IP Routing Basics

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Classification of Routing and Routing Protocols

- There are three main classification of routing and routing protocols:
  - Dynamic vs static routing
  - Interior vs exterior routing protocols
  - Link state vs distance vector routing protocols

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Dynamic Vs Static Routing

- Routing tables can contain directly connected, manually configured static routes and routes learned dynamically using a routing protocol.
- Static routing is when you manually configure a router to send traffic for particular destinations in preconfigured directions.
- Dynamic routing is when you use a routing protocol such as OSPF, ISIS, EIGRP, and/or BGP to figure out what paths traffic should take.

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Dynamic Vs Static Routing

- The purpose of any routing protocol is to:
  - dynamically communicate information about all network paths used to reach a destination,
  - build routing tables,
  - and to select from those paths, the best path to reach a destination network.
- Some of the most common routing protocols include IGRP, EIGRP, OSPF, IS-IS and BGP.
- There are two primary routing protocol types although many different routing protocols defined with those two types

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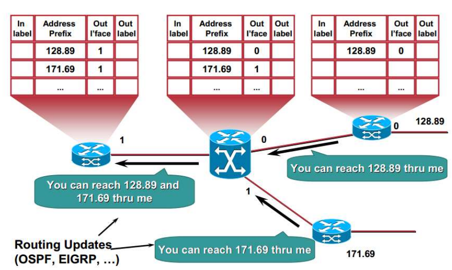
Router Example: Forwarding Packets



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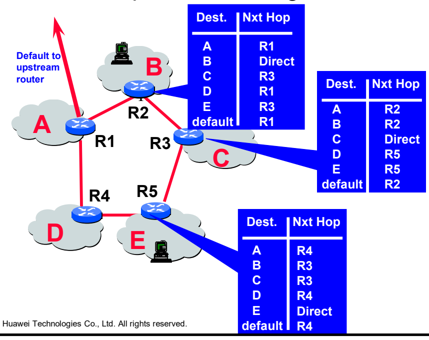
Router Example: Forwarding Packets



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Interior Gateway Routing Protocols

- Interior routing protocol designed for networks that are controlled by an organization.
- They keep track of paths used to move data from one end system to another inside a network or set of networks that you administrate (all of the networks you manage combined are usually just one Autonomous System).
- IGP's fall into two categories:
  - Distance Vector Protocols: Routing Information Protocol (RIP), Interior Gateway Routing Protocol (IGRP), Enhanced Interior Gateway Routing Protocol (EIGRP).
  - Link State Protocols: Open Shortest Path First (OSPF), Intermediate System to Intermediate System (IS-IS)

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Exterior Routing Protocols

- Exterior Gateway Protocols handle routing outside an Autonomous System and get you from your network, through your Internet provider's network and onto any other network.
- Exterior routing protocols are designed for use between two different networks that are controlled by two different organizations.
- Commonly used between ISPs in an ISP or between ISPs with the company.
- BGP (Border Gateway Protocol)is used by companies with more than one internet provider to allow them to have redundancy and load balancing of their data transported to and from the internet.

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Exterior Routing Protocols

- Examples of an EGP:
  - Border Gateway Protocol (BGP)
  - Exterior Gateway Protocol (Replaced by BGP)
- For example, a company runs BGP as an exterior routing protocol between the router of the company with the ISP router.
- IP exterior gateway protocols require three settings the following information before the router can be used:
  - List of neighboring routers to exchange routing information
  - The list of networks to advertise
  - Number of autonomous system from the local router

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Distance Vector vs Link State Routing Protocols

- "Distance Vector" and "Link State" are terms used to describe routing protocols which are used by routers to forward packets between networks.
- The terms distance vector and link state are used to group routing protocols into two broad categories based on whether:
  - the routing protocol selects the best routing path based on a distance metric (the number of hops) and an interface (the vector),
  - or selects the best routing path by calculating the state of each link in a path and finding the path that has the lowest total metric to reach the destination.

