip route 20.20.20.0/24 eth1	Add static route with eth1 as exit interface

Default VR/Non-Default VRF

`#con t`	Enter the router configuration mode
`(config)#ip vrf vrf1`	Create vrf1
`(config)#int eth1`	Enter interface mode
`(config-if)#ip vrf forwarding vrf1`	Associate the interface to vrf1
`(config-if)#`**`ip address 2.2.2.1/24`**	Configure the IP address **`2.2.2.1`** to eth1
`(config)#exit`	Exit configure mode.

Adding a Static Route

`#con t`	Enter the router configuration mode
`(config)# ip route vrf vrf1 20.20.20.0/24 eth1`	Add static route in vrf1 with eth1 as exit interface

CHAPTER 2 OSPF Configuration

Open Shortest Path First (OSPF) is an interior routing protocol operating within a single autonomous system (AS) that uses a link state routing algorithm. OSPF gathers link state information from available routers and constructs a topology map of the network. The topology determines the routing table presented to the Internet layer which makes routing decisions based solely on the destination IP address in IP packets.

This chapter covers OSPF configuration in non-default VR and non-default VRF.

Topology

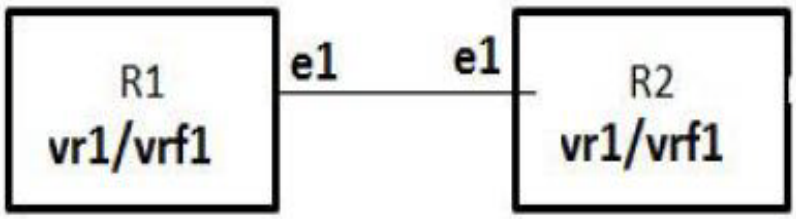

Figure 2-1: OSPF topology for VR/VRF

IPv4

R1

`#configure terminal`	Enter configure mode.
`(config)#virtual-router VR1`	Create virtual router VR1.
`(config-vr)#load ospf`	Load the OSPF module in VR1.
`(config)#exit`	Exit VR mode.
`(config)#int eth1`	Enter interface mode.
`(config-if)#virtual-router forwarding VR1`	Associate eth1 to VR1.
`(config-if)#exit`	Exit interface mode.
`(config)#exit`	Exit configure mode.
`#login virtual-router VR1`	Log in to virtual-router VR1
`>en`	Enter privileged exec mode
`#con t`	Enter the router config mode.
`(config)#ip vrf vrf1`	Create vrf1
`((config-vrf)#exit`	Exit VRF mode
`(config)#router ospf 1 vrf1`	Associate the ospf process with vrf1.
`(config-router)#network 2.2.2.0/24 area 0`	Specify the network type and area 0.
`(config-router)#ex`	Exit the OSPF configuration mode.

(config)#int eth1	Enter interface mode.
(config-if)#ip vrf forwarding vrf1	Associate eth1 to vrf1.
(config-if)#ip address 2.2.2.1/24	Assign the IP address 2.2.2.1 to eth1 in vrf1

R2

#configure terminal	Enter configure mode.
(config)#virtual-router VR1	Create virtual router VR1.
(config-vr)#load ospf	Load the OSPF module in VR1.
(config)#exit	Exit VR mode.
(config)#int eth1	Enter interface mode.
(config-if)#virtual-router forwarding VR1	Associate eth1 to VR1.
(config-if)#exit	Exit interface mode.
(config)#exit	Exit configure mode.
#login virtual-router VR1	Log in to virtual-router VR1
>en	Enter privileged exec mode
#con t	Enter the router config mode
(config)#ip vrf vrf1	Create vrf1
(config-vrf)#exit	Exit VRF mode
(config)#router ospf 1 vrf1	Associate the ospf process with vrf1
(config-router)#network 2.2.2.0/24 area 0	Specify the network type and area 0.
(config-router)#ex	Exit router mode.
(config)#int eth1	Enter interface mode.
(config-if)#ip vrf forwarding vrf1	Associate eth1 to vrf1.
(config-if)#ip address 2.2.2.2/24	Assign the IP address 2.2.2.1 to eth1 in vrf1

Validation

R1

```
#show ip ospf neighbor
OSPF process 1 VRF(vrf1):
Neighbor ID     Pri   State           Dead Time   Address    Interface Instance ID
2.2.2.2         1   Full/Backup   00:00:30   2.2.2.2     eth1       0
```

R2

```
#show ip ospf neighbor
OSPF process 1 VRF(vrf1):
Neighbor ID   Pri   State    Dead Time   Address         Interface Instance ID
2.2.2.1       1   Full/DR    00:00:35    2.2.2.1           eth1    0

Verify ospf routing table in R1 vrf1:

#show ip route vrf vrf1
Codes: K - kernel, C - connected, S - static, R - RIP, B - BGP
       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, L1 - IS-IS level-1, L2 - IS-IS level-2, ia - IS-IS inter
area
       * - candidate default
IP Route Table for VRF "vrf1"
C       2.2.2.0/24 is directly connected, eth1
Gateway of last resort is not set
```

Verify OSPF Routing Table in R1 vrf1

```
#show ip route vrf vrf1
Codes: K - kernel, C - connected, S - static, R - RIP, B - BGP
       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, L1 - IS-IS level-1, L2 - IS-IS level-2, ia - IS-IS inter
area
       * - candidate default
IP Route Table for VRF "vrf1"
C       2.2.2.0/24 is directly connected, eth1
Gateway of last resort is not set
```

Verify OSPF Routing Table in R2 vrf1

```
#show ip route vrf vrf1
Codes: K - kernel, C - connected, S - static, R - RIP, B - BGP
       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, L1 - IS-IS level-1, L2 - IS-IS level-2, ia - IS-IS interarea
       * - candidate default
IP Route Table for VRF "vrf1"
C       2.2.2.0/24 is directly connected, eth1
Gateway of last resort is not set
```

IPv6

R1

`#configure terminal`	Enter the Configure mode.
`(config)#virtual-router VR1`	Create a virtual router VR1.
`(config-vr)#load ipv6 ospf`	Load the ospf6 module to be used in VR1.
`(config)#exit`	Exit the VR mode .
`(config)#int eth1`	Switch to interface eth1.
`(config-if)#virtual-router forwarding VR1`	Associate eth1 to VR1.
`(config-if)#exit`	Exit the Interface mode.
`(config)#exit`	Exit the router config mode.
`#login virtual-router VR1`	Login in to virtual-router VR1.
`>en`	Enable the config mode.

