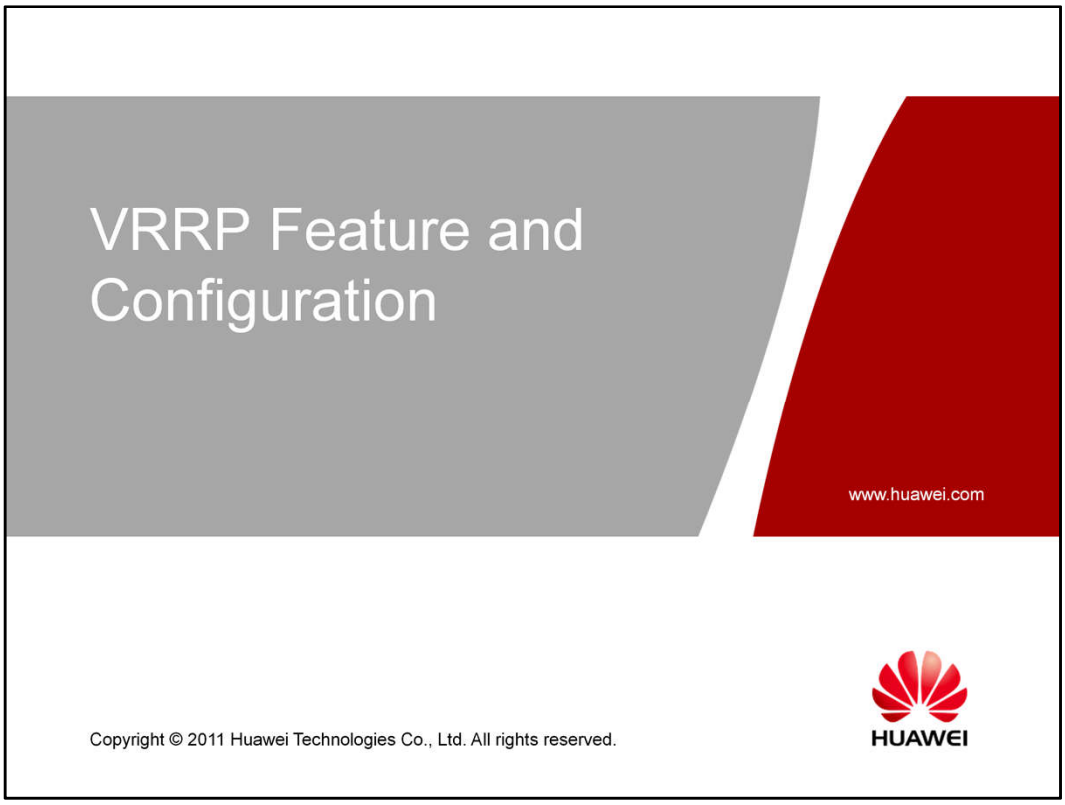

Foreword

- The Virtual Router Redundancy Protocol (VRRP) is a fault tolerant protocol. VRRP groups several physical routers into a virtual router. If the next hop switch of a host fails, VRRP switches traffic to another switch, ensuring continuous and reliable communication.

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Objectives

- Upon completion of this course, you will be able to:
  - Describe VRRP basic concept and principles
  - Configure VRRP on VRP platform

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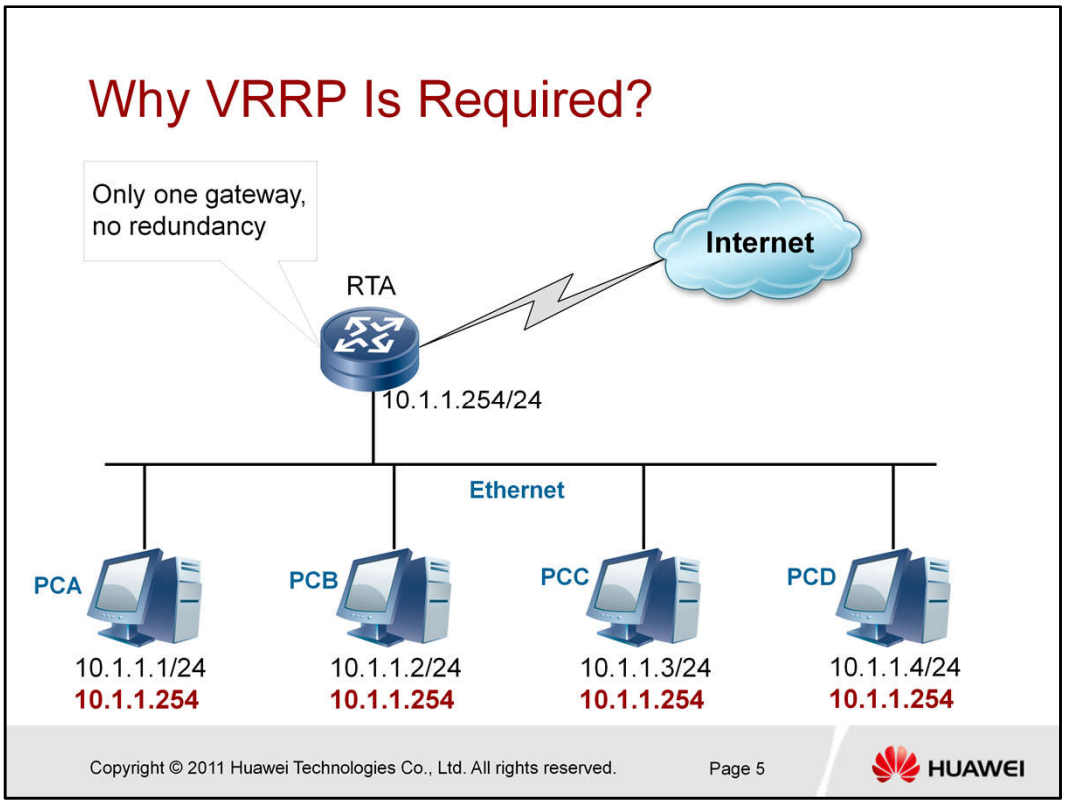

- In this example:
- There is only one router RTA in the LAN, which is used as the gateway by all the PCs, therefore there is no redundancy provided.
- If RTA fail, all PCs in the network will be unable to reach external networks. In other words, there is a single point failure within this kind of network, resulting in a high chance of isolation from external networks.

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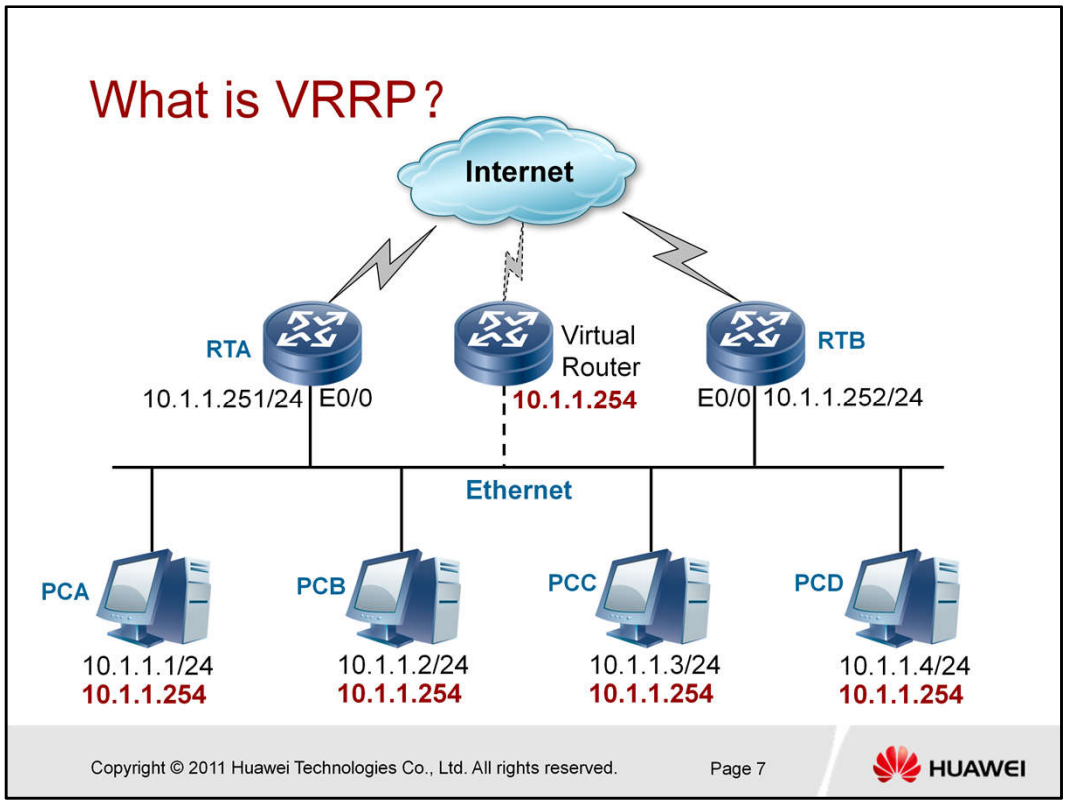
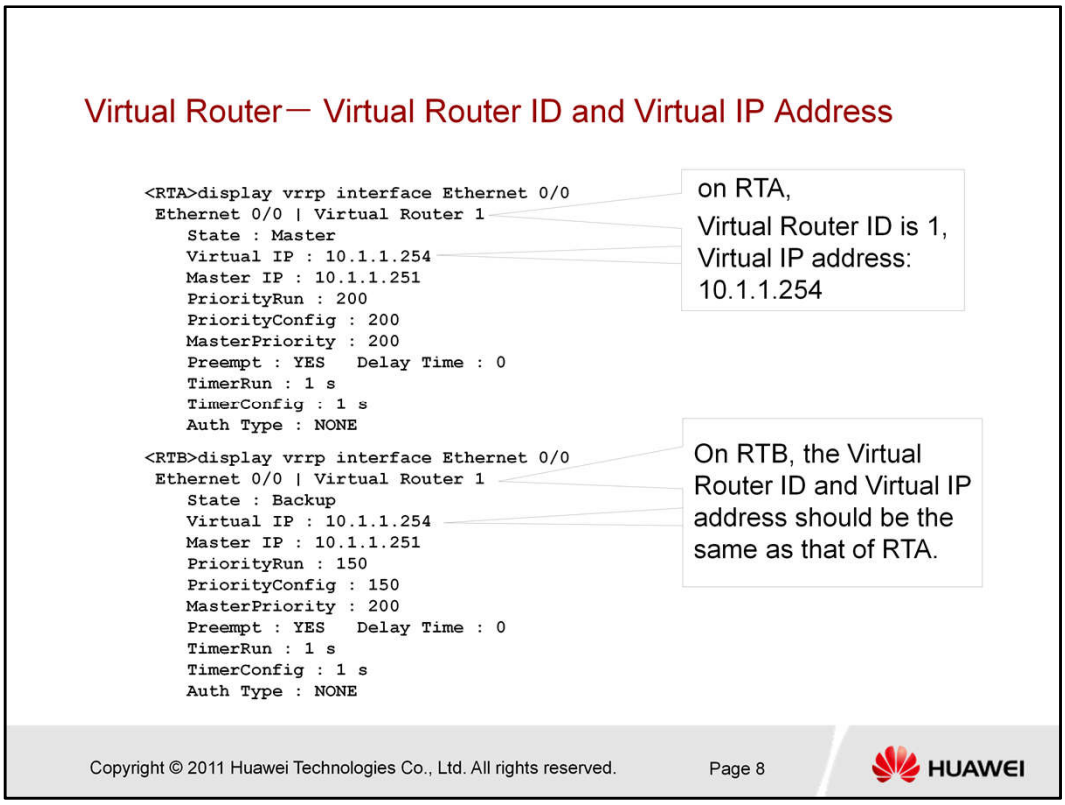


- VRRP is designed to provide a virtual router on a LAN.
- In this case:
- There are two routers (RTA and RTB) on this LAN, RTA has physical IP address 10.1.1.251/24; RTB has physical IP address 10.1.1.252/24. RTA and RTB are configured to be associated with the same Virtual Router. This Virtual Router has a virtual IP address 10.1.1.254. All the PCs on this LAN can use the virtual IP address 10.1.1.254 as the default gateway, regardless of the physical IP addresses of the two routers. VRRP elects one router from the VRRP routers as the Master, and the Master processes all the packets sent to the virtual IP address. If the Master is fails, VRRP elects a new Master from other VRRP routers.