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Distance Vector Routing Protocol

- Distance: Distance is the cost of reaching a destination, usually based on the number of hosts the path passes through, or the total of all the administrative metrics assigned to the links in the path.
- Vector: From the standpoint of routing protocols, the vector is the interface traffic will be forwarded out in order to reach a given destination network along a route or path selected by the routing protocol as the best path to the destination network.
- Distance vector protocols use a distance calculation plus an outgoing network interface (a vector) to choose the best path to a destination network.
- Common distance vector routing protocols include:
  - RIP
  - IGRP
  - EIGRP

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Link State Routing Protocol

- Link state protocols know whether a link is up or down and how fast it is (bandwidth and delay) and calculates a cost to 'get there'.
- Link State protocols will take a path which has more hops, but that uses a faster medium over a path using a slower medium with fewer hops.
- Because of their awareness of media types and other factors, link state protocols require more processing power (more circuit logic in the case of ASICs) and memory.
- Distance vector algorithms, being simpler, require simpler hardware.

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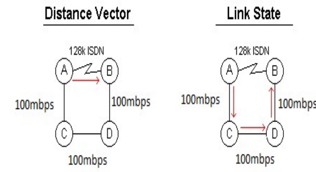
A Comparison: Link State vs. Distance Vector



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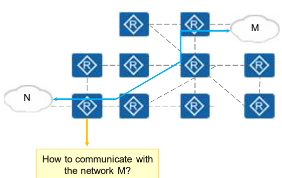
Background: Inter-Subnet Communication



- An IP address uniquely identifies a node on a network.
- Each IP address belongs to a unique subnet, and each subnet may belong to a different area of the network.
- To implement IP addressing, subnets in different areas need to communicate with each other.

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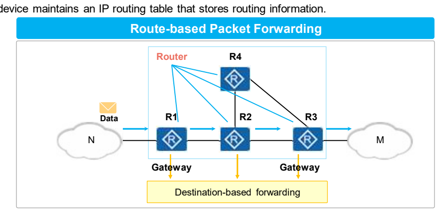
Routes

- Routes are the path information used to guide packet forwarding.
- A routing device is a network device that forwards packets to a destination subnet based on routes. The most common routing device is a router.
- A routing device maintains an IP routing table that stores routing information.



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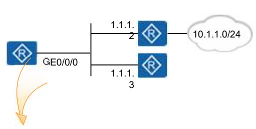
Routing Information



IP routing table

Destination/Mask	Outbound Interface	Next Hop
10.1.1.0/24	GE0/0/0	1.1.1.2

- A route contains the following information:
  - Destination: identifies a destination subnet.
  - Mask: identifies a subnet together with a destination IP address.
  - Outbound interface: indicates the interface through which a data packet is sent out of the local router.
  - Next hop: indicates the next-hop address used by the router to forward the data packet to the destination subnet.
- The information identifies the destination subnet and specifies the path for forwarding data packets.

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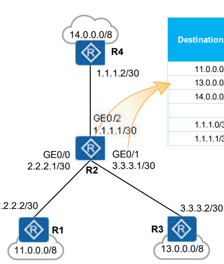
IP Routing Table



Destination/Mask	Next Hop	Outbound Interface
11.0.0.0/8	2.2.2.2	GE0/0
13.0.0.0/8	3.3.3.2	GE0/1
14.0.0.0/8	1.1.1.2	GE0/2
...		
1.1.1.0/30	1.1.1.1	GE0/2
1.1.1.1/32	127.0.0.1	GE0/2

- Routers discover routes using multiple methods.
- A router selects the optimal route and installs it in its IP routing table.
- The router forwards IP packets based on routes in the IP routing table.
- Routers manage path information by managing their IP routing tables.

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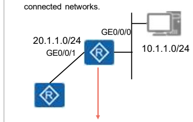
How to Obtain Routing Information

- A router forwards packets based on its IP routing table. To implement route-based packet forwarding, the router needs to obtain routes. The following describes the common methods of obtaining routes.

Direct Routes

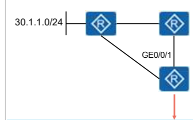
- Direct routes are automatically generated by devices and point to local directly connected networks.



Protocol	Destination/Mask	Outbound Interface
Direct	10.1.1.0/24	GE0/0/0
Direct	20.1.1.0/24	GE0/0/1

Static Routes

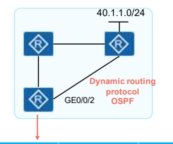
- Static routes are manually configured by network administrators.



Protocol	Destination/Mask	Outbound Interface
Static	30.1.1.0/24	GE0/0/1

Dynamic Routes

- Dynamic routes are learned by dynamic routing protocols running on routers.