#con t	Enter the router configuration mode.
(config)#ip vrf vrf1	Create the vrf1
((config-vrf)#exit	Exit the vrf
(config)#router ipv6 vrf ospf vrf1	Enable ipv6 rip
(config-router)#router-id 2.2.2.1	Provide the router-id 2.2.2.1
(config-router)#ex	exit.
(config)#int eth1	Switch to interface eth1
(config-if)#ip vrf forwarding vrf1	Associate eth1 to the vrf1
(config-if)#ip address 2.2.2.1/24	Configure the ip address 2.2.2.2 to eth eth1
(config-if)#ipv6 address 2222::1/48	Configure the ipv6 address.
(config-if)#ipv6 address fe80::1/48	Configure the link local address
(config-if)#ipv6 router ospf area 0 tag vrf1	Associate eth1 with ospf area 0

R2

#configure terminal	Enter the Configure mode.
(config)#virtual-router VR1	Create a virtual router VR1.
(config-vr)#load ipv6 ospf	Load the ospf6 module to be used in VR1.
(config)#exit	Exit the VR mode .
(config)#int eth1	Switch to interface eth1.
(config-if)#virtual-router forwarding VR1	Associate eth1 to VR1.
(config-if)#exit	Exit the Interface mode.
(config)#exit	Exit the router config mode.
#login virtual-router VR1	Login in to virtual-router VR1.
>en	Enable the config mode.
#con t	Enter the router configuration mode.
(config)#ip vrf vrf1	Create the vrf1
((config-vrf)#exit	Exit the vrf
(config)#router ipv6 vrf ospf vrf1	Associate ipv6 ospf 1 to vrf1
(config-router)#router-id 2.2.2.2	Specify the router-id
(config-router-af)#exit	exit the router ospf config mode
(config-router)#ex	Exit the router ospf mode.
(config)#int eth1	Exit to the router config mode
(config-if)#ip vrf forwarding vrf1	Associate eth1 to the vrf1
(config-if)#ip address 2.2.2.2/24	Configure the ip address 2.2.2.1 to eth eth1
(config-if)#ipv6 address 2222::2/48	Configure the ipv6 address.
(config-if)#ipv6 address fe80::2/48	Configure the link local address
(config-if)#ipv6 router ospf area 0 tag vrf1	Associate eth1 with ospf area 0

Validation

R1

```
rtr1#show ipv6 ospf neighbor
OSPFv3 Process (vrf1)
Neighbor ID     Pri   State           Dead Time   Interface  Instance ID
2.2.2.1         1     Full/Backup     00:00:33      eth1          0
```

R2

```
rtr2#show ipv6 ospf neighbor
OSPFv3 Process (vrf1)
Neighbor ID     Pri   State     Dead Time   Interface  Instance ID
2.2.2.1         1     Full/DR   00:00:33     eth2          0
```

CHAPTER 3 RIP Configuration

The Routing Information Protocol (RIP) is a distance-vector routing protocol which uses the hop count as a routing metric. RIP prevents routing loops by limiting the number of hops allowed (15) in a path from the source to a destination. This hop limit, however, also limits the size of networks that RIP can support. A hop count of 16 is considered an infinite distance and used to indicate inaccessible, inoperable, or otherwise undesirable routes in the selection process.

Note: This chapter covers RIP configuration in non-default VR and non-default VRF.

Topology

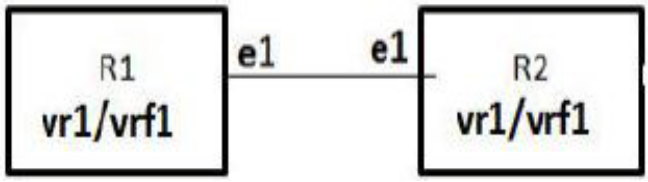

Figure 3-1: RIP topology for VR/VRF

IPv4

R1

`#configure terminal`	Enter configure mode.
`(config)#virtual-router VR1`	Create virtual router VR1.
`(config-vr)#load rip`	Load the RIP module in VR1.
`(config)#exit`	Exit VR mode.
`(config)#int eth1`	Enter interface mode.
`(config-if)#virtual-router forwarding VR1`	Associate eth1 to VR1.
`(config-if)#exit`	Exit interface mode.
`(config)#exit`	Exit configure mode.
`#login virtual-router VR1`	Log in to virtual-router VR1.
`>en`	Enter privileged exec mode.
`#con t`	Enter configuration mode.
`(config)#ip vrf vrf1`	Create vrf1
`((config-vrf)#exit`	Exit VRF mode
`(config)#router rip`	Enter router mode.
`(config-router)#version 2`	Specify RIP version 2.
`(config-router)#address-family ipv4 vrf  vrf1`	Enter address family mode for vrf1