- A Virtual Router is identified by both Virtual Router ID and associated Virtual IP Address. Multiple Virtual Routers could be configured on the same interface. A Virtual Router ID (VRID) is the identifier of a Virtual Router. Configurable item in the range 1-255 (decimal). The Virtual Router IDs configured on all the VRRP routers of the same virtual group must be the same. A Virtual Router can be associated with more than one Virtual IP Addresses. However, the Virtual IP Addresses configured for the VRRP routers of the same Virtual Router should be the same. If VRRP routers with the same VRIDs but different virtual IP addresses; or reversely, with same IP address but different VRIDs, in VRRP, they are regarded as different Virtual Routers.

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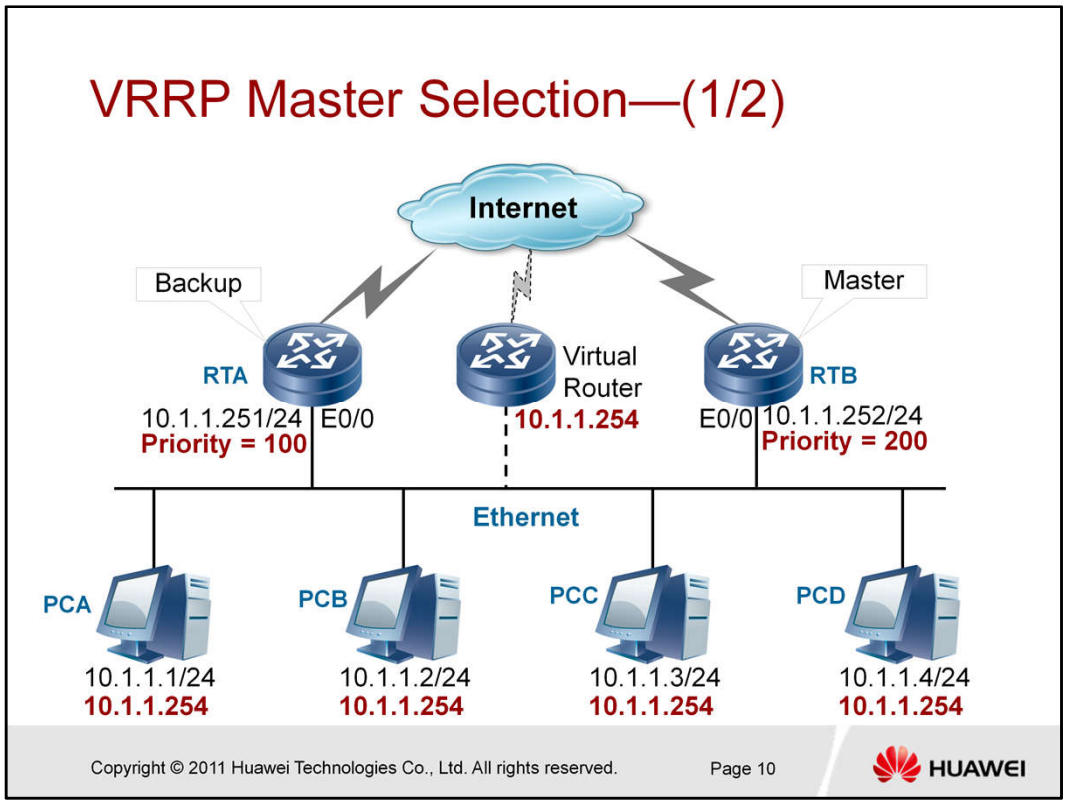
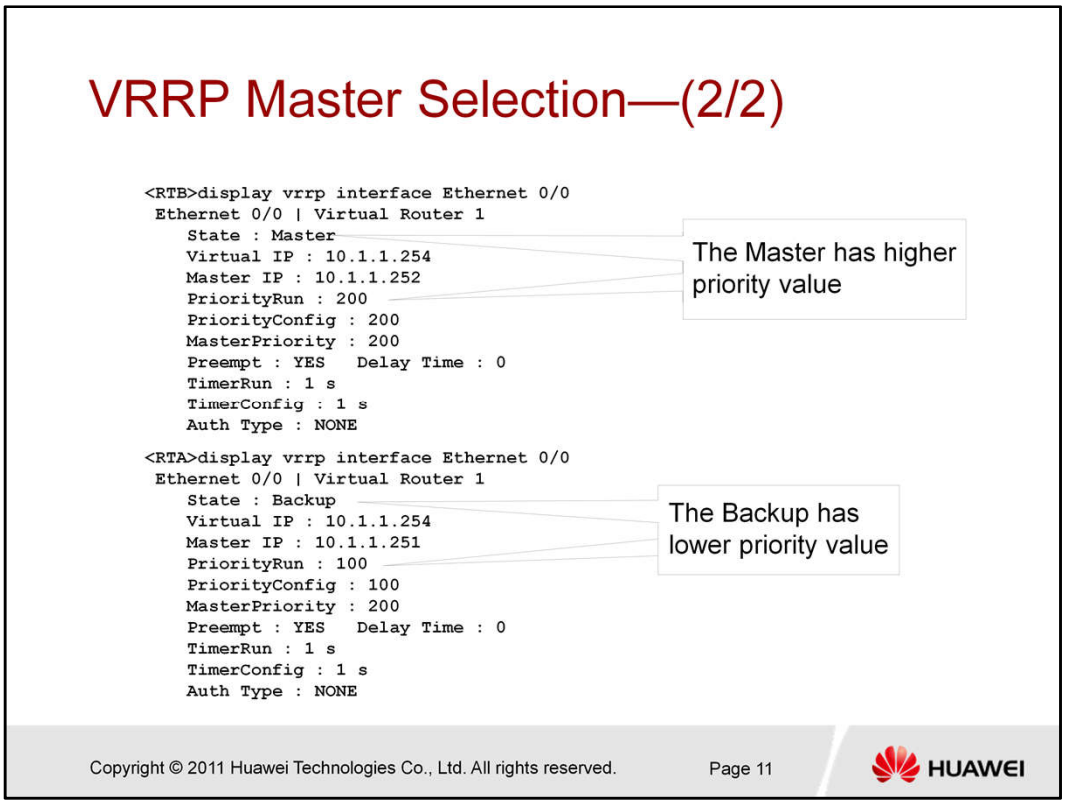
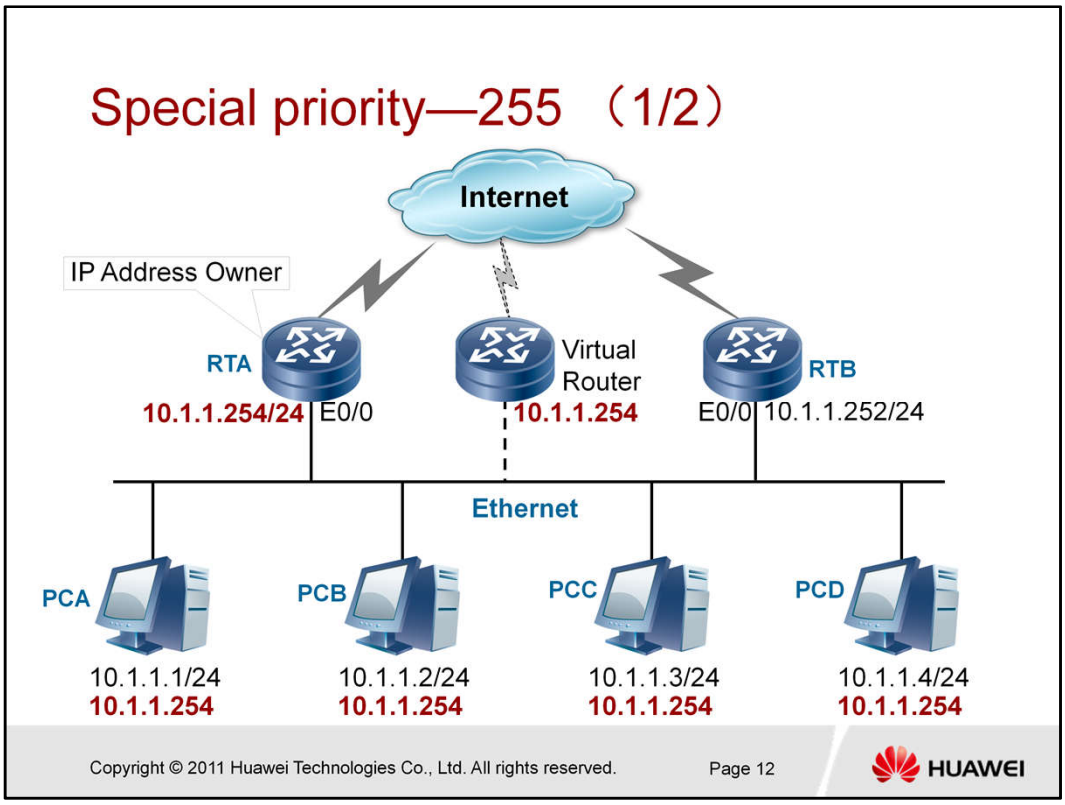


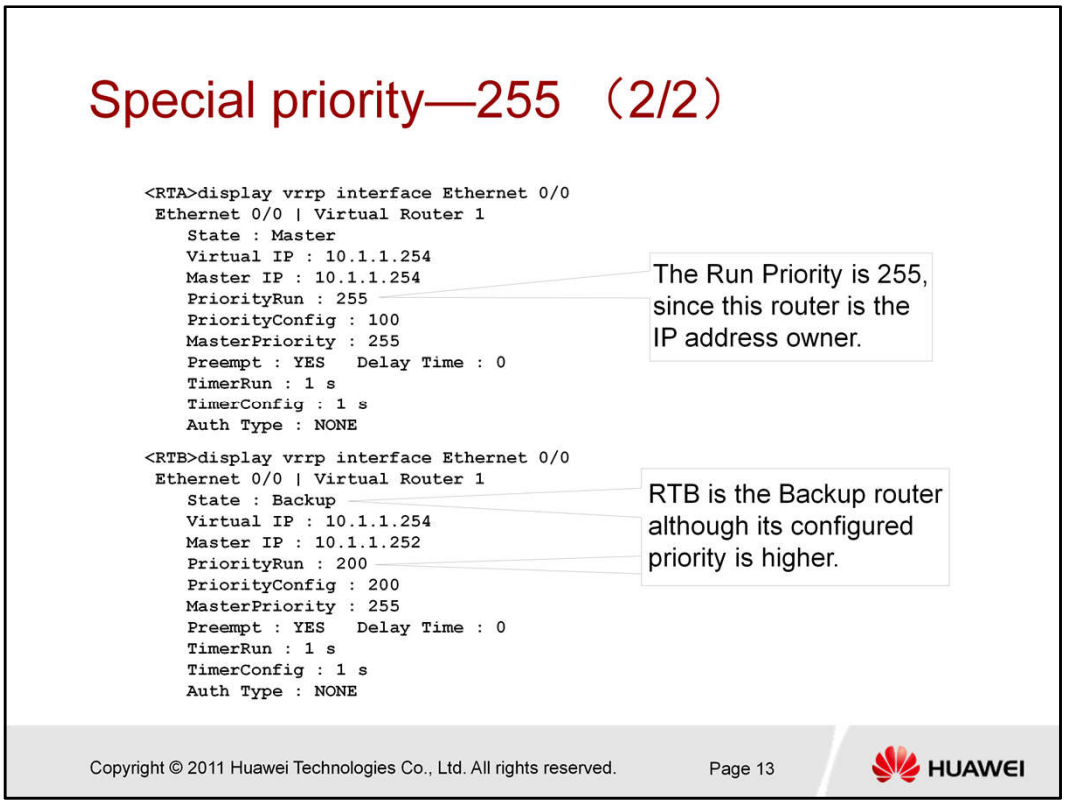
- Master: The VRRP router that is assuming the responsibility of forwarding packets sent to the IP address(es) associated with the virtual router, and answering ARP requests for these IP addresses.
- Backup: The set of VRRP routers available to assume forwarding responsibility for a virtual router if the current Master fails.
- The election of Master is based on the value of Priority. For the same interface, different Priority values could be assigned to different associated virtual routers.



