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1 Configuring VRRP Plus

1.1 Introduction

Virtual Router Redundancy Protocol Plus (VRRP Plus) is an extension of VRRP. It uses VRRP to implement gateway backup and load balancing in an IEEE 802.3 local area network (LAN). A backup router with VRRP enabled cannot forward packets. To use VRRP to implement load balancing, you need to manually configure multiple VRRP groups and set the gateway addresses of hosts in the LAN to virtual IP addresses of different VRRP groups. This increases the workload of the network administrator. VRRP Plus is designed to address this issue. VRRP Plus automatically implements load balancing. It automatically distributes traffic of different hosts to members of a VRRP Plus group, and you do not need to configure multiple VRRP groups or set the gateway addresses of hosts in the LAN to virtual IP addresses of different VRRP groups. This reduces the workload of the network administrator. You can enable a load balancing policy within a VRRP group without configuring multiple VRRP groups or different default gateways for hosts.

1.1.1 Basic Concepts

1. BVG

The balancing virtual gateway (BVG) allocates virtual MAC addresses to members of a VRRP Plus group. It responds to the gateway Address Resolution Protocol/Neighbor Discovery (ARP/ND) requests in the LAN, and forwards packets of hosts in the LAN.

2. BVF

The balancing virtual forwarder (BVF) forwards packets of hosts in the LAN. If a virtual MAC address is allocated to a BVF, the BVF participates in packet forwarding; otherwise, the BVF does not participate in packet forwarding.

3. Correlation with VRRP

VRRP Plus relies on VRRP, and runs in the following way:

- A master device in VRRP corresponds to a BVG in VRRP Plus.

- A backup device in VRRP corresponds to a BVF in VRRP Plus. Gateway addresses of hosts in a LAN are set to the virtual IPv4/IPv6 address of VRRP.

4. MAC Address Allocation

A BVG allocates virtual MAC addresses to BVFs. For an IPv4 VRRP Plus group, the BVG directly uses the virtual MAC address of VRRP to ensure compatibility between IPv4 VRRP Plus and IPv4 VRRP. That is, the virtual MAC address used by the BVG is 00-00-5E-00-01-{VRID} (VRID is the VRRP group number). The virtual MAC address used by a BVF is 00-1A-A9-16-{MemberID}-{VRID} (MemberID is the member ID of the BVF in the VRRP Plus group). Currently, a VRRP Plus group can have up to four members. The BVG uses the member ID 01, and the other BVFs use the member IDs 02 to 04.

For an IPv6 VRRP Plus group, the BVG directly uses the virtual MAC address of IPv6 VRRP to ensure compatibility between IPv6 VRRP Plus and IPv6 VRRP. That is, the virtual MAC address used by the BVG is 00-00-5E-00-02-{VRID} (VRID is the IPv6 VRRP group number). The virtual MAC address used by a BVF is 14-14-4B-72-{76 + MemberID }-{VRID}. The value range of MemberID is from 01 to 03.

5. **Load Balancing Policies**

The BVG responds to the gateway ARP/NS requests sent from hosts in a LAN. According to a specific load balancing policy, the BVG responds to hosts by using different virtual MAC addresses. The following load balancing policies are available:

- Host-dependent policy: A specific virtual MAC address is used to respond to the requests sent by a specific host.

- Round-robin policy: Virtual MAC addresses in a backup group are used in a cyclic manner to respond to the gateway ARP/NS requests sent by hosts.

- Weighted policy: The ARP/NA requests are responded based on the forwarding capability of a device.

Policy switching is described below:

- If the load balancing mode is changed, load balancing is always implemented in the new load balancing mode. For example, if the round-robin load balancing mode is previously used, and later the weighted mode is used, load balancing is implemented in weighted mode. Load balancing cannot be implemented for hosts that have learned the VRRP virtual gateway addresses before the configuration of VRRP Plus. Therefore, if VRRP Plus is configured after a VRRP group switches to the master state, real load balancing cannot be implemented before aging of the ARP/ND entries learned by hosts. Load balancing is implemented only after the gateway ARP/ND entries learned by the hosts age and the hosts request new gateway addresses.