(config-router-af)#network 2.2.2.0/24	Advertise the connected network under rip.
(config-router-af)#exit	Exit address-family mode.
(config-router)#ex	Exit router mode
(config)#int eth1	Enter interface mode
(config-if)#ip vrf forwarding vrf1	Associate the interface to vrf1
(config-if)#ip address 2.2.2.1/24	Configure the IP address 2.2.2.1 to eth1

R2

#configure terminal	Enter configure mode.
(config)#virtual-router VR1	Create virtual router VR1.
(config-vr)#load rip	Load the rip module in VR1.
(config)#exit	Exit VR mode.
(config)#int eth1	Enter interface mode.
(config-if)#virtual-router forwarding VR1	Associate eth1 to VR1.
(config-if)#exit	Exit interface mode.
(config)#exit	Exit configure mode.
#login virtual-router VR1	Log in to virtual router VR1.
>en	Enter privileged exec mode.
#con t	Enter configuration mode.
(config)#ip vrf vrf1	Create vrf1
((config-vrf)#exit	Exit VRF mode
(config)#router rip	Enter router mode.
(config-router)#version 2	Specify RIP version 2.
(config-router)#address-family ipv4 vrf vrf1	Enter address family mode for vrf1
(config-router-af)#network 2.2.2.0/24	Advertise the connected network under RIP.
(config-router-af)#exit	Exit address family mode.
(config-router)#ex	Exit router mode
(config)#int eth1	Enter interface mode
(config-if)#ip vrf forwarding vrf1	Associate the interface to vrf1
(config-if)#ip address 2.2.2.2/24	Configure the IP address 2.2.2.1 to eth1

Validation

Verify the routing table in R1:

```
#show ip route vrf vrf1
Codes: K - kernel, C - connected, S - static, R - RIP, B - BGP
       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, L1 - IS-IS level-1, L2 - IS-IS level-2, ia - IS-IS inter
       area
       * - candidate default
```

```
IP Route Table for VRF "vrf1"
C       2.2.2.0/24 is directly connected, eth1
Gateway of last resort is not set
```

Verify RIP database in R1:

```
#show ip rip database vrf vrf1
Codes: R - RIP, Rc - RIP connected, Rs - RIP static, K - Kernel,
       C - Connected, S - Static, O - OSPF, I - IS-IS, B - BGP
   Network            Next Hop         Metric  From            If     Time
  Rc 2.2.2.0/24                            1                        eth1
```

Verify the routing table in R2:

```
#show ip route vrf vrf1
Codes: K - kernel, C - connected, S - static, R - RIP, B - BGP
       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, L1 - IS-IS level-1, L2 - IS-IS level-2, ia - IS-IS inter
       area
       * - candidate default
IP Route Table for VRF "vrf1"
C       2.2.2.0/24 is directly connected, eth1
Gateway of last resort is not set
```

Verify RIP database in R2:

```
#show ip rip database vrf vrf1
Codes: R - RIP, Rc - RIP connected, Rs - RIP static, K - Kernel,
       C - Connected, S - Static, O - OSPF, I - IS-IS, B - BGP
   Network            Next Hop         Metric From            If     Time
  Rc 2.2.2.0/24                             1                        eth1
```

IPv6

R1

`#configure terminal`	Enter the Configure mode.
`(config)#virtual-router VR1`	Create a virtual router VR1.
`(config-vr)#load ipv6 rip`	Load the RIPng module to be used in VR1.
`(config)#exit`	Exit the VR mode .
`(config)#int eth1`	Switch to interface eth1.
`(config-if)#virtual-router forwarding VR1`	Associate eth1 to VR1.
`(config-if)#exit`	Exit the Interface mode.
`(config)#exit`	Exit the router config mode.
`#login virtual-router VR1`	Login in to virtual-router VR1.
`>en`	Enable the config mode.
`#con t`	Enter the router configuration mode.
`(config)#ip vrf vrf1`	Create the vrf1

(config-vrf)#exit	Exit the vrf
(config)#router ipv6 rip	Enable ipv6 rip
(config-router)#address-family ipv6 vrf vrf1	Switch to ipv6 rip address family
(config-router-af)#aggregate-address 2222::/48	Configure the ipv6 aggregate-address
(config-router-af)#exit	Exit the router rip mode.
(config-router)#ex	exit.
(config)#int eth1	Switch to interface eth1
(config-if)#ip vrf forwarding vrf1	Associate eth1 to the vrf1
(config-if)#ip address 2.2.2.1/24	Configure the ip address 2.2.2.2 to interface eth1
(config-if)#ipv6 address 2222::1/48	Configure the ipv6 address.
(config-if)#ipv6 address fe80::1/48	Configure the link local address
(config-if)#ipv6 router rip	Associate interface eth1 to ipv6 rip

R2

#configure terminal	Enter the Configure mode.
(config)#virtual-router VR1	Create a virtual router VR1.
(config-vr)#load ipv6 rip	Load the Ripng module to be used in VR1
(config)#exit	Exit the VR mode .
(config)#int eth1	Switch to interface eth1.
(config-if)#virtual-router forwarding VR1	Associate eth1 to VR1.
(config-if)#exit	Exit the Interface mode.
(config)#exit	Exit the router config mode.
#login virtual-router VR1	Login in to virtual-router VR1.
>en	Enable the config mode.
#con t	Enter the router configuration mode.
(config)#ip vrf vrf1	Create the vrf1
(config-vrf)#exit	Exit the vrf
(config)#router ipv6 rip	Switch to the rip ipv6 address family
(config-router)#address-family ipv6 vrf vrf1	Switch to the rip ipv6 address family
(config-router-af)#aggregate-address 2222::/48	Configure the ipv6 aggregate address
(config-router-af)#exit	Exit the address ipv6 rip address family
(config-router)#ex	Exit the router IPV6 rip mode.
(config)#int eth1	Exit to the router config mode
(config-if)#ip vrf forwarding vrf	Associate eth1 to the vrf1
(config-if)#ip address 2.2.2.2/24	Configure the ip address 2.2.2.1 to eth eth1
(config-if)#ipv6 address 2222::2/48	Configure the ipv6 address.
(config-if)#ipv6 address fe80::2/48	Configure the link local address
(config-if)#ipv6 router rip	Associate int eth1 to ipv6 rip