Protocol	Destination/Mask	Outbound Interface
OSPF	40.1.1.0/24	GE0/0/2

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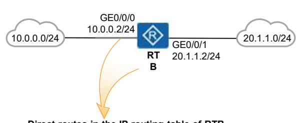
Direct Routes (1)

Direct Routes



Direct routes in the IP routing table of RTB

Destination/Mask	Protocol	Next Hop	Outbound Interface
10.0.0.0/24	Direct	10.0.0.2	GE0/0/0
20.1.1.0/24	Direct	20.1.1.2	GE0/0/1

- A direct route is automatically generated by a device and points to a local directly-connected network.
- When a router is the last hop router, IP packets to be forwarded will match a direct route and the router will directly forward the IP packet to the destination host.
- When a direct route is used for packet forwarding, the destination IP address of a packet to be forwarded and the IP address of the router's outbound interface are in the same subnet.

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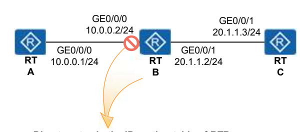
Direct Routes (2)

Direct routes



Direct routes in the IP routing table of RTB

Destination/Mask	Protocol	Next Hop	Outbound Interface
20.1.1.0/24	Direct	20.1.1.2	G0/0/1

- When GE0/0/0 goes down, the direct route for this interface is not installed in the IP routing table.

- Not all the direct routes generated for interfaces are installed in the IP routing table.
- Only the direct routes of which the physical status and protocol status of interfaces are up are installed in the IP routing table.

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Examining the IP Routing Table

```
<Quidway> display ip routing-table
Route Flags: R - relay, D - download to fib
------------------------------------------------------------------------------Routing
Tables: Public
      Destinations : 6      Routes : 6

  Destination/Mask    Proto     Pre  Cost  Flags     NextHop       Interface

     1.1.1.1/32       Static    60    0    D         0.0.0.0        NULL0
     2.2.2.2/32       Static    60    0    D         100.0.0.2      Vlanif100
    100.0.0.0/24      Direct    0     0    D         100.0.0.1      Vlanif100
    100.0.0.1/32      Direct    0     0    D         127.0.0.1      Vlanif100
    127.0.0.0/8       Direct    0     0    D         127.0.0.1      InLoopBack0
    127.0.0.1/32      Direct    0     0    D         127.0.0.1      InLoopBack0
```

Destination/Mask — Protocol — Route preference — Cost (Metric) — Flag — Next-hop address — Outbound interface

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Fields in the IP Routing Table

- Destination/Mask: indicates the destination network address and mask of a specific route. The subnet address of a destination host or router is obtained through the AND operation on the destination address and mask. For example, if the destination address is 1.1.1.1 and the mask is 255.255.255.0, the IP address of the subnet to which the host or router belongs is 1.1.1.0.
- Proto (Protocol): indicates the protocol type of the route, that is, the protocol through which a router learns the route.
- Pre (Preference): indicates the routing protocol preference of the route. There may be multiple routes to the same destination, which have different next hops and outbound interfaces. These routes may be discovered by different routing protocols or be manually configured. A router selects the route with the highest preference (with the lowest preference value) as the optimal route.
- Cost: indicates the cost of the route. When multiple routes to the same destination have the same preference, the route with the lowest cost is selected as the optimal route.
- NextHop: indicates the local router's next-hop address of the route to the destination network. This field specifies the next-hop device to which packets are forwarded.
- Interface: indicates the outbound interface of the route. This field specifies the local interface through which the local router forwards packets.

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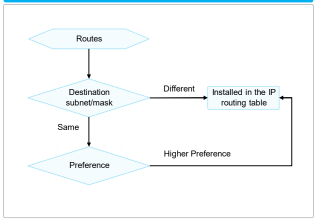
Route Preference - Basic Concepts

Comparing Route Preferences



- When a router obtains routes to the same destination subnet from different routing protocols (these routes have the same destination network address and mask), the router compares the preferences of these routes and prefers the route with the lowest preference value.
- A lower preference value indicates a higher preference.
- The route with the highest preference is installed in the IP routing table.