- Weight configuration means configuring different weights for different devices. In this way, more traffic is distributed to the device with a greater weight and less traffic is distributed to the device with a smaller weight, thereby fully utilizing the forwarding performance of different devices (if the total weight of virtual routers in a VRRP Plus group is 0, the ARP/NS requests are not responded). When the weight of a BVF in a backup group is smaller than the lower threshold, the BVF automatically exits the forwarding role. When the weight recovers and is greater than the upper threshold, the BVF automatically applies to the forwarding role. The forwarding role can be recovered when one or more remaining virtual MAC addresses or proxy virtual MAC addresses exist.

- The function of periodically sending of gratuitous ARP packets on an interface also affects the load balancing function of VRRP Plus. When VRRP Plus is enabled, the function of sending gratuitous ARP/NA packets of VRRP virtual IP addresses will be disabled. When a virtual IP address overlaps with an actual IP address, gratuitous ARP/NA packets of this address are no longer sent.

- When an address conflict occurs between a host and the local device, the ARP/NA module will broadcast gratuitous ARP/NA packets of this address. If a conflict occurs on the VRRP Plus virtual address, sending gratuitous ARP/NA packets results in re-learning of the host's gateway MAC address, which negatively affects the load balancing function of VRRP Plus. Therefore, the load balancing function of VRRP Plus is currently not supported in this scenario.

6. **Proxy Virtual MAC Address**

When a device with a virtual MAC address assigned becomes faulty in a backup group, traffic of hosts that use this virtual MAC address as the gateway MAC address will be interrupted. The BVG in the VRRP Plus backup

group can quickly detect the fault, and automatically allocate the virtual MAC address of the faulty BVF to another device in the backup group. The new device acts as the proxy of the faulty device to forward packets of the virtual MAC address. In addition, this proxy device takes over traffic of original hosts to prevent traffic interruption. The virtual MAC address allocated to a device in a backup group can be called a master virtual MAC address, and the virtual MAC address used by this device on behalf of another device is called a proxy virtual MAC address.

7. **Redirection Interval and Timeout**

VRRP Plus provides the virtual MAC address proxy function so that another device can take the place of a faulty device with a virtual MAC address assigned to forward packets. If a BVF recovers from the fault, its forwarding role should be restored and the BVF continues to forward packets of the virtual MAC address allocated to this BVF. If the faulty BVF does not recover all the time, the backup group stops redirecting traffic to this virtual MAC address. That is, when gateway ARP requests are received again, this virtual MAC address is no longer used to give responses. After a sufficient long period of time, it is believed that hosts that use the virtual MAC address as the gateway MAC address already update the ARP/ND table entry of the gateway address, and the traffic is already taken over by other devices. Now, this virtual MAC address can be deleted, and packets sent to this virtual MAC address should be discarded.

VRRP Plus allows configuring the redirection interval and timeout for a backup group. When a device is faulty, the backup group allocates the virtual MAC address of the faulty device to another device. Within the redirection interval, the backup group continues to use this virtual MAC address to respond to the ARP/NS requests. When the redirection time expires, the backup group no longer uses this virtual MAC address to respond to the requests. When the timeout time elapses, the backup group deletes this virtual MAC address and stops using it for proxy forwarding. Figure 1-1 shows the changes in the role of a virtual MAC address within the redirection interval and timeout time.