Validation

```
rtr1#show ipv6 route vrf vrf1
IPv6 Routing Table
Codes: K - kernel route, C - connected, S - static, R - RIP, O - OSPF,
       IA - OSPF inter area, E1 - OSPF external type 1,
       E2 - OSPF external type 2, I - IS-IS, B - BGP
Timers: Uptime
IP Route Table for VRF "vrf1"
C      2222::/48 via ::, eth1, 00:06:19
C      fe80::/48 via ::, eth1, 00:02:33
rtr18#show ipv6 rip database vrf vrf1
Codes: R - RIP, Rc - RIP connected, Rs - RIP static, Ra - RIP aggregated,
       Rcx - RIP connect suppressed, Rsx - RIP static suppressed,
       K - Kernel, C - Connected, S - Static, O - OSPF, I - IS-IS, B - BGP
   Network                    Next Hop                  If     Met Tag  Time
Rcx 2222::/48                 ::                        eth1     1   0

rtr2#show ipv6 rip interface
eth1 is up, line protocol is up
  Routing Protocol: RIPng
    VPN Routing/Forwarding: vrf1
    Passive interface: Disabled
    Split horizon: Enabled with Poisoned Reversed
    IPv6 interface address:
      2222::1/48
      fe80::1/48
eth2 is up, line protocol is up
  RIPng is not enabled on this interface
```

CHAPTER 4 BGP Configuration

Border Gateway Protocol (BGP) makes core routing decisions on the Internet using a table of IP networks or “prefixes” which designate network reachability among autonomous systems (AS). BGP is a path vector protocol or a variant of a distance-vector routing protocol. BGP does not involve traditional Interior Gateway Protocol (IGP) metrics, but routing decisions are made based on path, network policies, and/or rule sets. For this reason, it is more appropriately termed a reachability protocol rather than routing protocol.

Note: This chapter covers BGP configuration in non-default VR and non-default VRF.

Topology

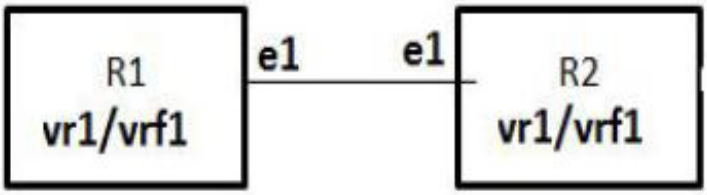

Figure 4-1: BGP topology for VR/VRF

R1

`#configure terminal`	Enter configure mode.
`(config)#virtual-router VR1`	Create virtual router VR1.
`(config-vr)#load bgp`	Load BGP in VR1.
`(config)#exit`	Exit VR mode.
`(config)#int eth1`	Enter interface mode.
`(config-if)#virtual-router forwarding VR1`	Associate eth1 to VR1.
`(config-if)#exit`	Exit interface mode.
`(config)#exit`	Exit configure mode.
`#login virtual-router VR1`	Log in to virtual-router VR1.
`>en`	Enter privileged exec mode.
`#con t`	Enter configuration mode.
`(config)#ip vrf vrf1`	Create vrf1
`(config-vrf)#rd 800:1`	Specify the route distinguisher in the VRF
`(config-vrf)#`route-target import 800:1	Specify the import route target
`(config-vrf)#`route target export 800:1	Specify the export route target
`((config-vrf)#exit`	Exit VRF mode
`(config)#router bgp 200`	Enter the bgp configuration mode
`(config-router)#address-family ipv4 vrf  vrf1`	Enter address family mode for vrf1

(config-router-af)#neighbor 2.2.2.2 remote-as 100	Specify the BGP neighbor and remote-AS.
(config-router-af)#exit	Exit address family mode.
(config-router)#ex	Exit router mode
(config)#int eth1	Enter interface mode
(config-if)#ip vrf forwarding vrf1	Associate the interface to vrf1
(config-if)#ip address 2.2.2.1/24	Configure the IP address 2.2.2.1 to eth1

R2

#configure terminal	Enter configure mode.
(config)#virtual-router VR1	Create virtual router VR1.
(config-vr)#load bgp	Load BGP in VR1.
(config)#exit	Exit VR mode.
(config)#int eth1	Enter interface mode.
(config-if)#virtual-router forwarding VR1	Associate eth1 to VR1.
(config-if)#exit	Exit interface mode.
(config)#exit	Exit configure mode.
#login virtual-router VR1	Log in to virtual router VR1.
>en	Enter privileged exec mode.
#con t	Enter configuration mode.
(config)#ip vrf vrf1	Create vrf1
(config-vrf)#rd 800:1	Specify the route distinguisher in the VRF
(config-vrf)#route-target import 800:1	Specify the import route target
(config-vrf)#route target export 800:1	Specify the export route target
(config-vrf)#exit	Exit VRF mode
(config)#router bgp 100	Enter router mode.
(config-router)#address-family ipv4 vrf vrf1	Enter address family mode for vrf1
(config-router-af)#neighbour 2.2.2.1 remote-as 200	Specify the BGP neighbor and remote-as.
(config-router-af)#exit	Exit address family mode.
(config-router)#ex	Exit router mode
(config)#int eth1	Enter interface mode
(config-if)#ip vrf forwarding vrf1	Associate the interface to vrf1
(config-if)#ip address 2.2.2.2/24	Configure the IP address 2.2.2.1 to eth1