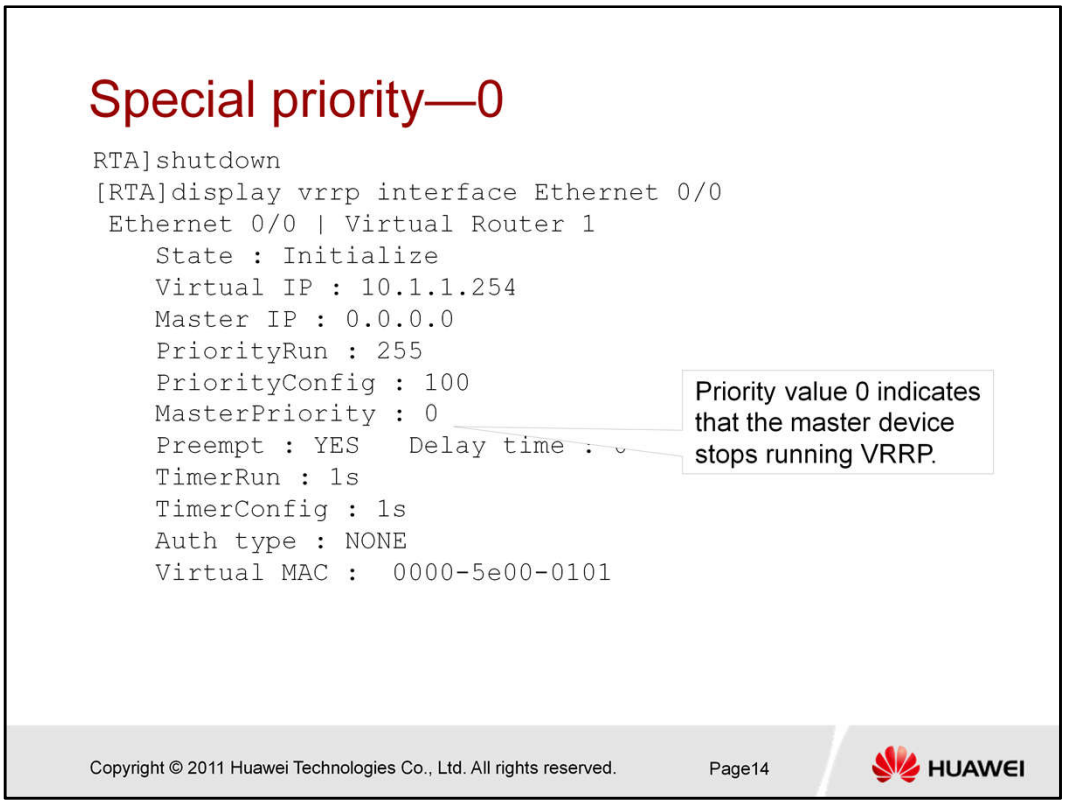
- Config Priority: The configured Priority, the default value is 100.
- Run Priority: The Priority used when the protocol is running; usually it is the same as Config Priority.
- The Priority is in the range of 0-255. The value 255 is reserved for the IP address owner, and the VRRP packet with Priority 0 is used to trigger the immediate changeover from Backup to Master.
- In this case: he priority of RTA is 100, which is lower than the priority 200 of RTB, RTB will be the Master while RTA is the Backup.



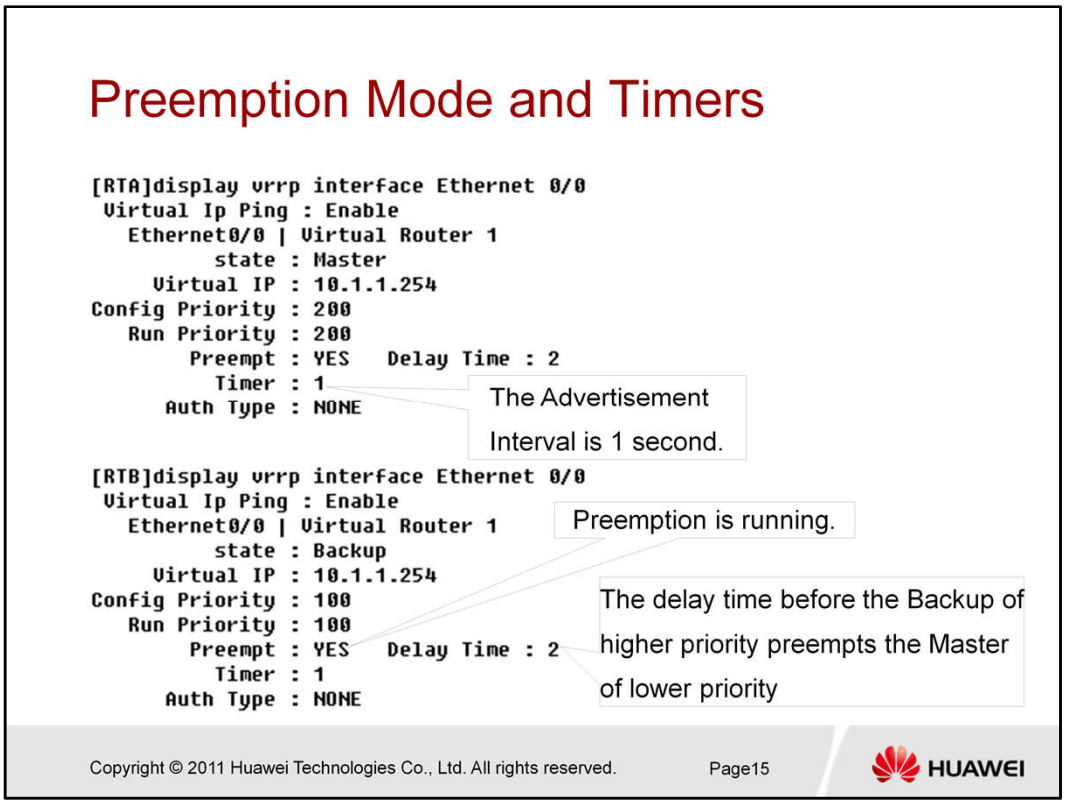
- The priority value ranges from 0 to 255, but the configurable value ranges from 1 to 254. The default priority value is 100.
- **Priority value: 255**
- Priority 255 is reserved for the IP address owner. If the IP address of a VRRP router's physical interface is the same as the virtual IP address of the virtual router, the VRRP router is called the owner of the virtual IP address.



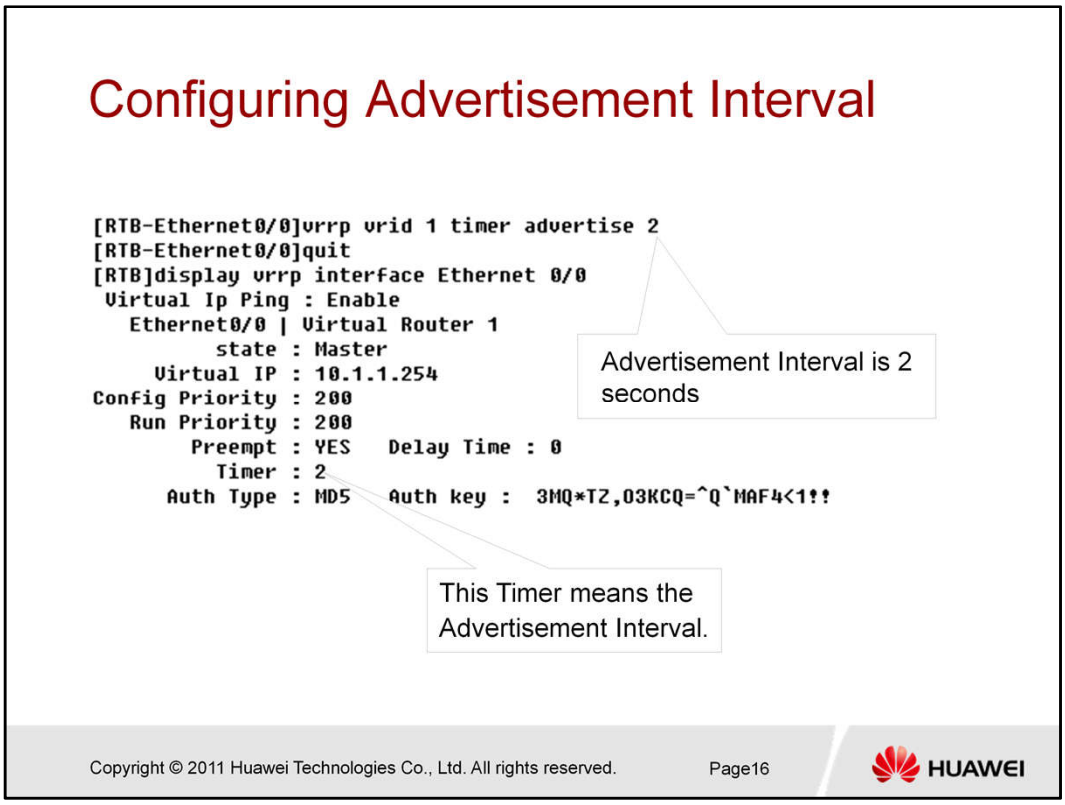
- No matter what the Config Priority is, the Run Priority of IP address owner is always 255. The IP address owner is always the Master. Although the configured priority value of RTB is higher than that of RTA, the RTB is still the Backup, since its Run Priority is lower than that of RTA. Hence, when it comes to the election of the Master, the contributing factor is the value of Run Priority instead of Config Priority.



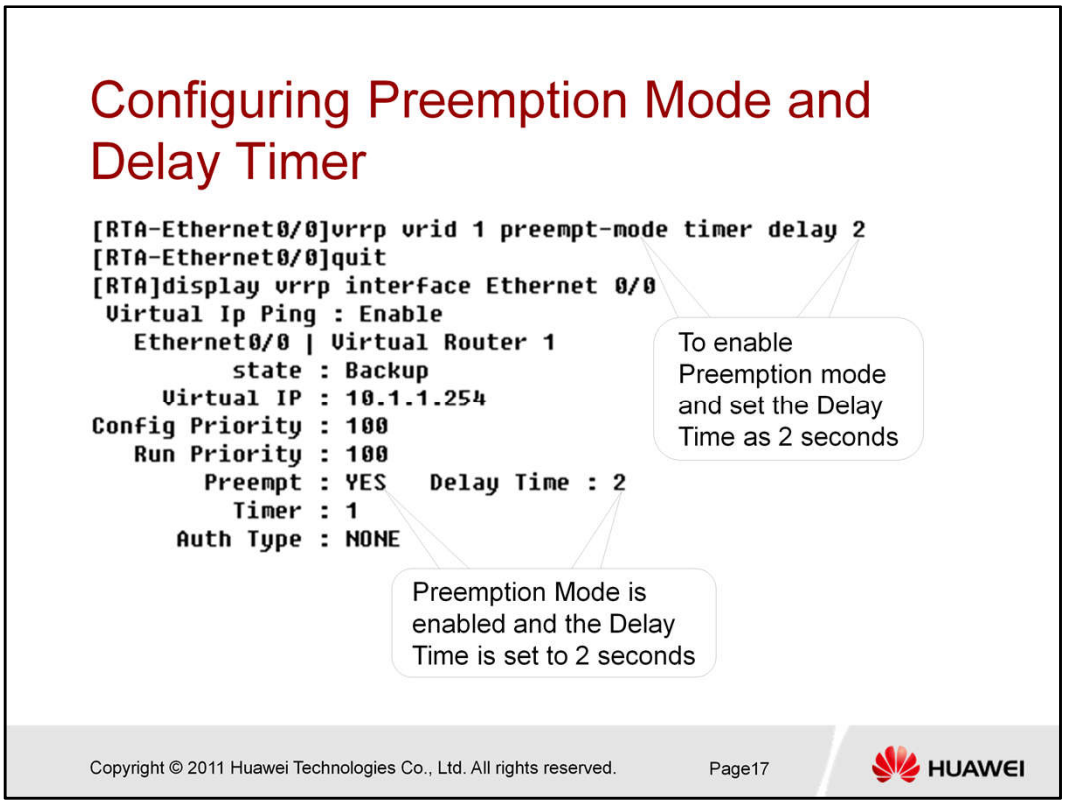
- The VRRP packets with the priority value 0 are used to trigger the backup switch to become the master immediately. When the master stops running the VRRP, it immediately sends a VRRP Advertisement packet with the Priority field set to 0. When the backup device receives the VRRP Advertisement packet, it immediately changes from the Backup state to the Master state.
- As shown in the preceding information, when the master RTA stops running the VRRP, RTA immediately sends a VRRP Advertisement packet with the Priority field set to 0. When the backup switch receives the VRRP Advertisement packet, the backup switch immediately changes from the Backup state to the Master state.