Figure 1-1   Diagram of Changes in the Role of an Allocated Virtual MAC Address
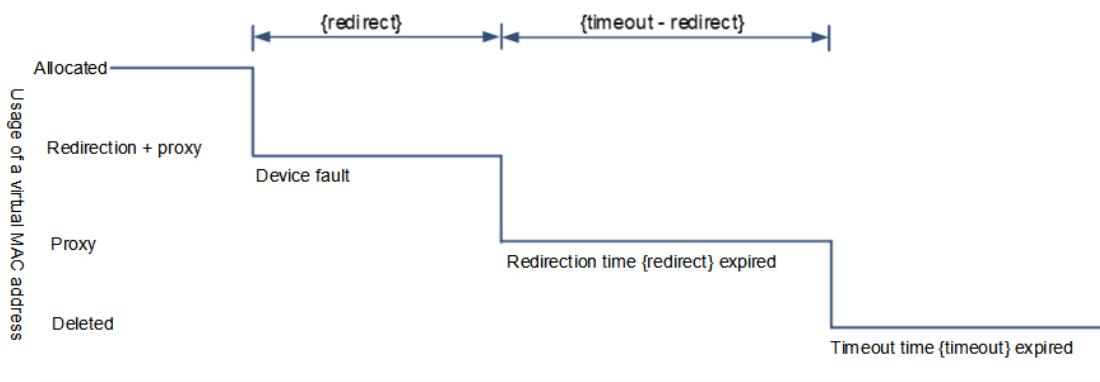
8. **Correlation with Track**

VRRP Plus supports correlation with bidirectional forwarding detection (BFD) and can adjust the weight based on the link status. Each device in a backup group can associate its weight with the link status. When a link is abnormal or unreachable, the device automatically decreases its weight. When the weight is too low, the device automatically exits the forwarding role. If a backup group is currently using the weighted load balancing policy, traffic can be distributed based on the new weight. When the associated link recovers, the device

automatically restores its original weight and the forwarding role. If the backup group is currently using the weighted load balancing policy, traffic is distributed based on the restored weight.

9. **Forwarding Preemption**

VRRP Plus supports the function of preempting the forwarding role. In VRRP Plus, at most four devices can participate in load balancing. That is, a VRRP Plus backup group generates at most four virtual MAC addresses. If more than four devices are added to a VRRP Plus group, only four devices participate in packet forwarding. The remaining devices only listen to the statuses of other devices and do not participate in packet forwarding. Only when a device participating in packet forwarding is faulty, another device that originally does not participate in packet forwarding takes the place of the faulty device to forward packets. Assume that a VRRP Plus backup group already has four devices and all these devices participate in packet forwarding; a fifth device is added to the VRRP Plus group, and the forwarding capability of this device is strong or a device taking the forwarding role encounters a link failure and consequently the degradation of forwarding performance. In this case, if the preemption mode is enabled, the fifth device preempts the forwarding role from a device with a smaller weight (that is, with weaker forwarding capability). A greater weight is configured for a device with stronger forwarding capability. When the weight of a device in listening state is greater than that of a forwarding device, the device in listening state automatically preempts the forwarding role from the forwarding device. That is, the device with stronger forwarding capability forwards packets, whereas the device with lower forwarding capability is in listening state. This minimizes the waste of resources.

The BVG in a backup group is responsible for allocating virtual MAC addresses. Therefore, the BVG role cannot be preempted, and only the forwarding role of a BVF can be seized. If the BVG is faulty, VRRP re-elects a new master device, which assumes the BVG role.

1.1.2 Packet Structure

Figure 1-1 shows the structure of VRRP Plus packets.
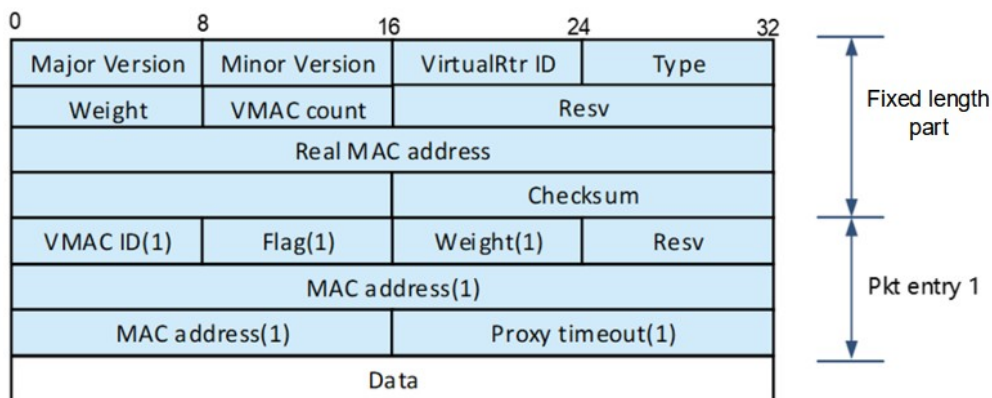
Figure 1-1   Structure of VRRP Plus Packets

Table 1-1   Field Description of VRRP Plus Packets

Packet Field	Description
Major Version	Major version number. The current version is 1.
Minor Version	Minor version number. The current version is 0.