Validation

Verify the routing table in R1:

```
R1: localhost#show ip bgp neighbors
```

```
BGP neighbor is 2.2.2.2, vrf vrf1, remote AS 2, local AS 1, external link
  BGP version 4, remote router ID 3.3.3.2
  BGP state = Established, up for 00:00:00
  Last read 00:00:00, hold time is 90, keepalive interval is 30 seconds
  Neighbor capabilities:
    Route refresh: advertised and received (old and new)
    Address family IPv4 Unicast: advertised and received
  Received 2 messages, 0 notifications, 0 in queue
  Sent 2 messages, 0 notifications, 0 in queue
  Route refresh request: received 0, sent 0
  Minimum time between advertisement runs is 30 seconds
 For address family: IPv4 Unicast
  BGP table version 1, neighbor version 0
  Index 1, Offset 0, Mask 0x2
  Community attribute sent to this neighbor (standard)
  0 accepted prefixes
  0 announced prefixes

 Connections established 1; dropped 0
Local host: 2.2.2.1, Local port: 48116
Foreign host: 2.2.2.2, Foreign port: 179
Nexthop: 2.2.2.1
Nexthop global: ::
Nexthop local: ::
BGP connection: non shared network
```

Verify the routing table in R2:

```
#show ip bgp neighbors
BGP neighbor is 2.2.2.1, vrf vrf1, remote AS 1, local AS 2, external link
  BGP version 4, remote router ID 2.2.2.1
  BGP state = Established, up for 00:02:01
  Last read 00:02:01, hold time is 90, keepalive interval is 30 seconds
  Neighbor capabilities:
    Route refresh: advertised and received (old and new)
    Address family IPv4 Unicast: advertised and received
  Received 6 messages, 0 notifications, 0 in queue
  Sent 6 messages, 0 notifications, 0 in queue
  Route refresh request: received 0, sent 0
  Minimum time between advertisement runs is 30 seconds
 For address family: IPv4 Unicast
  BGP table version 1, neighbor version 1
  Index 1, Offset 0, Mask 0x2
  Community attribute sent to this neighbor (standard)
  0 accepted prefixes
  0 announced prefixes

 Connections established 1; dropped 0
Local host: 2.2.2.2, Local port: 179
Foreign host: 2.2.2.1, Foreign port: 48116
Nexthop: 2.2.2.2
Nexthop global: ::
Nexthop local: ::
BGP connection: non shared network
[II]
```

R1:

```
localhost#show ip route vrf vrf1
Codes: K - kernel, C - connected, S - static, R - RIP, B - BGP
       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, L1 - IS-IS level-1, L2 - IS-IS level-2, ia - IS-IS inter
area
       * - candidate default

IP Route Table for VRF "vrf1"
C       2.2.2.0/24 is directly connected, eth1

Gateway of last resort is not set
```

R2:

```
#show ip route vrf vrf1
Codes: K - kernel, C - connected, S - static, R - RIP, B - BGP
       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, L1 - IS-IS level-1, L2 - IS-IS level-2, ia - IS-IS inter
area
       * - candidate default

IP Route Table for VRF "vrf1"
C       2.2.2.0/24 is directly connected, eth1

Gateway of last resort is not set
```

Verify BGP Adjacency

Use the following `show` commands to verify the BGP adjacency:

- `show ip bgp neighbor`
- `show ip route vrf vrf1`

CHAPTER 5 SVI Configuration

A switch virtual interface (SVI) is a VLAN of switch ports represented by one interface to a routing or bridging system. There is no physical interface for the VLAN and the SVI provides the Layer 3 processing for packets from all switch ports associated with the VLAN.

There is one-to-one mapping between a VLAN and SVI, thus only a single SVI can be mapped to a VLAN. In default setting, an SVI is created for the default VLAN (VLAN1) to permit remote switch administration. An SVI cannot be activated unless associated with a physical port.

Note: This chapter covers the scenario of SVI configuration in non-default VR and non-default VRF.

Topology

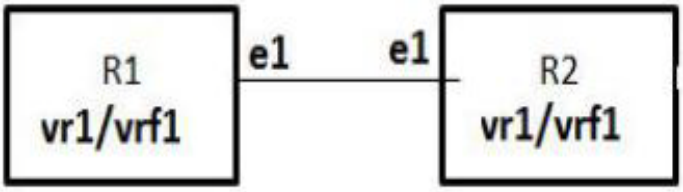

Figure 5-1: SVI topology for VR/VRF

R1

`#configure terminal`	Enter configure mode.
`(config)#bridge 1 protocol ieee vlan-bridge`	Configure bridge 1
`(config-vr)#vlan database`	Enter VLAN database mode.
`(config)#vlan 2 bridge 1 state enable`	Enable VLAN 2
`(config)#ex`	Exit VLAN database mode.
`(config-if)#virtual-router forwarding VR1`	Configure virtual router VR1.
`(config-if)#exit`	Exit interface mode.
`(config)#int eth1`	Enter interface mode
`(config)#switchport`	Make eth1 a layer 2 interface.
`(config)#bridge-group 1`	Associate eth1 to bridge-group 1.
`(config-if)#switchport mode trunk`	Configure eth1 as trunk port.
`(config-if)#switchport trunk allowed vlan add 2`	Allow VLAN 2 on eth1 interface.
`(config-if)#exit`	Exit interface mode.
`(config-if)#int vlan 1.2`	Enter interface mode
`(config)#virtual-router forwarding VR1`	Associate VLAN 1.2 interface to VR1
`(config-router)#exit`	Exit router mode.
`(config)#exit`	Exit configure mode.