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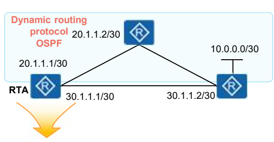
Route Preference - Comparison Process

Comparing Route Preferences



IP routing table of RTA

Destination/Mask	Protocol	Preference	Next Hop
10.0.0.0/30	Static	**60**	30.1.1.2
10.0.0.0/30	OSPF	**10**	20.1.1.2

Installed in the IP routing table

- RTA discovers two routes to 10.0.0.0/30, one is an OSPF route and the other a static route. In this case, RTA compares the preferences of the two routes and selects the route with the lowest preference value.
- Each routing protocol has a unique preference.
- OSPF has a higher preference. Therefore, the OSPF route is installed in the IP routing table.

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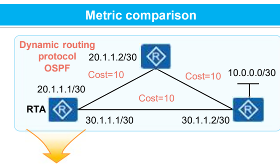
Metric - Comparison Process

Metric comparison



IP routing table of RTA

Destination/Mask	Protocol	Cost	Next Hop
10.0.0.0/30	OSPF	**20**	20.1.1.2
10.0.0.0/30	OSPF	**10**	30.1.1.2

Installed in the IP routing table

- RTA learns two routes with the same destination address (10.0.0.0/30) and preference through OSPF. In this case, RTA needs to compare the metrics of the two routes.
- The two routes have different metrics. The OSPF route with the next hop being 30.1.1.2 has a lower metric (with the cost 10), so it is installed in the IP routing table.

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Route Preference - Common Default Values

- The following table lists the default preference values of common route types:

Protocol	Route Type	Default Preference
Direct	Direct route	0
Static	Static route	60
Dynamic routing protocol	OSPF internal route	10
	OSPF external route	150

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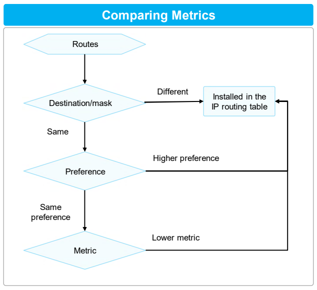
Metric - Basic Concepts

Comparing Metrics



- When a router discovers multiple routes to the same destination network through the same routing protocol, the router selects the optimal route based on the metrics of these routes if these routes have the same preference.
- The metric of a route indicates the cost of reaching the destination address of the route.
- Common metrics include the hop count, bandwidth, delay, cost, load, and reliability.
- The route with the lowest metric is installed in the IP routing table.
- The metric is also known as the cost.

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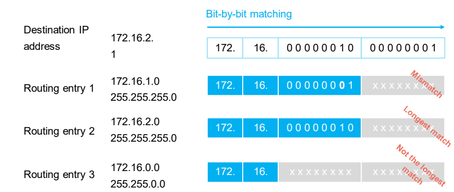
Longest Matching

- When a router receives an IP packet, it compares the destination IP address of the packet with all routing entries in the local routing table bit by bit until the longest matching entry is found. This is the longest matching mechanism.



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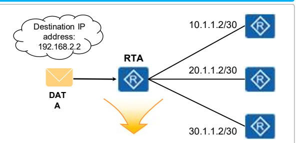
Example of Longest Matching (1)

Example of Longest Matching



IP routing table of RTA

Destination/Mask	Next Hop
192.168.0.0/16	10.1.1.2
192.168.2.0/24	20.1.1.2
192.168.3.0/24	30.1.1.2

Match

- There are two routes to 192.168.2.2 in the IP routing table of RTA, one has the 16-bit mask and the other has the 24-bit mask. According to the longest matching rule, the route with the 24-bit mask is preferred to guide the forwarding of packets destined for 192.168.2.2.

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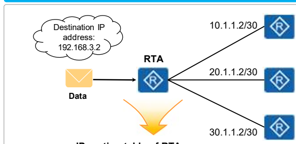
Example of Longest Matching (2)

Example of Longest Matching



IP routing table of RTA

Destination/Mask	Next Hop
192.168.0.0/16	10.1.1.2
192.168.2.0/24	20.1.1.2
192.168.3.0/24	30.1.1.2

Match

- According to the longest matching rule, only the route to 192.168.3.0/24 in the IP routing table matches the destination IP address 192.168.3.2. Therefore, this route is used to forward packets destined for 192.168.3.2.