Packet Field	Description
VirtualRtr ID	Virtual router ID, that is, the ID of a VRRP Plus backup group.
Type	Type of VRRP Plus packets. Values and corresponding types are as follows: ● **0**: Indicates a tricky packet. ● **1**: Indicates a virtual MAC request packet. ● **2**: Indicates a keepalive packet of a BVF. ● **3**: Indicates the virtual MAC address release packet sent by the BVF to the BVG. ● **4**: Indicates the virtual MAC address allocation packet sent by the BVG to a BVF.
Weight	Weight of the device.
VMAC count	Number of virtual MAC addresses filled in the packet.
Resv	Reserved field in the fixed length part.
Real MAC address	Real MAC address of the interface on the local device.
Checksum	Packet checksum (including the fixed length part and filling part).
VMAC ID	Filled virtual MAC ID.
Flag	Flag information of the virtual MAC address.
Weight	Weight of the device to which the virtual MAC address is allocated.
Resv	Reserved field in the filling part.
MAC address	Real MAC address of the interface on the device to which the virtual MAC address is allocated.
Proxy timeout	Remaining time before timeout of the virtual MAC address filling in the case of a proxy virtual MAC address.

1.2 Configuration Task Summary

VRRP Plus configuration includes the following tasks:

(1) [Configuring VRRP Plus](#)

1.3 Configuring VRRP Plus

1.3.1 Overview

This section describes how to enable the VRRP Plus function and adjust the VRRP Plus weight based on the track object, to implement automatic balancing among multiple backup groups.

1.3.2 Restrictions and Guidelines

To enable the VRRP Plus function, you must configure a VRRP virtual IP address for the corresponding backup group.

1.3.3 Procedure

(1) Enter the privileged EXEC mode.

enable

(2) Enter the global configuration mode.

configure terminal

(3) Enter the L3 interface configuration mode.

interface *interface-type interface-number*

(4) Enable IPv4 VRRP.

vrrp *group-id* **ip** *ipv4-address* [**secondary**]

IPv4 VRRP is disabled on a port by default.

(5) Configure a priority for the IPv4 VRRP backup group.

vrrp *group-id* **priority** *Priority*

The default priority of an IPv4 VRRP backup group is **100**.

(6) Enable the VRRP Plus function on the interface.

vrrp [**ipv6**] *group-id* **balance**

The VRRP Plus function is disabled by default.

(7) Configure a VRRP Plus load balancing policy.

vrrp [**ipv6**] *group-id* **load-balancing** { **host-dependent** | **round-robin** | **weighted** }

By default, VRRP Plus uses the host-dependent load balancing policy, that is, host-dependent.

(8) Configure the redirection interval and timeout time for proxy virtual MAC addresses of the VRRP Plus backup group.

vrrp [**ipv6**] *group-id* **timers redirect** *redirect-interval redirect-timeout*

The default redirection interval of proxy virtual MAC addresses of a VRRP Plus backup group is **300** seconds and the default redirection timeout time is **14400** seconds.

(9) Configure the weight and upper and lower thresholds for the VRRP Plus backup group.

vrrp [**ipv6**] *group-id* **weighting** *weight-limit* [**lower** *min-weight-value*] [**upper** *max-weight-value*]

The default weight, default upper threshold, and default lower threshold of a VRRP Plus backup group are **100**, **1**, and **100** respectively.

(10) Configure the forwarding preemption function for the VRRP Plus backup group.

vrrp [**ipv6**] *group-id* **forwarder preempt**

The forwarding preemption function is enabled for a VRRP Plus backup group by default.