- **Advertisement_Interval**:
  - Time interval between ADVERTISEMENTS (seconds). Default is 1 second. The Advertisement_Interval configured in all the VRRP routers associated to the same Virtual router should be the same. Or, in VRRP, it is regarded as the VRRP routers are associated to different Virtual Routers.
- **Preemption Mode**:
  - If Preemption Mode is enabled, a Backup router with higher priority than the current Master router will change its Backup state to Master state.
  - If Preemption Mode is disabled, even though a Backup router is of higher priority than the current Master router, it will not change its Backup state to Master state.
  - By default, the Preemption Mode is enabled.
- **Delay Time**:
  - To delay the interval of Master failure. (Master_Down_Interval）
  - The delay before the Backup preempts the Master. The default value is 0.
- **Master_Down_Interval**:
  - (3*Advertisement_Interval) + Delay Time.



- The Advertisement_Interval configured in all the VRRP routers associated to the same Virtual router should be the same.
  - **vrrp vrid** *virtual-router-ID* **timer advertise** *adver-interval*
  - **undo vrrp vrid** *virtual-router-ID* **timer advertise**
- *virtual-router-ID*：The identifier of Virtual Router, in the range of 1-255.
- *adver-interval*：Time interval between ADVERTISEMENTS send by the Master, in the range of 1-255. Default value is 1 second.
- In this example, the Advertisement_Interval is modified to 2 seconds.



- Preemption Mode：
- Controls whether a higher priority Backup router preempts a lower priority Master.
  - **vrrp vrid** *virtual-router-ID* **preempt-mode** [**timer delay** *delay-value*]
  - **undo vrrp vrid** *virtual-router-ID* **preempt-mode**
- *virtual-router-ID*：The identifier of Virtual Router, in the range of 1-255.
- *delay-value*：It is the Delay Time, in seconds, in the range of 0-255. By default, the preemption mode is enabled, and the delay time is 0 second.
- If the network is very busy, sometimes, the Backup cannot receive the Advertisement although the Master works properly. Under this circumstance, the Delay Time could be modified to prevent the Backup becoming the Master immediately, so as to reduce the network flapping.
- In the previous slide, the Advertisement Interval is 2 seconds. In this example, the Delay Time is configured as 2 seconds. Hence, the Master_Down_Interval is 3*2+2=8 seconds.

Packet Authentication

Auth Type	Authentication Method
0	No Authentication
1	Simple Text Password
2	MD5 Password

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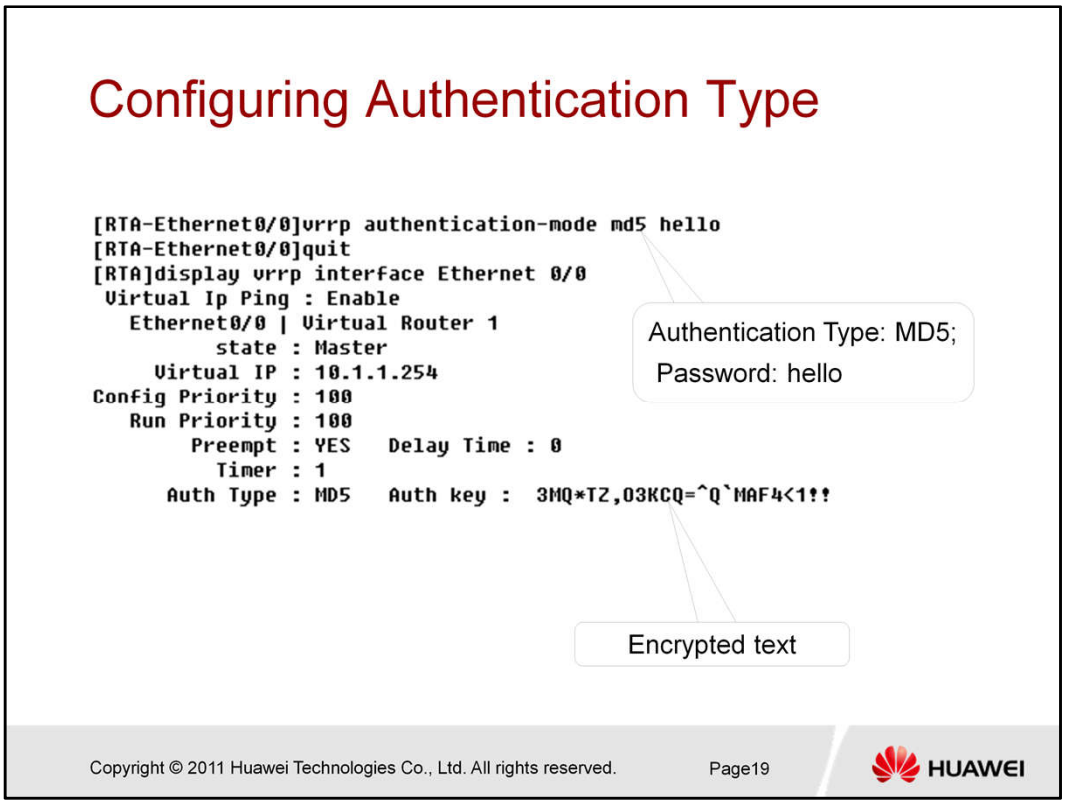
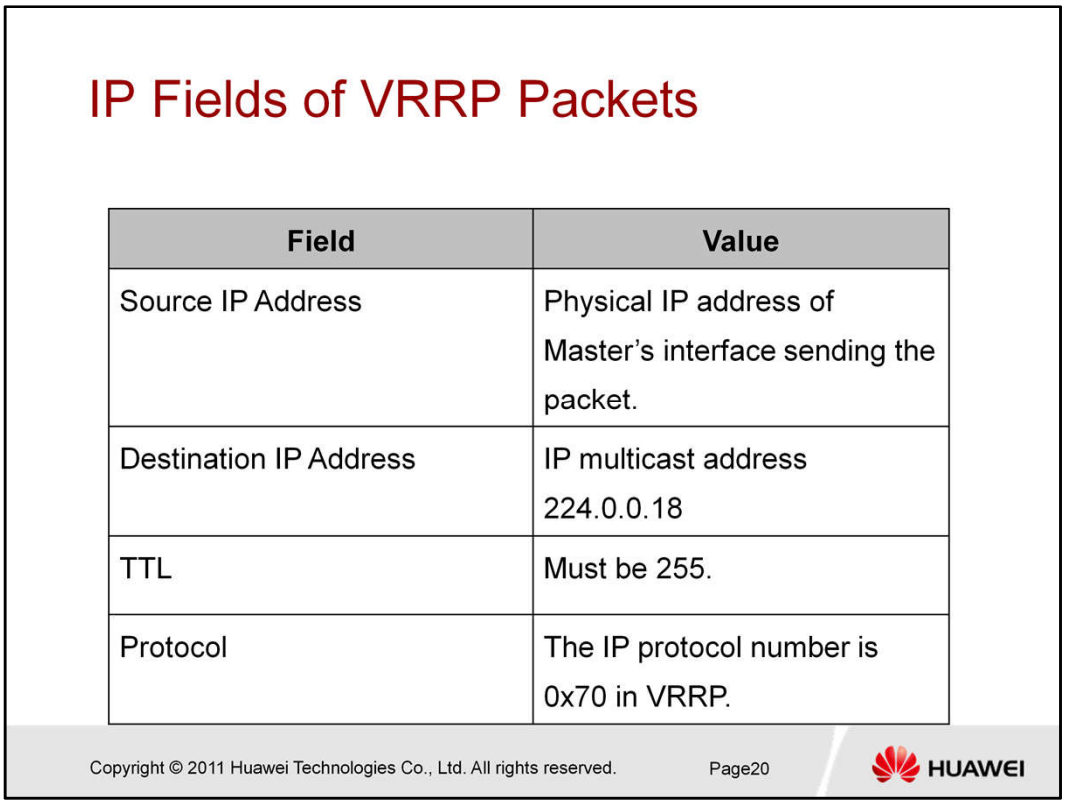
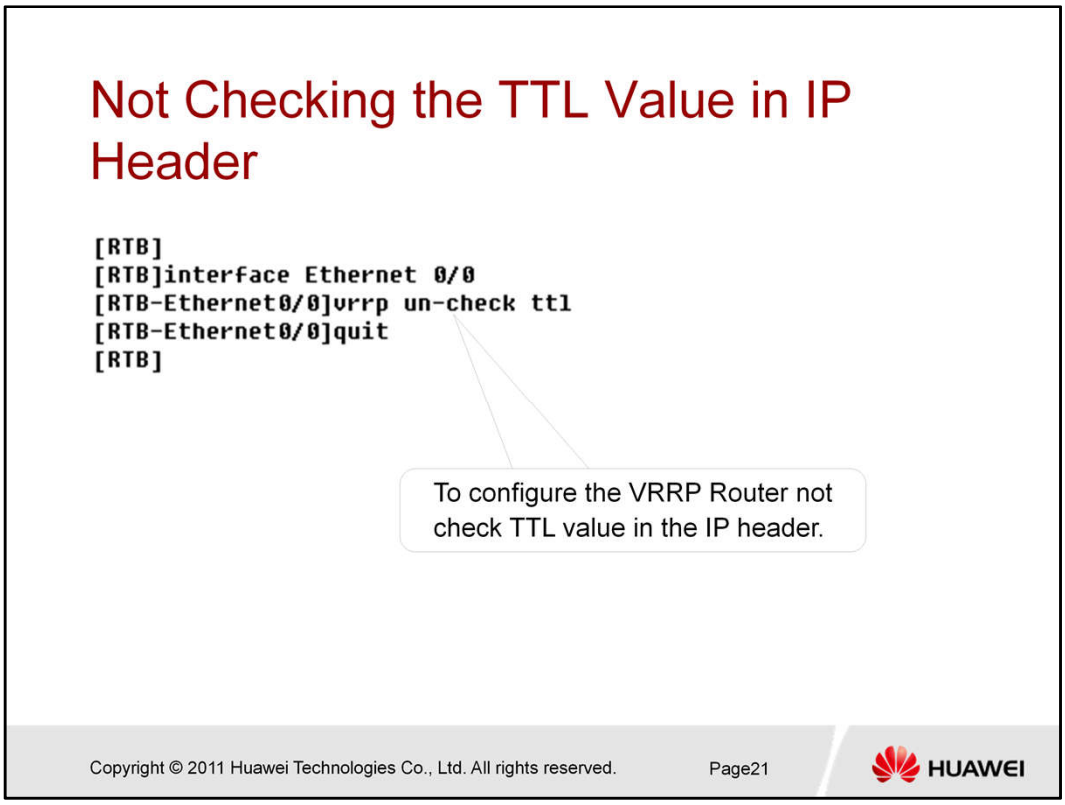
- **No Authentication**
  - The use of this authentication type means that VRRP protocol exchanges are not authenticated. The contents of the Authentication Data field should be set to zero on transmission and ignored on reception.
- **Simple Text Password:**
  - The use of this authentication type means that VRRP protocol exchanges are authenticated by a clear text password. The contents of the Authentication Data field should be set to the locally configured password.
- **MD5 Password:**
  - The use of this authentication type means the VRRP protocol exchanges are authenticated using MD5 encrypted message.
  - If the authentication type in the received VRRP packet is different from that locally configured, the received VRRP packet will be discarded.