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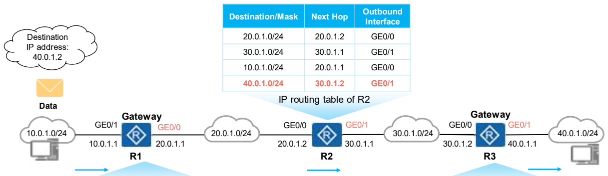
Route-based Forwarding Process

Destination/Mask	Next Hop	Outbound Interface
20.0.1.0/24	20.0.1.2	GE0/0
30.0.1.0/24	30.0.1.1	GE0/1
10.0.1.0/24	20.0.1.1	GE0/0
40.0.1.0/24	30.0.1.2	GE0/1

IP routing table of R2



IP routing table of R1

Destination/Mask	Next Hop	Outbound Interface
10.0.1.0/24	10.0.1.1	GE0/1
20.0.1.0/24	20.0.1.1	GE0/0
30.0.1.0/24	20.0.1.2	GE0/0
40.0.1.0/24	20.0.1.2	GE0/0

IP routing table of R3

Destination/Mask	Next Hop	Outbound Interface
40.0.1.0/24	40.0.1.1	GE0/1
30.0.1.0/24	30.0.1.2	GE0/0
10.0.1.0/24	30.0.1.1	GE0/0
20.0.1.0/24	30.0.1.1	GE0/0

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Summary of the IP Routing Table

- When a router obtains routes to the same destination subnet with the same mask from different routing protocols, the router prefers the route with the lowest preference value of these routing protocols. If these routes are learned from the same routing protocol, the router prefers the route with the lowest cost. In summary, only the optimal route is installed in the IP routing table.
- When a router receives a packet, it searches its IP routing table for the outbound interface and next hop based on the destination IP address of the packet. If it finds a matching routing entry, it forwards the packet according to the outbound interface and next hop specified by this entry. Otherwise, it discards the packet.
- Packets are forwarded hop by hop. Therefore, all the routers along the path from the source to the destination must have routes destined for the destination. Otherwise, packet loss occurs.
- Data communication is bidirectional. Therefore, both forward and backward routes must be available.

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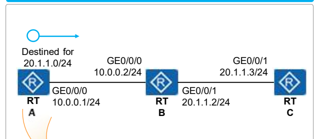
Application Scenarios of Static Routes



Destination	Protocol	Next Hop
20.1.1.0	Static	10.0.0.2
10.0.0.0	Direct	10.0.0.1

- Static routes are manually configured by network administrators, have low system requirements, and apply to simple, stable, and small networks.
- The disadvantage of static routes is that they cannot automatically adapt to network topology changes and so require manual intervention.
- RTA needs to forward the packets with the destination address 20.1.1.0/24. However, the IP routing table of RTA has only one direct route, which does not match 20.1.1.0/24. In this case, a static route needs to be manually configured so that the packets sent from RTA to 20.1.1.0/24 can be forwarded to the next hop 10.0.0.2.

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Static Route Configuration

- Specify a next-hop IP address for a static route.
  [Huawei] **ip route-static** *ip-address* { *mask* | *mask-length* } *nexthop-address*
- Specify an outbound interface for a static route.
  [Huawei] ***ip route-static ip-address { mask | mask-length } interface-type interface-number***
- Specify both the outbound interface and next hop for a static route.
  [Huawei] **ip route-static** *ip-address* { *mask* | *mask-length* } *interface-type interface-number* [*nexthop-address*]

When creating a static route, you can specify both the outbound interface and next hop. Alternatively, you can specify either the outbound interface or next hop, depending on the interface type:
For a point-to-point interface (such as a serial interface), you must specify the outbound interface.
For a broadcast interface (for example, an Ethernet interface) or a virtual template (VT) interface, you must specify the next hop.

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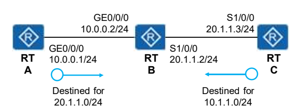
Configuration Example



- Configure static routes on RTA and RTC for communication between 10.0.0.0/24 and 20.1.1.0/24.
- Packets are forwarded hop by hop. Therefore, all the routers along the path from the source to the destination must have routes destined for the destination.
- Data communication is bidirectional. Therefore, both forward and backward routes must be available.

Configure RTA.

[RTA] **ip route-static 20.1.1.0 255.255.255.0 10.0.0.2**

Configure RTC.