(11) Configure a track object for adjusting the weight for the VRRP Plus backup group.

vrrp [**ipv6**] *group-id* **weighting track** *object-number* [**decrement** *value*]

VRRP Plus tracking is not configured by default.

1.4 Monitoring

Run the **show** commands to check the running status of a configured function to verify the configuration effect.

Run the **debug** command to output debugging information.

⚠ **Caution**

- The output debugging information occupies system resources. Therefore, disable the debugging function immediately after use.

Table 1-1   VRRP Plus Monitoring

Command	Purpose
show [**ipv6**] **vrrp balance**	Displays the brief or detailed information about VRRP Plus.
show [**ipv6**] **vrrp balance interface** *interface-type interface-number* [**brief**]	Displays the actions of a VRRP Plus group on a specified interface.
debug [**ipv6**] **vrrp balance**	Debugs the VRRP Plus function.
debug [**ipv6**] **vrrp balance error**	Debugs errors.
debug [**ipv6**] **vrrp balance event**	Debugs events of a VRRP Plus group.
debug [**ipv6**] **vrrp balance messages**	Debugs messages of VRRP Plus.
debug [**ipv6**] **vrrp balance packets**	Debugs the VRRP Plus packets.
debug [**ipv6**] **vrrp balance state**	Debugs the VRRP Plus group status.
debug vrrp balance timer	Debugs the timers of a VRRP Plus group.
debug [**ipv6**] **vrrp balance**	Debugs the VRRP Plus function.
debug [**ipv6**] **vrrp balance error**	Debugs errors.

1.5 Configuration Examples
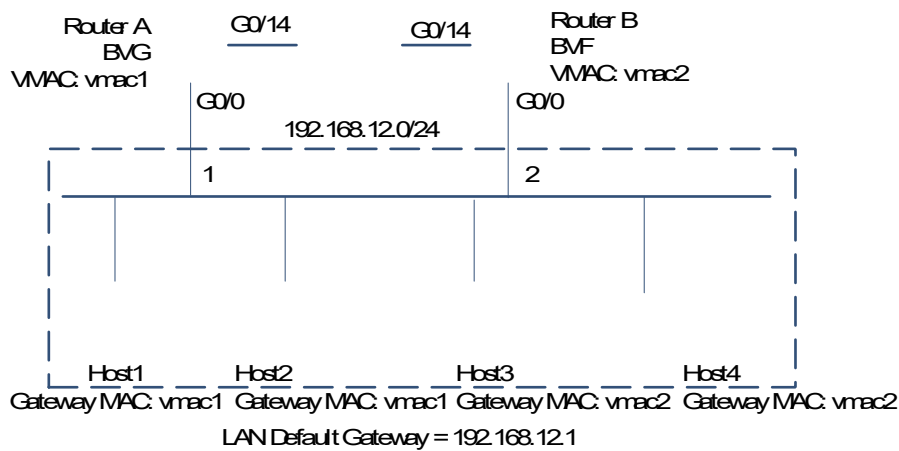
1.5.1 Configuring IPv4 VRRP Plus

1. Requirements

A load balancing policy needs to be enabled in an IPv4 VRRP group.

2. Topology

Figure 1-1   Topology for Configuring IPv4 VRRP Plus

3. Notes

- Configure a VRRP group and enable VRRP Plus on both routers A and B. Configure the local IP addresses so that router A becomes the BVG (master) device and router B becomes a BVF (backup) device.

- Configure the weighted load balancing policy for VRRP Plus. Configure a track object for adjusting the weight, and set the weight decrement value to 100.

- Retain default configurations for the weight, upper and lower thresholds, redirection interval, timeout time, and forwarding preemption function of the backup group.

- Set the default gateway addresses of hosts 1 to 4 in the LAN to the virtual IP address of VRRP, that is, 192.168.12.1.

