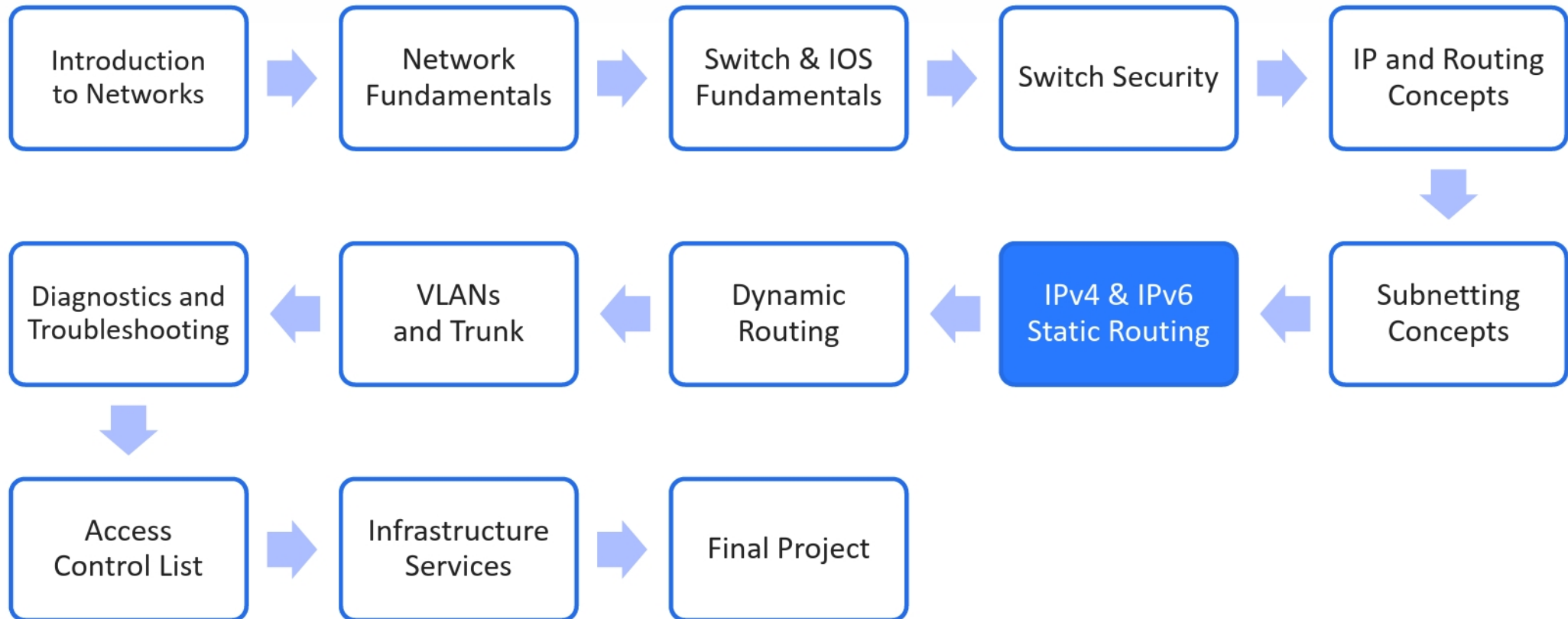


Cybersecurity Professional Program

IPv4 & IPv6 Static Routing

Computer Networking

Computer Networking Course Path



Overview

Lesson Objective

The objective of this lesson is to learn about the static routing method and how to configure it in IPv4 and IPv6.



Router Operation

IPv4 Static Routing

IPv6 Static Routing

IPv4 & IPv6 Static Routing

ROUTER OPERATION

Routing Review

How a Router Operates



One of the router's main jobs is to select the best path for a packet.

The decision is based on its destination address.

After determining the best path on which to forward the packet, the router encapsulates the packet in a new frame in accordance with the relevant outgoing interface.



Packet Forwarding Review

Examination

In the first step, the router decides whether to process a packet or ignore it. Routers will ignore packets with errors, or packets they don't know how to process.

1

Decision-Making

The router decides where to forward the packet to, based on its destination IP address and the routing table.

3

Forwarding

After a decision is made, the router forwards the packet to the interface from which the packet must exit.

5

Decapsulation

The router examines the Layer 2 address to decide if the packet was intended for itself (the default gateway), and verifies the integrity of the frame using the FCS (Layer 2 trailer).

2

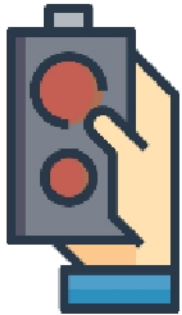
Encapsulation

The router re-encapsulates the packet with new Layer 2 headers for the next hop (MAC address of the next hop), according to the decision made in step 3.

4

Remote Networks

What is a Remote Network?



A router's best routing decision is based on its routing table. But where does the routing table get its information from?

Networks connected directly are added to the table immediately, but a remote network must be configured by the user.

A remote network is any network not connected locally to the router.



The ICMP message "Destination unreachable" is displayed whenever the router cannot find a match for the path in its routing table.

Remote Network Learning

A remote network can be learned by a router in one of two ways: statically or dynamically.

Static Method



Using the static routing method, the user enters every network manually in the routing table.



Dynamic Method



In the dynamic routing method, the router automatically learns the remote network from the routing tables of adjacent routers, by using various protocols.



Static Method Pros and Cons

Advantages

A simple solution for small networks.

Not advertised over the network, meaning better security.

No CPU and memory usage for routing purposes.

Every path a packet takes is known, which improves network traffic management.



VS

Disadvantages

Error-prone in large network environments.

Does not support verification methods.