[RTC] **ip route-static 10.0.0.0 255.255.255.0 S1/0/0**

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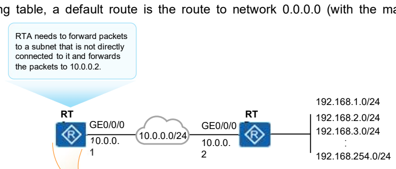
Default Routes

- Default routes are used only when packets to be forwarded do not match any routing entry in an IP routing table.
- In an IP routing table, a default route is the route to network 0.0.0.0 (with the mask 0.0.0.0), namely, 0.0.0.0/0.



[RTA] **ip route-static 0.0.0.0 0 10.0.0.2**

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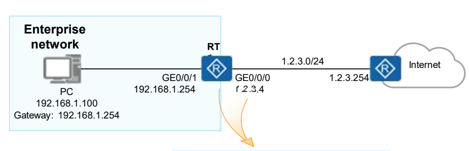
Application Scenarios of Default Routes

- Default routes are typically used at the egress of an enterprise network. For example, you can configure a default route on an egress device to enable the device to forward IP packets destined for any address on the Internet.



[RTA] **ip route-static 0.0.0.0 0 1.2.3.254**

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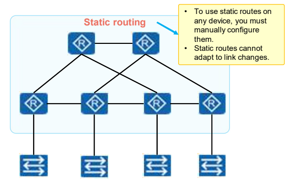
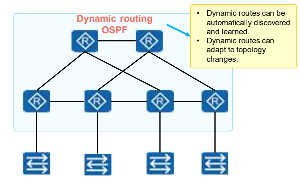
Overview of Dynamic Routing

Static Routing



- When the network scale expands, it becomes increasingly complex to manually configure static routes. In addition, when the network topology changes, static routes cannot adapt to these changes in a timely and flexible manner.

Dynamic Routing



- Dynamic routing protocols automatically discover and generate routes, and update routes when the topology changes. These protocols effectively reduce the workload of network administrators and are widely used on large networks.

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Classification of Dynamic Routing Protocols

Classification by the application scope

Interior Gateway Protocol (IGP): RIP, OSPF, IS-IS

Exterior Gateway Protocol (EGP): BGP

Classification by working mechanism and routing algorithm

Distance-vector routing protocol: RIP

Link-state routing protocol: OSPF, IS-IS

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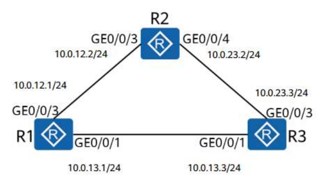
Review of Lab 1



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Review of Lab 1

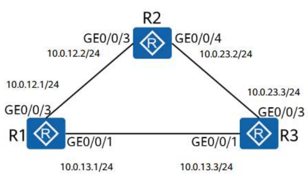

Table 2-2 IP addresses of loopback interfaces

Router	Interface	IP Address/Mask
R1	LoopBack0	10.0.1.1/32
R2	LoopBack0	10.0.1.2/32
R3	LoopBack0	10.0.1.3/32

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Route Recursion (1)

- Route recursion is a recursive search process of the IP routing table where the next-hop IP address is wanted to route packets towards its destination but when found it is not part of any directly connected network.

[RTA] **ip route-static 30.1.2.0 24 20.1.1.3**

The next hop of the route to 30.1.2.0/24 is 20.1.1.3, which is not on a directly connected network of RTA. If the IP routing table does not have a route to 20.1.1.3, this static route does not take effect and cannot be installed in the IP routing table.

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Route Recursion (2)

[RTA] **ip route-static 30.1.2.0 24 20.1.1.3**
Recursion
[RTA] **ip route-static 20.1.1.0 24 10.0.0.2**

Destination/Mask	Next Hop	Outbound Interface
30.1.2.0/24	20.1.1.3	GE0/0/0
20.1.1.0/24	10.0.0.2	GE0/0/0

Configure a route to 20.1.1.3, with the next hop pointing to 10.0.0.2 on the directly connected network. In this way, RTA can recurse the route with the destination 30.1.2.0/24 to the route with the destination 10.0.0.2.