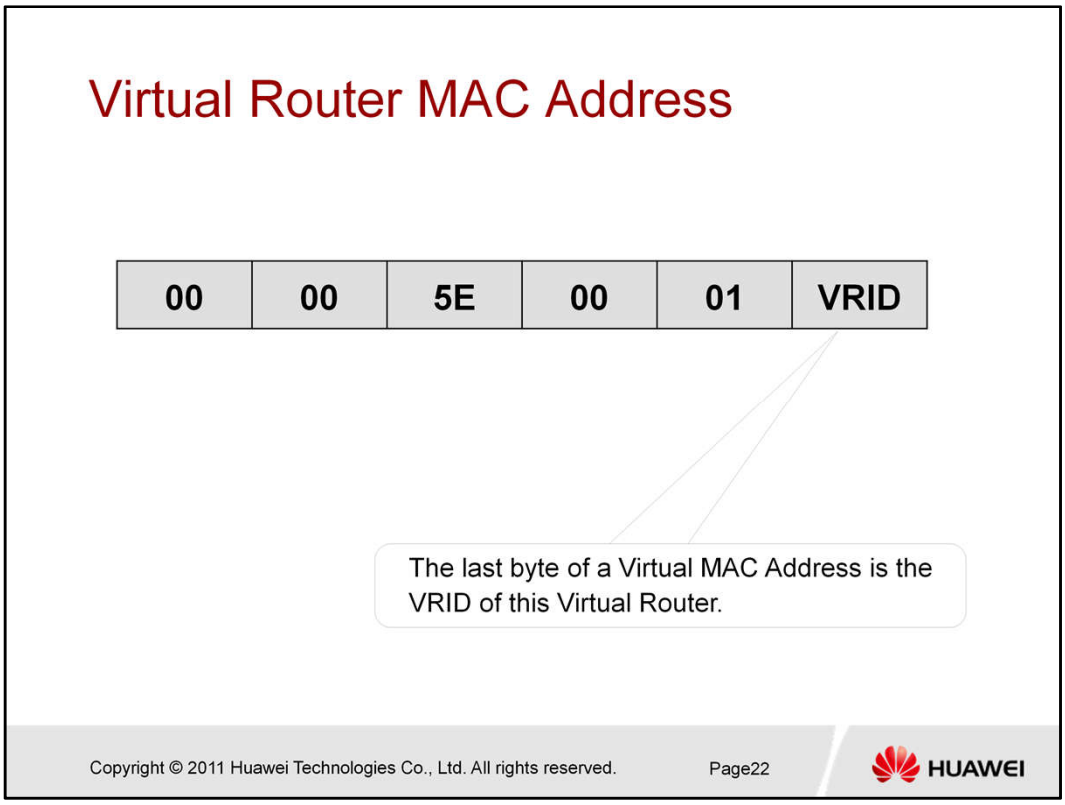
- Three types of authentication modes are supported in VRRP: No Authentication, Simple Text Password, and MD5 Password. By default, there is no authentication.
- For VRRP routers associated to the same Virtual Router, the authentication mode and password information configured must be same.
  - **vrrp authentication-mode** { **md5** *key* | **simple** *key* }
  - **undo vrrp authentication-mode**
- **simple**：It means that VRRP protocol exchanges are authenticated by a clear text password.
- **md5**：It means the VRRP protocol exchanges are authenticated using MD5 encrypted message.
- *key*：Authentication word. When the authentication mode is simple, the *key* is in plain text, in the range of 1-8 bits; When the authentication mode is md5, the *key* is in MD5 cryptograph, if it is inputted in plain text, the length is in the range of 1-8 bits. (For example:1234567); if it is inputted in encrypted text, the length must be 24 bits. (For example: _(TT8F]Y\5SQ=^Q`MAF4<1!!.



- The VRRP packet is directly encapsulated in the IP packet.
- In the IP header, the source address is the IP address of the interface the packet is being sent from.
- The Destination Address is a IP multicast address: 224.0.0.18. This is a link local scope multicast address. Routers MUST NOT forward a datagram with this destination address regardless of its TTL.
- The TTL MUST be set to 255. A VRRP router receiving a packet with the TTL not equal to 255 MUST discard it.
- The IP protocol number assigned by the IANA for VRRP is 112 (decimal).



- By default, the VRRP router will check the TTL field of IP header in the received VRRP packet, and the TTL value must be 255. On the VRP platform, the function could be disabled by command.
  - **vrrp un-check ttl**
  - **undo vrrp un-check ttl**

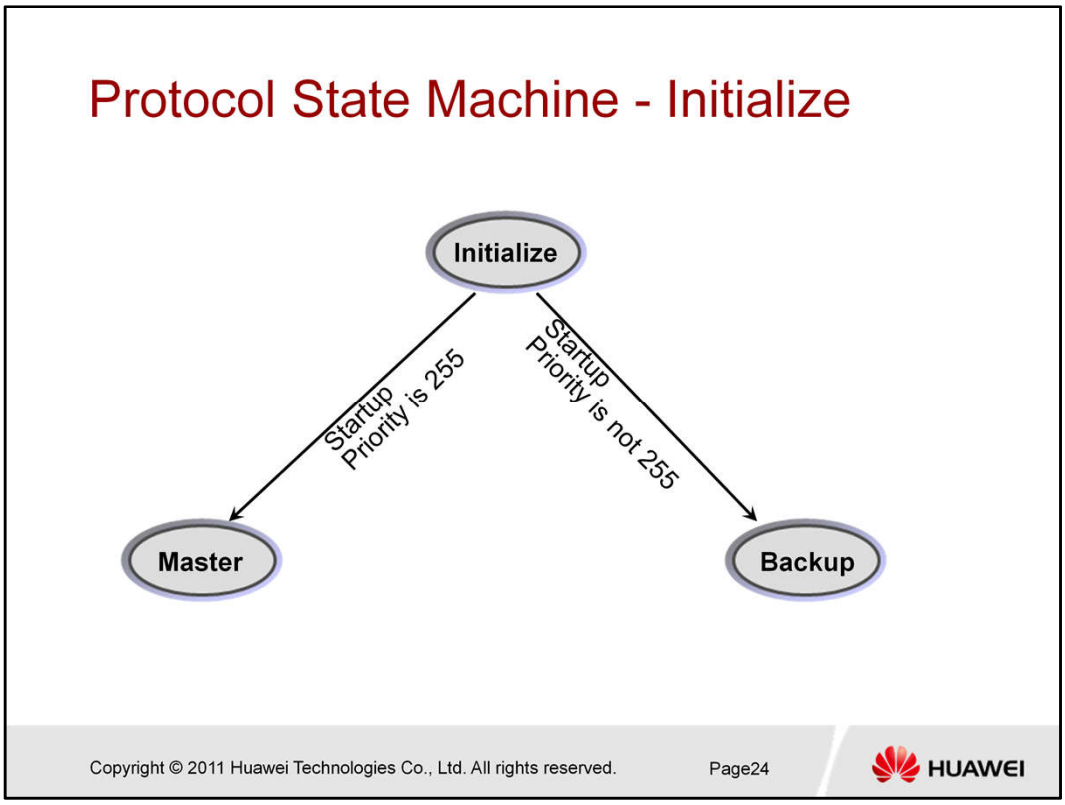


- Every virtual router has a virtual MAC address, in the format: 00-00-5E-00-01-{VRID}.
- The first 5 bytes of the virtual MAC address is fixed.
- The final byte of the virtual MAC address is the VRID of the virtual router.

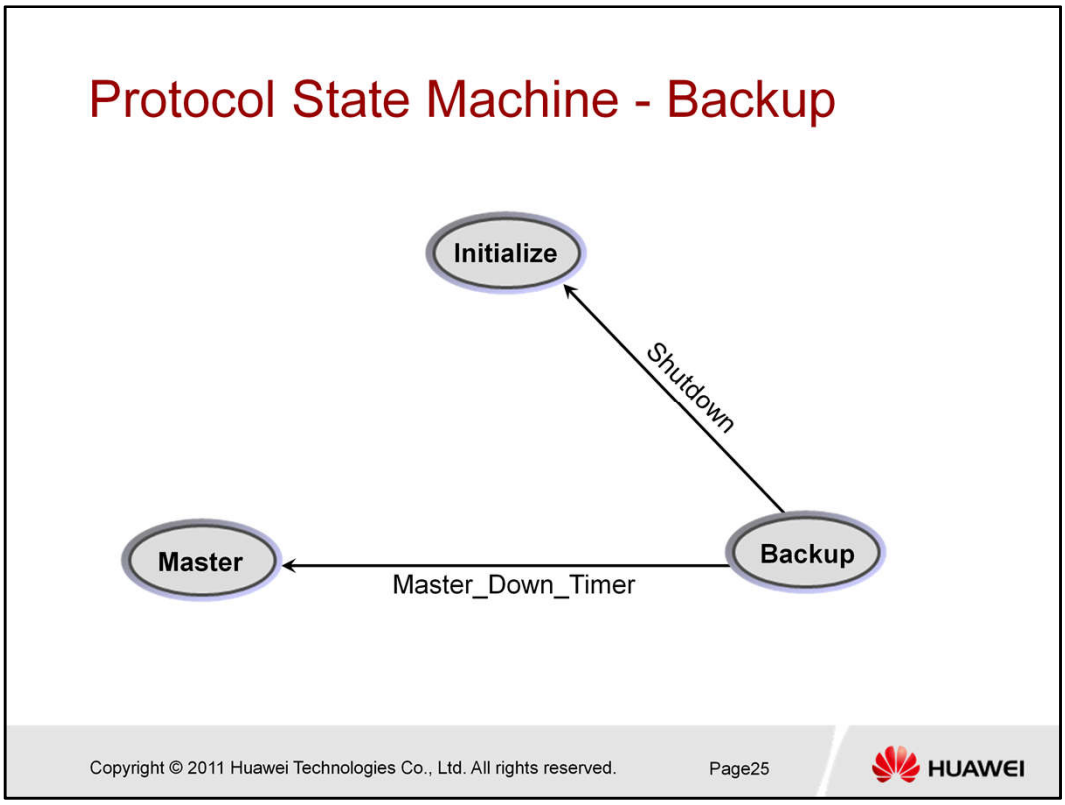
Layer 2 Fields of VRRP Packets

Field	Value
Destination MAC Address	Multicast MAC Address: 01-00-5E-00-00-12
Source MAC Address	The MAC Address of Virtual Router
Type	0x0800

- When the VRRP router sends out VRRP advertisement periodically:
  - The destination MAC address is the corresponding multicast MAC address of the Layer 3 IP address 224.0.0.18.
  - The source MAC address is the virtual MAC address of the virtual router.
  - The virtual router MAC address is used as the source in all periodic VRRP messages sent by the Master router to enable bridge learning in an extended LAN, to update the MAC table of the layer 2 switch through which the VRRP packet is passed through, and to ensure all the packets sent to the virtual router could be forwarded properly by the switch.
  - The type field set to be 0x0800 indicates the packet encapsulated in the frame is the IP packet.