#login virtual-router VR1	Log in to virtual router VR1.
>en	Enter privileged exec mode
#con t	Enter configure mode
(config)#ip vrf vrf1	Create vrf1
(config-vrf)#exit	Exit VRF mode
(config)#int vlan1.2	Enter interface mode
(config-if)#ip vrf forwarding vrf1	Associate vlan1.2 interface to vrf2
(config)#ip address 2.2.2.1/24	Configure an IP address to the vlan1.2 interface

R2

#configure terminal	Enter configure mode.
(config)#bridge 1 protocol ieee vlan-bridge	Configure bridge 1
(config-vr)#vlan database	Enter VLAN database mode
(config)#vlan 2 bridge 1 state enable	Enable VLAN 2
(config)#ex	Exit VLAN database mode.
(config-if)#virtual-router forwarding VR1	Configure virtual router VR1.
(config-if)#exit	Exit interface mode.
(config)#int eth1	Enter interface mode
(config-if)#switchport	Change eth1 to a l2 interface.
(config-if)#bridge-group 1	Associate eth1 to bridge-group 1.
(config-if)#switchport mode trunk	Configure eth1 as trunk port.
(config-if)#switchport trunk allowed vlan add 2	Allow VLAN 2 on eth1 interface.
(config-if)#exit	Exit interface mode.
(config)#int vlan 1.2	Enter interface mode
(config)#virtual-router forwarding VR1	Associate VLAN 1.2 interface to VR1
(config-router)#exit	Exit router mode
(config)#exit	Exit configure mode.
#login virtual-router VR1	Log in to virtual router VR1.
>en	Enter privileged exec mode
(config)#ip vrf vrf1	Create vrf1
(config-vrf)#exit	Exit VRF mode
(config)#int vlan1.2	Enter interface mode
(config-if)#ip vrf forwarding vrf1	Associate vlan1.2 interface to vrf2
(config)#ip address 2.2.2.2/24	Configure an IP address to the vlan1.2 interface

Validation

Log in to the VR by using login virtual-router VR1 and from R1 vlan 1.2 ip address ping to R2 vlan 1.2 ip address.ping should be ok.

R1

```
(config)#exit                                   Exit configure mode.
#login virtual-router VR1                  Log in to virtual-router VR1.
>en                                                      Enable
#ping 2.2.2.1
```

R2

```
(config)#exit                                   Exit configure mode.
#login virtual-router VR1                  Log in to virtual-router VR1.
>en                                                      Enable
#ping 2.2.2.2
```

CHAPTER 6 IGMP Configuration

The Internet Group Management Protocol (IGMP) is used by hosts and adjacent routers on IP networks to establish multicast group memberships. IGMP is an integral part of IP multicast.

IGMP can be used for one-to-many networking applications such as online streaming video and gaming, and allows more efficient use of resources when supporting these types of applications.

Note: This chapter covers IGMP configuration in non-default VR and non-default VRF.

Topology

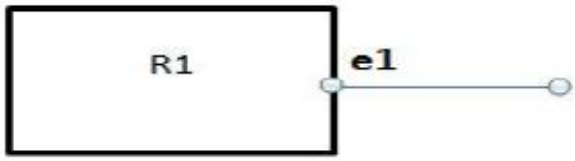

Figure 6-1: IGMP topology for VR/VRF

R1

`#configure terminal`	Enter configure mode.
`(config)#virtual-router VR1`	Create virtual router VR1.
`(config-vr)#load pim`	Load the PIM module in VR1.
`(config)#exit`	Exit VR mode.
`(config)#int eth1`	Enter interface mode.
`(config-if)#virtual-router forwarding VR1`	Associate eth1 with the VR1.
`#login virtual-router VR1`	Log in to VR1
`>en`	Enter privileged exec mode
`#conf t`	Enter configure mode
`(config)#ip vrf vrf1`	Create vrf1
`(config-vrf1)#exit`	Exit VRF mode.
`(config)#ip multicast routing vrf vrf1`	Configure multicasting in vrf1.
`(config)#int eth1`	Enter interface mode.
`(config-if)#ip vrf forwarding vrf1`	Associate eth1 to vrf1
`(config-if)#ip igmp`	Enable IGMP in eth1
`(config-if)#ip igmp static-group 226.0.0.1`	Create a static multicast group in eth1
`(config-if)#ip pim sparse-mode`	Enable PIM sparse mode

Validation

Verify IGMP group membership:

```
#show ip igmp vrf vrf1 groups
IGMP Connected Group Membership
Group Address    Interface            Uptime   Expires  Last Reporter
226.0.0.1        eth1                 00:18:43  stopped 0.0.0.0
```

Verify IGMP interface details:

```
#show ip igmp vrf vrf1 interface
Interface eth1 (Index 3)
 IGMP Enabled, Active, Querier, Version 3 (default)
 Internet address is 10.10.10.1
 IGMP interface has 1 group-record states
 IGMP activity: 0 joins, 0 leaves
 IGMP query interval is 125 seconds
 IGMP Startup query interval is 31 seconds
 IGMP Startup query count is 2
 IGMP querier timeout is 255 seconds
 IGMP max query response time is 10 seconds
 Group Membership interval is 260 seconds
 IGMP Last member query count is 2
 Last member query response interval is 1000 milliseconds.
```

Verify PIM route:

```
#sh ip pim vrf vrf1 mroute
IP Multicast Routing Table
(*,*,RP) Entries: 0
(*,G) Entries: 1
(S,G) Entries: 0
(S,G,rpt) Entries: 0
FCR Entries: 0
(*, 226.0.0.1)
RP: 0.0.0.0
RPF nbr: 0.0.0.0
RPF idx: None
Upstream State: JOINED
 Local     i.............................
 Joined    .............................
 Asserted  .............................
FCR:
```

CHAPTER 7 PIM Configuration

Protocol-Independent Multicast (PIM) is a family of multicast routing protocols for IP networks that provide one-to-many and many-to-many distribution of data over a LAN, WAN or the Internet. PIM is called “protocol-independent” because it does not include its own topology discovery mechanism, but instead uses routing information supplied by other traditional routing protocols such as OSPF, IS-IS, RIP and BGP.