4. Procedure

Perform the following configuration on router A:

```
RouterA> enable
RouterA# configure
RouterA(config)# interface GigabitEthernet0/0
RouterA(config-if-GigabitEthernet 0/0)# no switchport
RouterA(config-if-GigabitEthernet 0/0)# ip address 192.168.12.3 255.255.255.0
RouterA(config-if-GigabitEthernet 0/0)# vrrp 1 ip 192.168.12.1
RouterA(config-if-GigabitEthernet 0/0)# vrrp 1 balance
RouterA(config-if-GigabitEthernet 0/0)# vrrp 1 load-balancing weighted
```

Perform the following configuration on router B:

```
RouterB> enable
RouterB# configure
RouterB(config)# interface GigabitEthernet0/0
RouterB(config-if-GigabitEthernet 0/0)# no switchport
RouterB(config-if-GigabitEthernet 0/0)# ip address 192.168.12.2 255.255.255.0
RouterB(config-if-GigabitEthernet 0/0)# vrrp 1 ip 192.168.12.1
```

```
RouterB(config-if-GigabitEthernet 0/0)# vrrp 1 balance
RouterB(config-if-GigabitEthernet 0/0)# vrrp 1 load-balancing weighted
```

5.   Verification

Run the **show vrrp balance** command to display the configuration of the VRRP Plus backup group. If the backup group has packet forwarding tasks, "local" is displayed in the "Forwarder" column, and the virtual MAC address allocated to this backup group is also displayed.

```
RouterA# show vrrp balance interface GigabitEthernet0/0
State is BVG
  Virtual IP address is 192.168.12.1
  Hello time 1 sec, hold time 3 sec
  Load balancing: weighted
  Redirect time 300 sec, forwarder time-out 14400 sec
  Weighting 100 (configured 100), thresholds: lower 1, upper 100
  There are 2 forwarders
  Forwarder 1 (local)
    MAC address:
      0000.5e00.0101
    Owner ID is 0000.0001.0006
    Preemption disabled (BVG cannot be preempted)
  Forwarder 2
    MAC address:
001a.a916.0201
    Owner ID is 00d0.f822.33a3
Preemption enabled
```

```
RouterB# show vrrp balance interface GigabitEthernet0/0
  State is BVF
  Virtual IP address is 192.168.12.1
  Hello time 1 sec, hold time 3 sec
  Load balancing: weighted
  Redirect time 300 sec, forwarder time-out 14400 sec
  Weighting 100 (configured 100), thresholds: lower 1, upper 100
  There are 2 forwarders
  Forwarder 1
    MAC address:
      0000.5e00.0101
    Owner ID is 0000.0001.0006
    Preemption disabled (BVG cannot be preempted)
  Forwarder 2 (local)
    MAC address:
001a.a916.0201
    Owner ID is 00d0.f822.33a3
    Preemption enabled
```
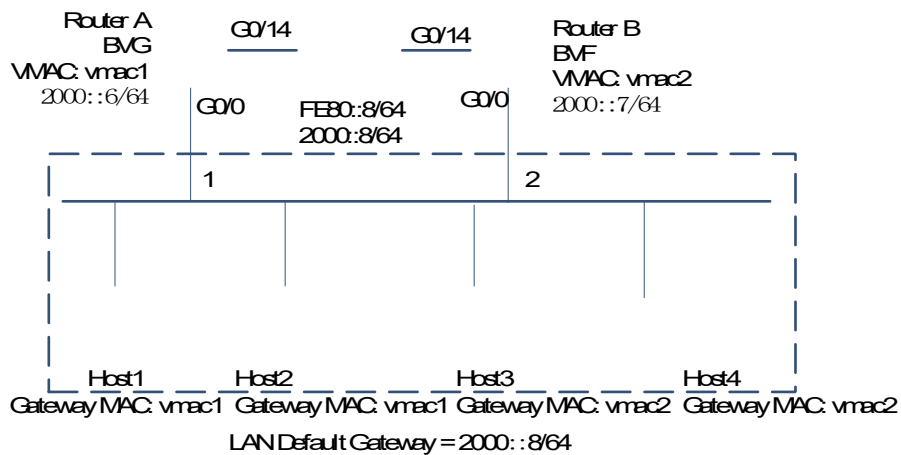
1.5.2 Configuring IPv6 VRRP Plus

1.   Requirements

A load balancing policy needs to be enabled in an IPv6 VRRP group.