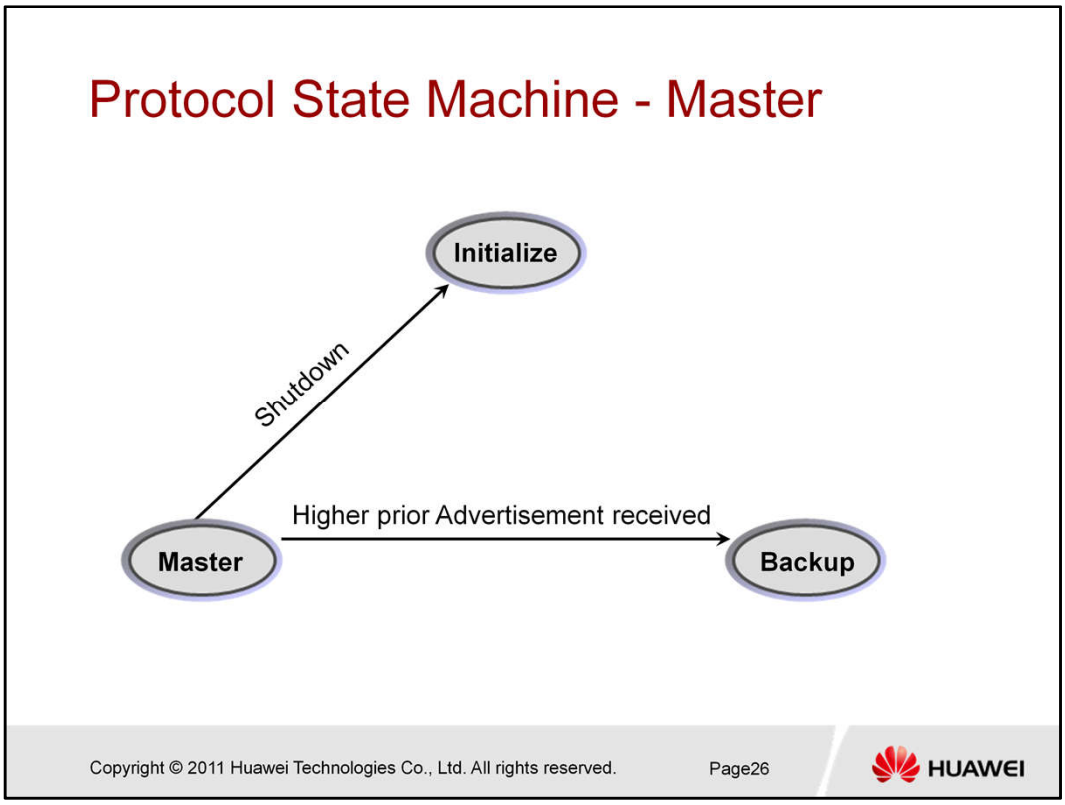


- **Initialize:**
- The purpose of this state is to wait for a Startup event.
- A Startup event could be triggered automatically as long as the VRRP is configured completely; also, if the VRRP has been already configured in some interface, the Startup event could be triggered by the change of underside layer from down to up.
- If a Startup event is received, and the Priority = 255 (i.e., the router owns the IP address) associated with the virtual router, the state will be transited to Master state, and the router begins to send VRRP packet periodically.
- If a Startup event is received, and the Priority is not 255, the state will be transited to Backup state, and the router begins to monitor the state of Master Router.



- **Backup:**
- The purpose of the Backup state is to monitor the availability and state of the Master Router.
- While in this state, a VRRP router MUST do the following: MUST NOT respond to ARP requests for the IP address associated with the virtual router; MUST discard packets with a destination link layer MAC address equal to the virtual router MAC address; MUST NOT accept packets addressed to the IP address associated with the virtual router.
- If a Shutdown event is received, such as the deletion of relative configuration of VRRP, then the router stops monitoring the state of Master Router and transit to the Initialize state.
- If the Master_Down_Timer is set, the state is changed to Master, and the VRRP advertisement begins to be sent periodically.
- If an ADVERTISEMENT is received whose Priority is Zero, the Master_Down_Timer is set to be Delay time. And if the Delay Time is 0, the Master_Down_Timer will fire immediately, and state transforms to Master.
- If an ADVERTISEMENT is received whose Priority is greater than or equal to the local Priority; or If the Priority in the ADVERTISEMENT is lower than the local Priority, but Preempt_Mode is False, then the Master_Down_Timer will be reset to 0 and the router continues to monitor the state of Master Router.
- If an ADVERTISEMENT is received whose Priority is lower than the local Priority, and Preempt_Mode is True, then the ADVERTISEMENT will be discarded. The Master_Down_Timer will be increased along the time. After the timer fires, the state will be

changed to Master.



- **Master:**
- While in the Master state the router functions as the forwarding router for the IP address associated with the virtual router.
- While in this state, the VRRP router must respond to ARP requests for the IP address associated with the virtual router and must forward packets with a destination link layer MAC address equal to the virtual router MAC address.
- In the Master state, the VRRP router sends out VRRP Advertisement periodically.
- After every VRRP Advertisement is sent, the Advertise_Timer is reset to 0.
- And when the Advertise_Timer fires, the next VRRP Advertisement will be sent.
- If a Shutdown event is received, the Advertise_Timer is canceled, a VRRP
- Advertisement with Priority 0 is sent, and the state is changed to Initialize.
- If an ADVERTISEMENT is received whose Priority is greater than the local Priority; or If the Priority in the ADVERTISEMENT is equal to the local Priority, but the remote IP address is higher than that of local, then the Advertise_Timer is canceled, and a VRRP Advertisement with Priority 0 is sent, and the state is changed to Backup.

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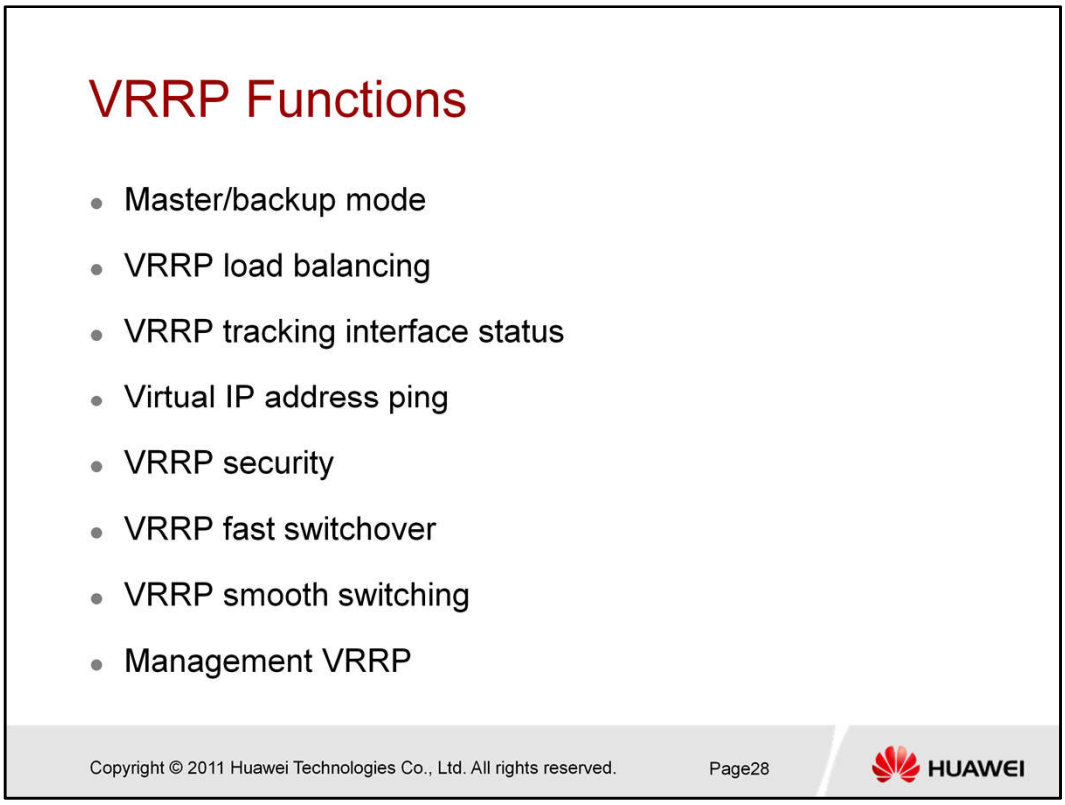
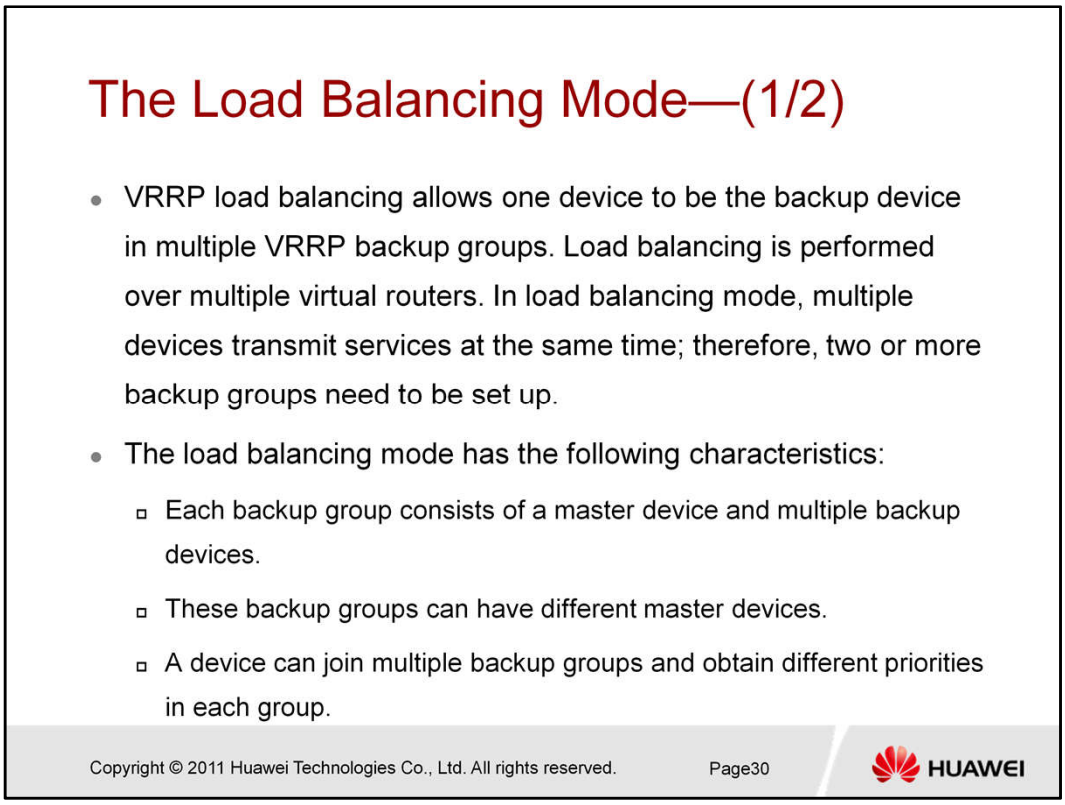