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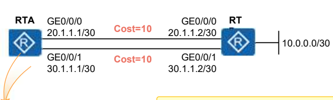
Equal-Cost Route

- When there are equal-cost routes in the IP routing table, a router forwards IP packets to be sent to the destination subnet through all valid outbound interfaces and next hops in the equal-cost routes, achieving load balancing.



RTA's IP routing table

Destination/Mask	Next Hop
10.0.0.0/30	20.1.1.2
	30.1.1.2

If there are multiple routes to the same destination from the same source, with the same cost, but pointing to different next hops, the routes are installed in the IP routing table as equal-cost routes. Traffic to be sent to the destination will be distributed to these equal-cost routes.

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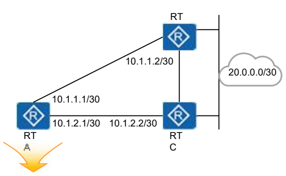
Floating Route - Basic Concepts

Floating Route



Configure a floating route on RTA.

[RTA] **ip route-static 20.0.0.0 30 10.1.1.2**
[RTA] **ip route-static 20.0.0.0 30 10.1.2.2 preference 70**

- Different preferences can be manually configured for static routes. Therefore, you can configure two static routes with the same destination address/mask but different preferences and next hops to implement backup of forwarding paths.
- A backup route is known as a floating route, which is used only when the primary route is unavailable. That is, a floating route is installed in the IP routing table only when the next hop of the primary route is unreachable.

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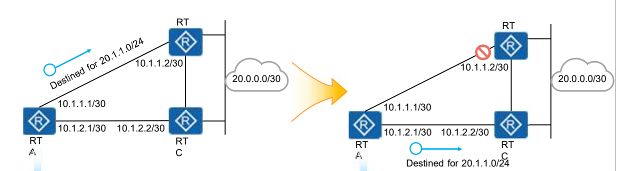
Floating Route - Example

Floating Route Switching



RTA's IP routing table when the primary link is available

Destination	Next Hop	Preference
20.0.0.0	10.1.1.2	60

RTA's IP routing table when the primary link fails

Destination	Next Hop	Preference
20.0.0.0	10.1.2.2	70

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CIDR

- Classless Inter-Domain Routing (CIDR) uses IP addresses and masks to identify networks and subnets. CIDR replaces the previous addressing architecture of classful network design (such as classes A, B, and C addresses).
- CIDR is based on variable length subnet mask (VLSM). CIDR uses prefixes of any lengths to divide the address space with continuous IP addresses. Multiple address segments with continuous prefixes can be summarized into a network, effectively reducing the number of routing entries.

192.	168.	0 0 0 0 1 1 0 0	0 0 0 0 0 0 0 0	192.168.12.0/22
192.	168.	0 0 0 0 1 0 1 0	0 0 0 0 0 0 0 0	192.168.10.0/23
192.	168.	0 0 0 0 1 0 0 1	0 0 0 0 0 0 0 0	192.168.9.0/21
192.	168.	0 0 0 0 1 1 1 0	0 0 0 0 0 0 0 0	192.168.14.0/23

192.168.8.0/21

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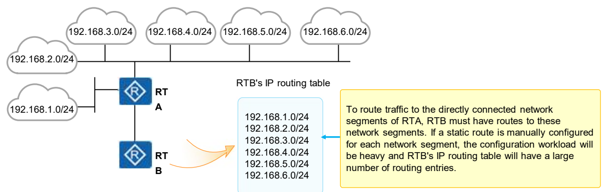
Background of Route Summarization

- Subnet division and VLSM resolve the problem of address space waste, but also bring a new challenge: increasing routing entries in the IP routing table.
- Route summarization can minimize routing entries.



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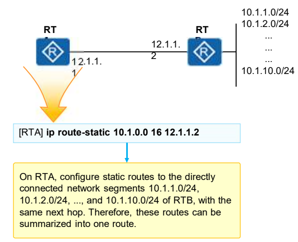
Overview of Route Summarization



- Route summarization is an approach of summarizing routes with the same prefix into one summary route to minimize the IP routing table size and improve device resource usage.
- Route summarization uses CIDR to summarize network segments with the same prefix into a single one.
- The routes before being summarized are known as specific routes, and the routes created after summarization are known as summarized routes or summary routes.