Note: This chapter covers PIM configuration in non-default VR and non-default VRF.

Topology

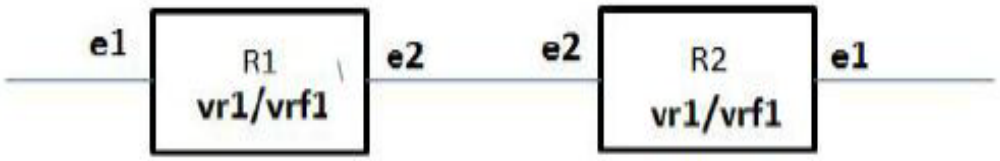

Figure 7-1: PIM topology for VR/VRF

R1

`#configure terminal`	Enter configure mode.
`(config)#virtual-router VR1`	Create virtual router VR1.
`(config-vr)#load pim`	Load the PIM module in VR1.
`(config-vr)#load ospf`	Load the OSPF module
`(config)#exit`	Exit VR mode.
`(config)#int eth1`	Enter interface mode.
`(config-if)#virtual-router forwarding VR1`	Associate eth1 with the VR1.
`(config)#exit`	Exit configure mode.
`#login virtual-router VR1`	Log in to virtual-router VR1.
`>en`	Enter privileged exec mode.
`#con t`	Enter configure mode
`(config)#ip vrf vrf1`	Create the vrf1
`(config-vrf)#exit`	Exit VRF mode
`(config)#ip multicast-routing vrf vrf1`	Enable multicast routing in vrf1
`(config)#ip pim vrf vrf1 rp-address 1.1.1.1`	Enable PIM in vrf1.
`(config)#router ospf 1 vrf1`	Enter router mode.
`(config)#ospf router-id 30.30.30.1`	Configure router-id
`(config-rtr)#network 1.1.1.0/24 area 0`	Advertise the connected network in OSPF.
`(config-rtr)#network 10.10.10.0/24 area 0`	Advertise the connected network in OSPF

(config-rtr)#exit	Exit router mode
(config)#int eth1	Enter interface mode.
(config-if)#ip vrf forwarding vrf1	Associate vrf1 with eth1
(config-if)#ip address 10.10.10.1/24	Configure an ip address eth1
(config-if)#ip igmp	Enable IGMP in eth1
(config)#ip igmp static-group 226.0.0.1	Create a static multicast group
(config-if)#ip pim sparse-mode	Enable PIM in sparse-mode
(config-if)#exit	Exit interface mode
(config-if)#int eth2	Enter interface mode.
(config-if)#ip vrf forwarding vrf1	Associate eth2 with vrf1
(config-if)#ip address 1.1.1.1/24	Configure an IP address for eth2
(config-if)#ip pim sparse-mode	Enable PIM in sparse mode

R2

#configure terminal	Enter configure mode.
(config)#virtual-router VR1	Create virtual router VR1.
(config-vr)#load pim	Load the PIM module in VR1.
(config-vr)#load ospf	Load the OSPF module
(config)#exit	Exit VR mode.
(config)#int eth1	Enter interface mode
(config-if)#virtual-router forwarding VR1	Associate eth1 to VR1
(config)#exit	Exit interface mode.
#login virtual-router VR1	Log in to virtual-router VR1
>en	Enter privileged exec mode
#con t	Enter configure mode.
(config)#ip vrf vrf1	Create vrf1
(config-vrf)#exit	Exit VRF mode
(config)#ip multicast-routing vrf vrf1	Enable multicast support in vrf1
(config)#ip pim vrf vrf1 rp-address 1.1.1.1	Configure PIM in vrf1
(config)#router ospf 1 vrf1	Enter router mode.
(config-rtr)#ospf router-id 50.50.50.1	Configure the router-id
(config-rtr)#network 1.1.1.0/24 area 0	Advertise the network 1.1.1.0
(config-rtr)#network 20.20.20.0/24 area 0	Advertise the network 20.20.20.0
(config-rtr)#exit	Exit router mode.
(config)#int eth1	Enter interface mode.
(config-if)#ip vrf forwarding vrf1	Associate the interface to vrf1
(config-if)#ip address 20.20.20.2/24	Configure the IP address 20.20.20.1 to eth1
(config)#ip pim sparse-mode	Enable PIM sparse-mode

(config)#int eth2	Enter interface mode.
(config-if)#ip vrf forwarding vrf1	Associate vrf1 to eth1
(config-if)#ip address 20.20.20.2/24	Configure IP address for eth1
(config-if)#ip pim sparse-mode	Enable PIM sparse-mode

Validation

Validate R1 and R2:

```
#show ip ospf neighbor
OSPF process 1 VRF(vrf1):
Neighbor ID     Pri   State           Dead Time   Address         Interface
Instance ID
30.30.30.1        1   Full/Backup     00:00:34    1.1.1.2         eth2       0
```

Verify the OSPF routing able in R1:

```
#show ip route vrf vrf1
Codes: K - kernel, C - connected, S - static, R - RIP, B - BGP
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, L1 - IS-IS level-1, L2 - IS-IS level-2, ia - IS-IS inter area
       * - candidate default
IP Route Table for VRF "vrf1"
C       1.1.1.0/24 is directly connected, eth2
C       10.10.10.0/24 is directly connected, eth1
O       20.20.20.0/24 [110/2] via 1.1.1.2, eth2, 00:26:09

Gateway of last resort is not set
```