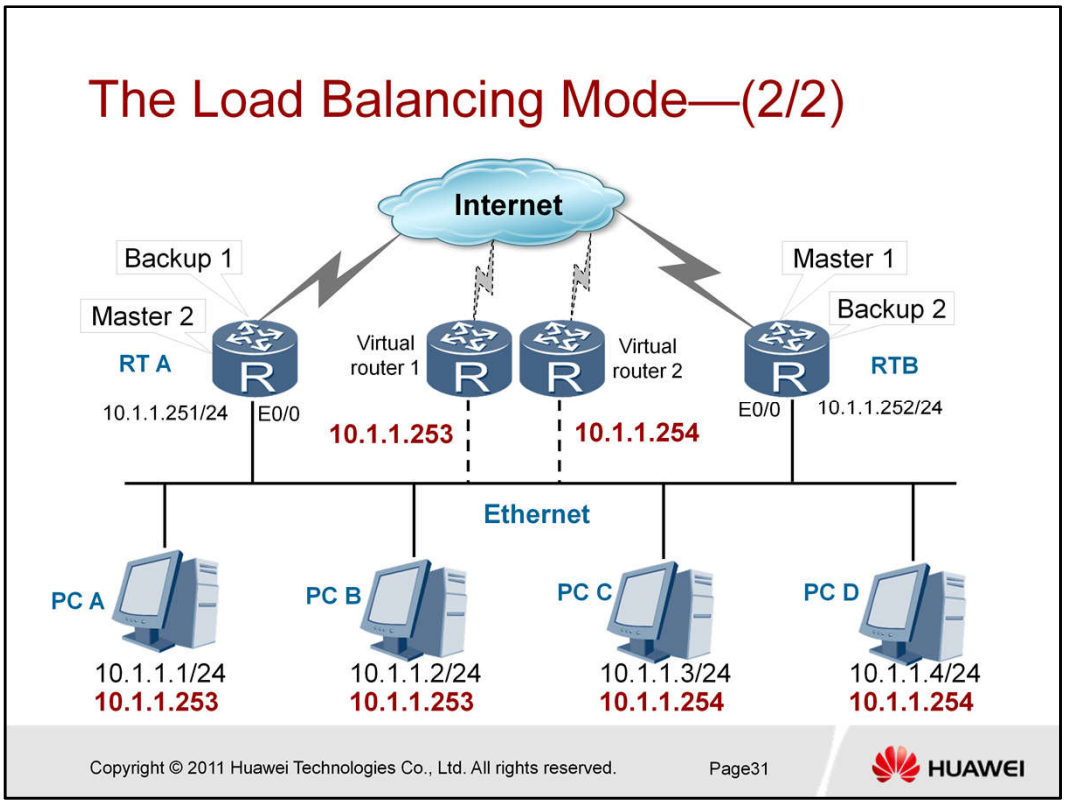
- Master/backup mode: It is the basic backup mode provided by VRRP.
- VRRP load balancing: Multiple virtual routers transmit service at the same time.
- VRRP tracking interface status: Each VRRP backup group can track the status of all interfaces bound to it. When an interface fails, the device with the highest priority is re-selected as the master device.
- Virtual IP address ping: A ping command is provided for pinging to the virtual IP address of a VRRP backup group.
- VRRP security: According to network environments of different security levels, you can set different authentication modes and authenticators in the packet header.
- VRRP fast switchover: VRRP tracks BFD session status to perform a fast switchover within milliseconds.
- VRRP smooth switching: It prevents service traffic from being affected by master/backup switchover.
- Management VRRP: The mVRRP backup group sends VRRP packets to determine its status and the status of all its bound service VRRP backup groups. This reduces the bandwidth that VRRP packets occupy.

The Master/Backup Mode

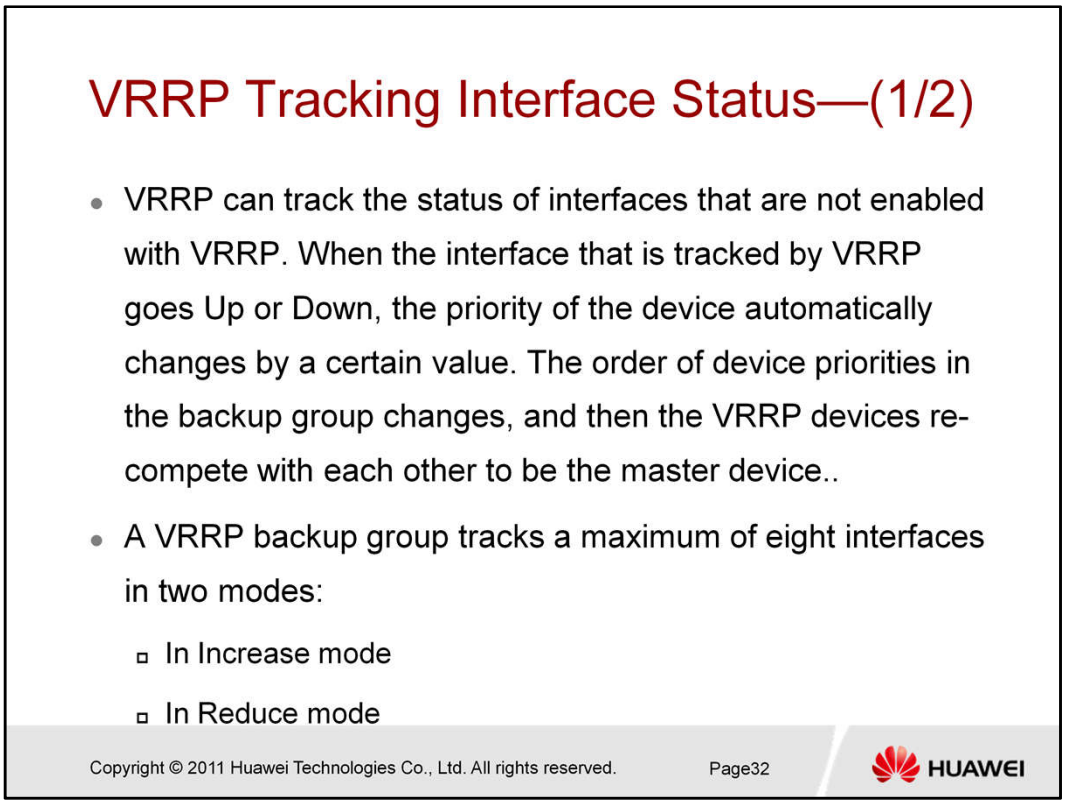
- The master/backup mode is the basic backup mode provided by VRRP. A virtual router must be set up, with a master device and multiple backup devices.
- The master/backup mode has the following characteristics:
  - Normally, the master device transmits all services.
  - When the master device fails, a backup device takes over the services.



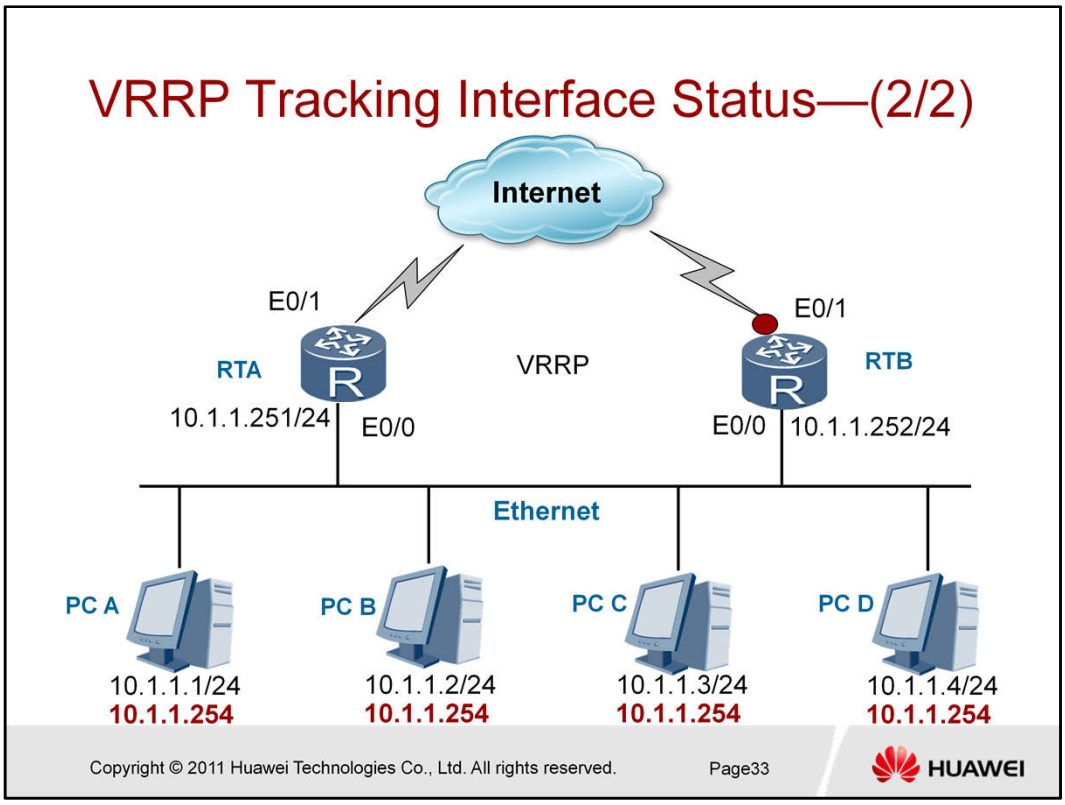
- VRRP load balancing allows one device to be the backup device in multiple VRRP backup groups. Load balancing is performed over multiple virtual routers. In load balancing mode, multiple devices transmit services at the same time; therefore, two or more backup groups need to be set up.
- The load balancing mode has the following characteristics:
  - Each backup group consists of a master device and multiple backup devices.
  - These backup groups can have different master devices.
  - A device can join multiple backup groups and obtain different priorities in each group.



- As shown in the preceding figure, two VRRP backup groups are configured:
- RTA is the backup device in backup group 1 and the master device in backup group 2.
- RTB is the master device in backup group 1 and the backup device in backup group 2.
- Backup groups 1 and 2 are gateways for different PCs.
- In this manner, load balancing of data traffic and the mutual backup can be implemented.



- VRRP can track the status of interfaces that are not enabled with VRRP. When the interface that is tracked by VRRP goes Up or Down, the priority of the device automatically changes by a certain value. The order of device priorities in the backup group changes, and then the VRRP devices re-compete with each other to be the master device.
- A VRRP backup group tracks a maximum of eight interfaces in Increase mode or Reduce mode.
- In Increase mode, when a tracked interface goes **Down**, the priority of the VRRP device increases by a specified value. The Increase mode takes effect on both master and backup devices.
- In Reduce mode, when a tracked interface goes **Down**, the priority of the VRRP device decreases by a specified value. The Reduce mode takes effect on both master and backup routers.



- As shown in the preceding figure, RTA and RTB are enabled with VRRP. The priority of the VRRP backup group on RTB is higher than the priority of the VRRP group on RTA. RTB tracks interfaces in Reduce mode. RTB functions as the master device and the user traffic is sent by RTB. When GE0/1 on RTB connected to the Internet is faulty, the VRRP backup group that tracks GE0/1 in Reduce mode decreases the priority. Then, RTA preempts to be the master device and forwards user traffic to the Internet.

VRRP Fast Switchover—(1/2)

- Bidirectional forwarding detection (BFD) quickly detects connectivity of network links or IP routes. VRRP tracks BFD session status to perform fast switchover between the master and backup devices within 1 second.
- BFD can notify the interface board of detected faults to speed up VRRP master/backup switchover in the following cases:
  - Faults occur on the interfaces where VRRP backup groups are created.
  - The master device and the backup device are not directly connected.
  - The master device and the backup device are directly connected; however, other transmission devices exist on the link between them.