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Summarization and Calculation

	192	168	X	0
192.168.1.0/24	1 1 0 0 0 0 0 0	1 0 1 0 1 0 0 0	0 0 0 0 0 0 0 1	0 0 0 0 0 0 0 0
192.168.2.0/24	1 1 0 0 0 0 0 0	1 0 1 0 1 0 0 0	0 0 0 0 0 0 1 0	0 0 0 0 0 0 0 0
192.168.3.0/24	1 1 0 0 0 0 0 0	1 0 1 0 1 0 0 0	0 0 0 0 0 0 1 1	0 0 0 0 0 0 0 0
	Network address			Host address
192.168.0.0/22	1 1 0 0 0 0 0 0	1 0 1 0 1 0 0 0	0 0 0 0 0 0 0 0	0 0 0 0 0 0 0 0

- To summarize routes to multiple continuous network segments into one summary route that just includes these network segments, ensure that the mask length of the summary route is as long as possible.
- The key to achieve this is to convert the destination addresses of specific routes into binary numbers and then find out the identical bits in these binary numbers.

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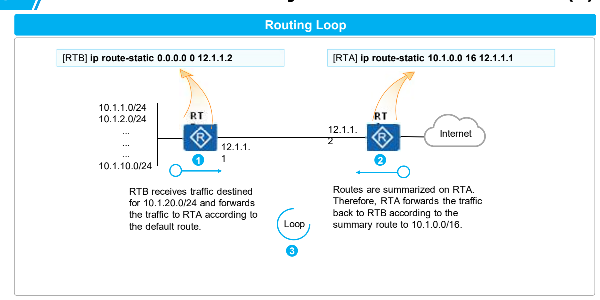
Problems Caused by Route Summarization (1)



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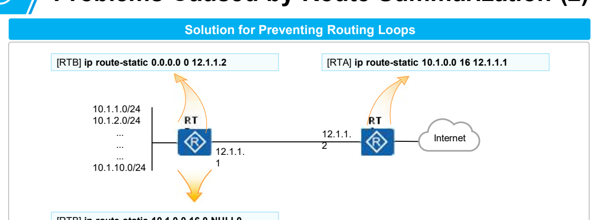
Problems Caused by Route Summarization (2)



- Configure a route pointing to Null0 on RTB to prevent routing loops when summarizing routes.

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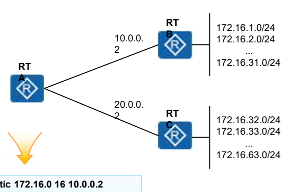
Accurate Route Summarization (1)



- To simplify the configuration, an administrator may configure a static summary route on RTA to allow RTA to reach network segments 172.16.1.0/24 to 172.16.31.0/24 of RTB. However, this summary route also includes the network segments of RTC. As a result, RTA forwards the traffic destined for network segments of RTC to RTB, causing data packet loss. This problem is caused by inaccurate route summarization. To resolve this problem, the summary route must be as accurate as possible; that is, it just covers all specific routes that are to be summarized, with no extra route included.

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Accurate Route Summarization (2)

	10	1	0	0
10.1.1.0/24	0 0 0 0 1 0 1 0	0 0 0 0 0 0 0 1	0 0 0 0 0 0 0 1	0 0 0 0 0 0 0 0
10.1.2.0/24	0 0 0 0 1 0 1 0	0 0 0 0 0 0 0 1	0 0 0 0 0 0 1 0	0 0 0 0 0 0 0 0
10.1.3.0/24	0 0 0 0 1 0 1 0	0 0 0 0 0 0 0 1	0 0 0 0 0 0 1 1	0 0 0 0 0 0 0 0

/22

```
ip route-static 10.1.1.0 24 12.1.1.2
ip route-static 10.1.2.0 24 12.1.1.2
ip route-static 10.1.3.0 24 12.1.1.2
```

```
ip route-static 10.1.1.0 22 12.1.1.2
```

Accurately calculate the summarized network address and mask to ensure accurate route summarization.

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Quiz

1. How does a router select the optimal route?
2. How do I configure a floating route?
3. What is the summary route for routes to 10.1.1.0/24, 10.1.3.0/24, and 10.1.9.0/24?

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Summary

- This section presents the basic concepts of routes, how routes instruct routers to forward IP packets, common route attributes, and default routes (special static routes).
- In addition, this section describes advanced routing features including route recursion, floating routes, and equal-cost routes, which are widely used on live networks.

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