Verify IGMP group details in R1:

```
#show ip igmp vrf vrf1 groups
IGMP Connected Group Membership
Group Address    Interface            Uptime   Expires Last Reporter
226.0.0.1        eth1                 03:41:24  stopped 0.0.0.0
#show ip pim vrf vrf1 ne
Neighbor nexthop.
```

Verify PIM route details:

```
#show ip pim vrf vrf1 mroute
IP Multicast Routing Table
(*,*,RP) Entries: 0
(*,G) Entries: 1
(S,G) Entries: 0
(S,G,rpt) Entries: 0
FCR Entries: 0
(*, 226.0.0.1)
RP: 1.1.1.1
RPF nbr: 0.0.0.0
RPF idx: None
Upstream State: JOINED
 Local     i.............................
 Joined    .............................
 Asserted.............................
```

```
FCR:
```

Verify RP mapping in R1:

```
#show ip pim vrf vrf1 rp mapping
PIM Group-to-RP Mappings
Override RP cnt: 0
Group(s): 224.0.0.0/4, Static
    RP: 1.1.1.1
         Uptime: 00:29:08
```

Verify R1 and R2:

```
#show ip pim vrf vrf1 neighbor
controller1#show ip pim vrf vrf1 neighbor
Neighbor  Interface  Uptime/Expires  Ver DR priority/Mode
Address
5.5.5.2  eth2 00:30:49/00:01:27 v2 1 / DR
```

CHAPTER 8 VRRP configuration

The Virtual Router Redundancy Protocol (VRRP) provides for automatic assignment of available Internet Protocol (IP) routers to participating hosts. This increases the availability and reliability of routing paths via automatic default gateway selections on an IP subnetwork.

The protocol achieves this by creation of virtual routers, which are an abstract representation of multiple routers, i.e. master and backup routers, acting as a group. The default gateway of a participating host is assigned to the virtual router instead of a physical router. If the physical router that is routing packets on behalf of the virtual router fails, another physical router is selected to automatically replace it. The physical router that is forwarding packets at any given time is called the master router.

Note: This chapter covers VRRP configuration in non-default VR and non-default VRF.

Topology

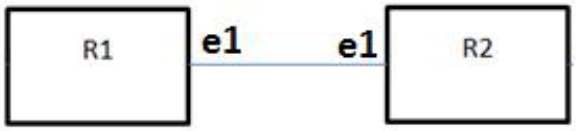

Figure 8-1: VRRP topology for VR/VRF

R1

`#configure terminal`	Enter the Configure mode.
`(config)#virtual-router VR1`	Create a virtual router VR1.
`(config-vr)#load vrrp`	Load the VRRP module
`(config)#exit`	Exit configure mode.
`(config)#int eth1`	Enter interface mode
`(config-if)#virtual-router forwarding VR1`	Associate eth1 to VR1.
`(config-if)#end`	Exit the interface mode
`#login virtual-router VR1`	Login to virtual router VR1
`#configure terminal`	Enter the Configure mode.
`(config)#int eth1`	Enter interface mode
`(config-if)#ip address 2.2.2.1/24`	Assign ip address to the interface eth1.
`(config-if)#exit`	Exit the interface mode
`(config)#router vrrp 1 eth1`	Enable vrrp mode for the router.
`(config-router)#virtual-ip 2.2.2.1 owner`	Configure the virtual ip address and owner.
`(config-router)#advertisement-interval 3000`	Configure the advertisement interval

(config-router)#enable	Enable the vrrp configuration.
(config-router)#exit	Exit the vrrp config mode.

R2

#configure terminal	Enter the Configure mode.
(config)#virtual-router VR1	Create a virtual router VR1.
(config-vr)#load vrrp	Load the VRRP module
(config)#exit	Exit configure mode.
(config)#int eth1	Enter interface mode
(config-if)#virtual-router forwarding VR1	Associate eth1 to VR1.
(config-if)#end	Exit the interface mode
#login virtual-router VR1	Login to virtual router VR1
#configure terminal	Enter the Configure mode.
(config)#int eth1	Enter interface mode
(config-vr)#ip address 2.2.2.2/24	Assign ip address to the interface eth1.
(config-vr)#ex	Exit the interface mode
(config)#router vrrp 1 eth1	Enable vrrp mode for the router.
(config-router)#virtual-ip 2.2.2.1	Configure the virtual ip address
(config-router)#advertisement-interval 3000	Configure the advertisement interval
(config-router)#priority 120	Configure the priority for the back-up vrrp router
(config-router)#enable	Enable the vrrp configuration
(config-router)#exit	Exit the vrrp config mode.

Validation

Validate R1 and R2:

```
Rtr1#show vrrp 1 eth1
VRRP Version: 3
VMAC enabled
Backward Compatibility disabled
Address family IPv4
VRRP Id: 1 on interface: eth1
State: AdminUp   - Master
Virtual IP address: 2.2.2.1 (Owner)
Priority is 255
Advertisement interval: 3000 centi sec
Master Advertisement interval: 3000 centi sec
Skew time: 11 centi sec
Accept mode: FALSE
Preempt mode: TRUE
Multicast membership on IPv4 interface eth1: JOINED
```

In R2:

```
Rtr2#show vrrp 1 eth1
VRRP Version: 3
VMAC enabled
Backward Compatibility disabled

Address family IPv4
VRRP Id: 1 on interface: eth1
State: AdminUp   - Backup
Virtual IP address: 2.2.2.1 (Not-owner)
Priority is 80
Advertisement interval: 300 centi sec
Master Advertisement interval: 2059 centi sec
Skew time: 1415 centi sec
Accept mode: FALSE
Preempt mode: TRUE
Multicast membership on IPv4 interface eth1: JOINED.
```

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