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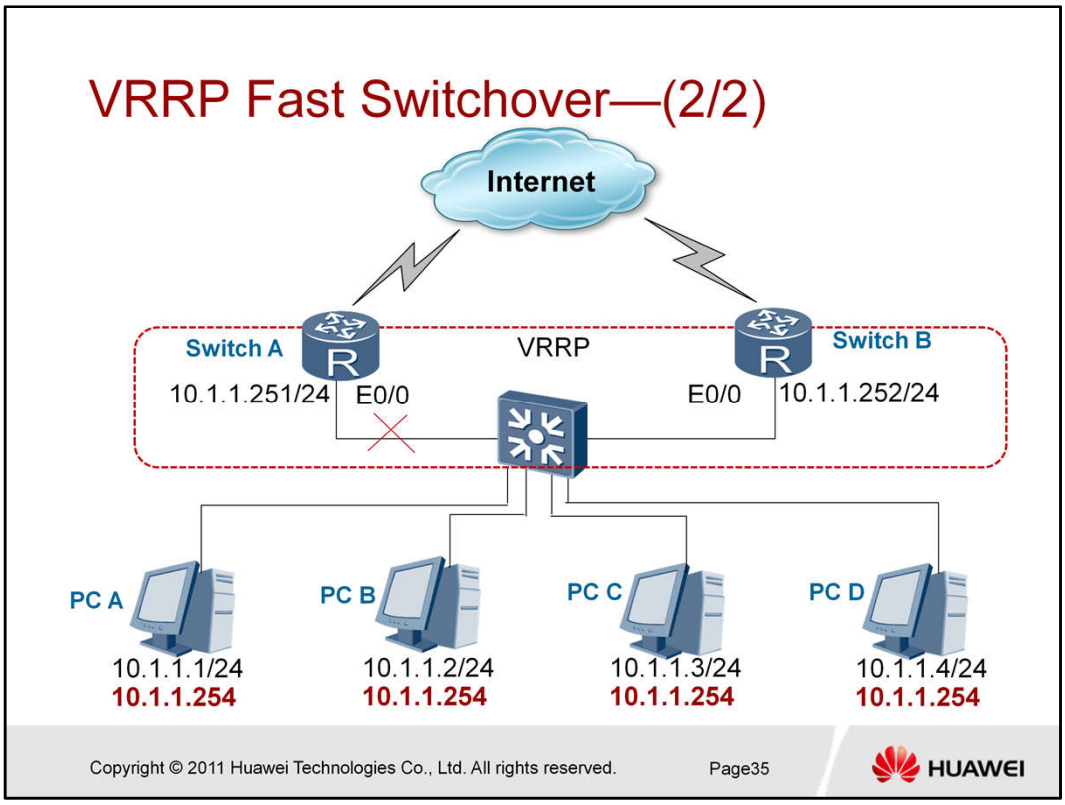


- As shown in the preceding figure, RTA and RTB are enabled with VRRP. RTA functions as the master device and Router B functions as the backup device. The user traffic is transmitted through RTA. A BFD session is established between RTA and RTB. The VRRP backup group tracks the status of the BFD session. When the status of the BFD session changes, the priorities of the backup group are changed and then the master/backup switchover is performed. When a BFD session detects a link fault between RTA and RTB, a Down event is notified to VRRP. Then, the priority of RTB is increased to be higher than the priority of RTA. RTB becomes the master device immediately and the subsequent user traffic is forwarded through RTB. In this manner, the VRRP master/backup switchover is quickly performed.

VRRP Overview Exercises

2.(Single choice) What is the default priority value of VRRP?

( )

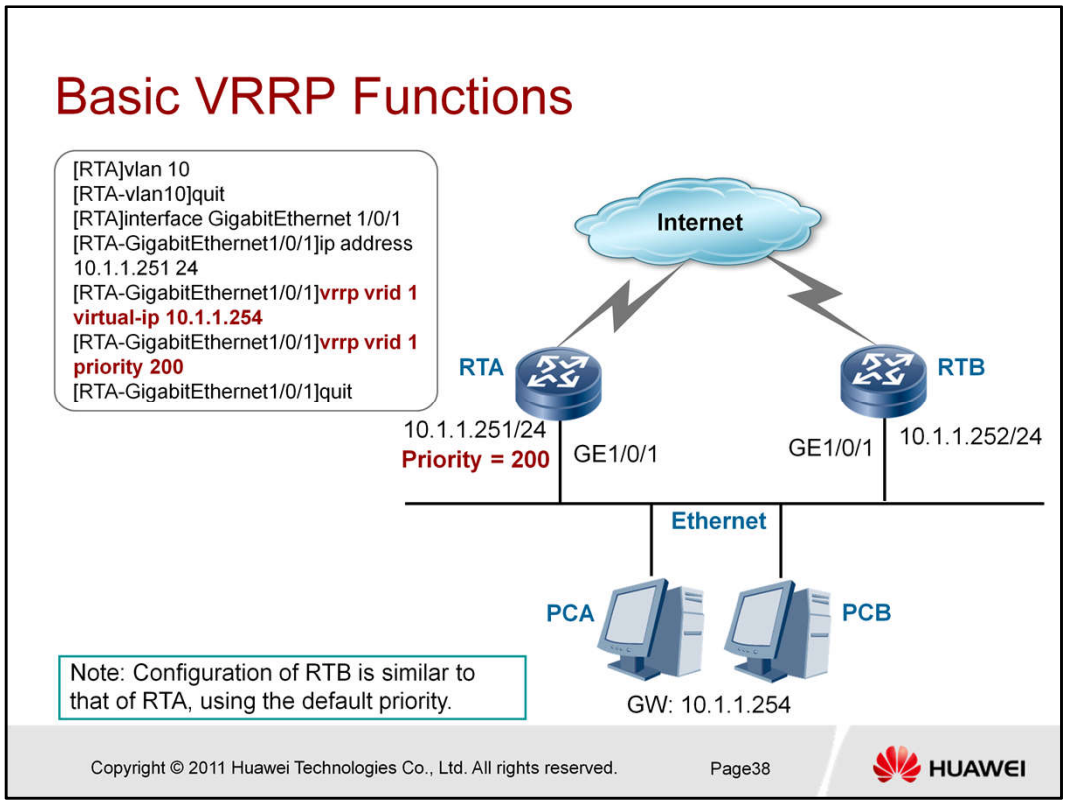
A.0

B.1

C.100

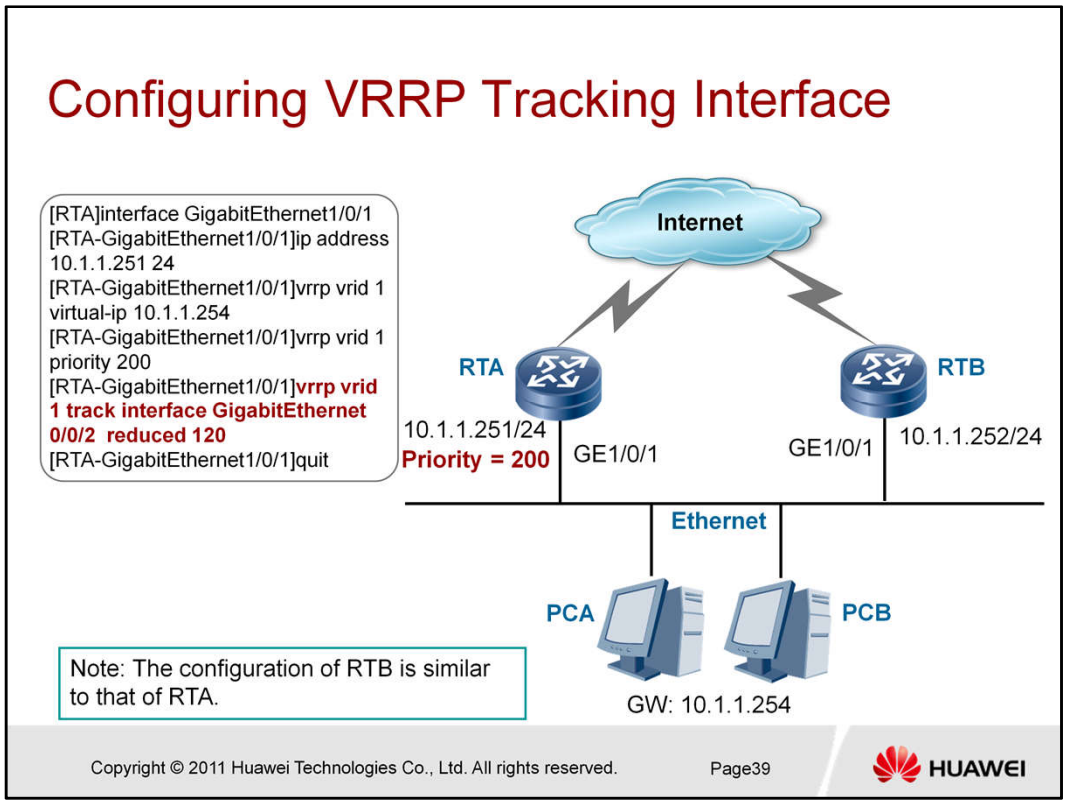
D.255

Contents



- **vrrp vrid virtual-ip**
- Function
  - Using the **vrrp vrid virtual-ip** command, you can create a VRRP group and assign a virtual IP address to the VRRP group.
  - Using the **undo vrrp vrid virtual-ip** command, you can delete a virtual IP address.
  - By default, no VRRP group exists in the system.
- Format
  - **vrrp vrid** *virtual-router-id* **virtual-ip** *virtual-address*
  - **undo vrrp vrid** *virtual-router-id* [**virtual-ip** *virtual-address*]
- Parameters
  - **vrid** *virtual-router-id* specifies the ID of the VRRP group. The value is a decimal integer that ranges from 1 to 255.
  - **virtual-ip** *virtual-address* indicates the virtual IP address.
- View
  - Layer 3 interface view
- Usage Guidelines

- If all the addresses in a VRRP group are deleted, the VRRP group is deleted automatically.



- **vrrp vrid track interface**
- Function
  - Using the **vrrp vrid track interface** command, you can configure VRRP to track the interface status to implement VRRP fast master/backup switchover.
  - Using the **undo vrrp vrid track interface** command, you can disable VRRP from tracking the interface status.
  - By default, VRRP is not configured to track the interface status to implement VRRP fast master/backup switchover.
- Format
  - **vrrp vrid** *virtual-router-id* **track interface** *interface-type interface-number* [**increased** *value-increased* | **reduced** *value-reduced*]
  - **undo vrrp vrid** *virtual-router-id* **track interface** [*interface-type interface-number*]
- Parameters
  - **vrid** *virtual-router-id* specifies the ID of the VRRP backup groups. The value is an integer ranging from 1 to 255.
  - **interface** *interface-type interface-number* specifies the type and number of the tracked interfaces.
  - **increased** *value-increased* specifies the priority value increased each time the

tracked interface goes Down. This parameter is valid only when the VRRP

Configuring VRRP Groups Working in Load Balancing Mode

```
[RTA]interface GigabitEthernet1/0/1
[RTA-GigabitEthernet1/0/1]ip address 10.1.1.251 24
[RTA-GigabitEthernet1/0/1]vrrp vrid 1 virtual-ip 10.1.1.254
[RTA-GigabitEthernet1/0/1]vrrp vrid 1 priority 200
[RTA-GigabitEthernet1/0/1]vrrp vrid 1 track interface GigabitEthernet 0/0/2
[RTA-GigabitEthernet1/0/1]vrrp vrid 2 virtual-ip 10.1.1.253
[RTA-GigabitEthernet1/0/1]quit
```

```
[RTB]interface GigabitEthernet1/0/1
[RTB-GigabitEthernet1/0/1]ip address 10.1.1.252 24
[RTB-GigabitEthernet1/0/1]vrrp vrid 1 virtual-ip 10.1.1.254
[RTB-GigabitEthernet1/0/1]vrrp vrid 2 virtual-ip 10.1.1.253
[RTB-GigabitEthernet1/0/1]vrrp vrid 2 priority 200
[RTB-GigabitEthernet1/0/1]vrrp vrid 2 track interface GigabitEthernet 0/0/2
[RTB-GigabitEthernet1/0/1]quit
```


- Create two VRRP groups on the same Layer 3 interface.

Configuration Verification

```
[RTA]dis vrrp
  GigabitEthernet1/0/1 | Virtual Router 1
    state : Master
    Virtual IP : 10.1.1.254
    PriorityRun : 200
    PriorityConfig : 200
    MasterPriority : 200
    Preempt : YES   Delay Time : 0
    Timer : 1
    Auth Type : NONE
    Check TTL : YES
    Track IF : GigabitEthernet0/0/2   Priority reduced : 120
    IF State : UP

  GigabitEthernet1/0/1 | Virtual Router 2
    state : Backup
    Virtual IP : 10.1.1.253
    PriorityRun : 100
    PriorityConfig : 100
    MasterPriority : 200
    Preempt : YES   Delay Time : 0
    Timer : 1
    Auth Type : NONE
    Check TTL : YES
```