2.   Topology

Figure 1-1   Topology for Configuring IPv6 VRRP Plus

3.   Notes

● Configure an IPv6 VRRP group and enable IPv6 VRRP Plus on both routers A and B. Configure the priorities so that router A becomes the BVG (master) device and router B becomes a BVF (backup) device.

● Configure the weighted load balancing policy for the IPv6 VRRP Plus backup group.

● Retain default configurations for the weight, upper and lower thresholds, redirection interval, timeout time, and forwarding preemption function of the backup group.

● Hosts 1 to 4 are hosts in the LAN. Set their IPv6 gateway addresses to 2000::8.

4.   Procedure

Perform the following configuration on router A:

```
RouterA> enable
RouterA# configure
RouterA(config)# interface GigabitEthernet0/0
RouterA(config-if-GigabitEthernet 0/0)# no switchport
RouterA(config-if-GigabitEthernet 0/0)# ipv6 address 2000::6/64
RouterA(config-if-GigabitEthernet 0/0)# vrrp 1 ipv6fe80::8
RouterA(config-if-GigabitEthernet 0/0)# vrrp 1 ipv62000::8
RouterA(config-if-GigabitEthernet 0/0)# vrrp ipv6 1 priority 120
RouterA(config-if-GigabitEthernet 0/0)# vrrp ipv6 1 load-balancing weighted
RouterA(config-if-GigabitEthernet 0/0)# vrrp ipv6 1 balance
```

Perform the following configuration on router B:

```
RouterB> enable
```

```
RouterB# configure
RouterB(config)# interface GigabitEthernet0/0
RouterB(config-if-GigabitEthernet 0/0)# no switchport
RouterB(config-if-GigabitEthernet 0/0)# ipv6 address 2000::7/64
RouterB(config-if-GigabitEthernet 0/0)# vrrp 1 ipv6fe80::8
RouterB(config-if-GigabitEthernet 0/0)# vrrp 1 ipv62000::8
RouterB(config-if-GigabitEthernet 0/0)# vrrp ipv6 1 load-balancing weighted
RouterB(config-if-GigabitEthernet 0/0)# vrrp ipv6 1 balance
```

5.   Verification

Run the **show ipv6 vrrp balance** command to display the configuration of the VRRP Plus backup group. If the backup group has packet forwarding tasks, "local" is displayed in the "Forwarder" column, and the virtual MAC address allocated to this backup group is also displayed.

```
RouterA# show ipv6 vrrp balance interface GigabitEthernet0/0
GigabitEthernet 0/0 - Group 1
  State is BVG
  Virtual IPv6 address is as follows:
    FE80::8
    2000::8
  Hello time 1 sec, hold time 3 sec
  Load balancing: weighted
  Redirect time 300 sec, forwarder time-out 14400 sec
  Weighting 100 (configured 100), thresholds: lower 1, upper 100
  There are 2 forwarders
  Forwarder 1 (local)
    MAC address:
      0000.5e00.0201
    Owner ID is 00d0.f8fb.96f3
    Preemption disabled (BVG cannot be preempted)
  Forwarder 2
    MAC address:
      1414.4b72.7701
    Owner ID is 00d0.f8fb.6c42
    Preemption enabled
```

```
RouterB# show ipv6 vrrp balance interface GigabitEthernet0/0
GigabitEthernet 0/0 - Group 1
  State is BVF
  Virtual IPv6 address is as follows:
    FE80::8
    2000::8
  Hello time 1 sec, hold time 3 sec
  Load balancing: weighted
  Redirect time 300 sec, forwarder time-out 14400 sec
  Weighting 150 (configured 150), thresholds: lower 1, upper 100
```

```
  There are 2 forwarders
  Forwarder 1
    MAC address:
      0000.5e00.0201
    Owner ID is 00d0.f8fb.96f3
    Preemption disabled (BVG cannot be preempted)
  Forwarder 2 (local)
    MAC address:
      1414.4b72.7701
    Owner ID is 00d0.f8fb.6c42
Preemption enabled
```

6. Common Errors

- VRRP Plus does not take effect because no VRRP virtual IP address is configured for a group.