Configuration and maintenance are time-consuming.

Requires complete knowledge of the entire network.



When to Use Static Routing

Network administrators decide if and when to use Static Routing, based on network requirements.

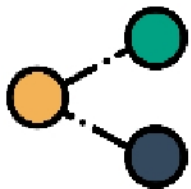
Stub Networks



Static routing is a better choice when routing to and from stub networks. Stub networks consist of a single router that sends and receives non-local traffic via a single path.



Small Networks



Although Static Routing is simple and secure, and saves resources, it does not provide a sufficient level of scalability in larger networks.



IPv4 & IPv6 Static Routing

IPV4 STATIC ROUTING

Static Route Types

The following are the most common types of Static Route implementation.

Standard Static Route



Manually configured route that forwards traffic to a specific network.



Default Static Route



Typically used as a Gateway of Last Resort, which is used for any packet that does not have a destination route in the routing table. The destination in such cases is often set to the Internet.



Network Topology Example

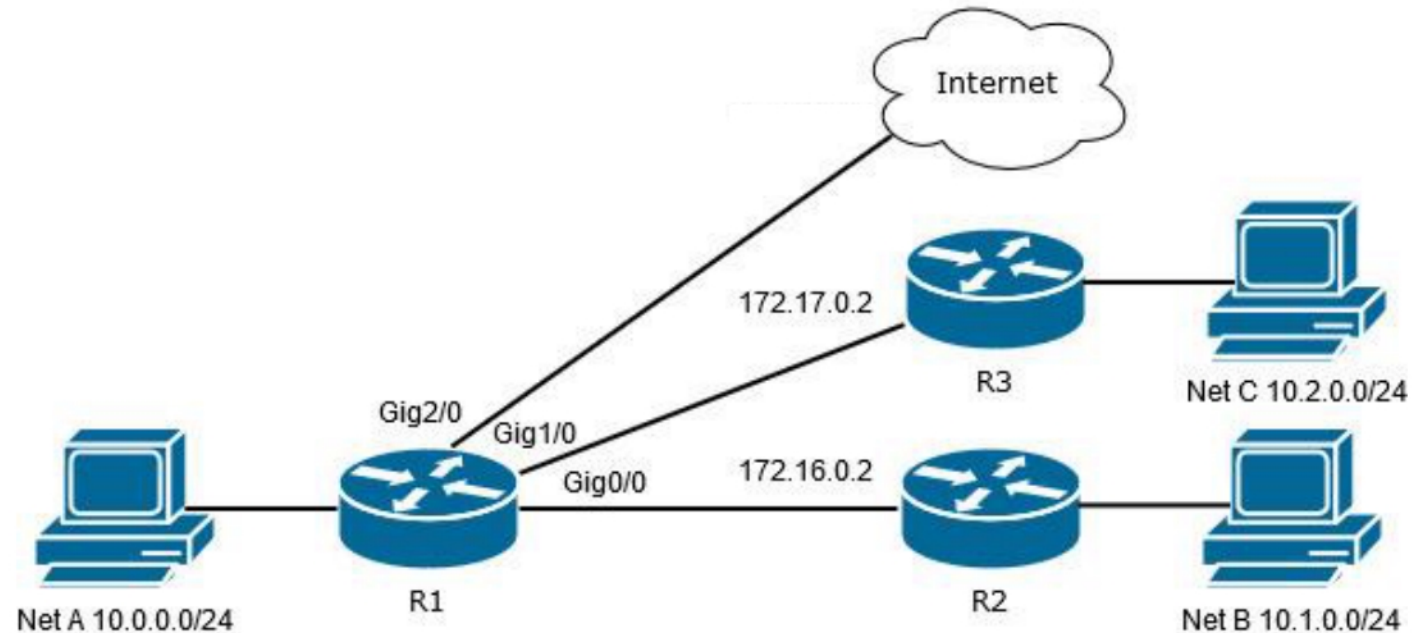
A host on network A wants to communicate with a host on network B.

If no static or dynamic routing is used, R1 does not know the destination network and its direction.

For R1 to know network B, add the network and direction to the routing table. Now, R1 will forward network A host packets to the correct destination.

The same is required for R2 and R3 to recognize network A.

Network Topology Illustration



Syntax Usage

Command

```
Router(config)# ip route <network-address> <subnet-mask> <direction>
```

1 2 3



1. Specifies the remote network address.
2. Specifies the remote network subnet mask.
3. Sets the direction of the network, which can be:
 - Directly-connected* - the local outgoing interface.
 - Next-hop* - the IP address of the interconnected router.

Code Example

```
R1(config)#ip route 10.1.0.0  
255.255.255.0 172.16.0.2
```



Standard Configuration Example

The example on the right is a static route configuration example, based on the topology in the previous slide.

The **ip route** command is used to add a new network route to the routing table.

Verify the addition of static routes by displaying the routing table using the **show ip route** command.

Note: The next-hop and directly-connected options are also known as recursive and directly-attached routes.

Standard Route

```
R1(config)#ip route 10.1.0.0 255.255.255.0 172.16.0.2
```

```
R1(config)#ip route 10.2.0.0 255.255.255.0 gigabitEthernet 1/0  
%Default route without gateway, if not a point-to-point interface,  
may impact performance
```

```
R1(config)#do show ip route
```

```
10.0.0.0/24 is subnetted, 2 subnets
```

```
S      10.1.0.0 [1/0] via 172.16.0.2
```

```
S      10.2.0.0 is directly connected, GigabitEthernet1/0
```

```
C      172.16.0.0/16 is directly connected, GigabitEthernet0/0
```

```
C      172.17.0.0/16 is directly connected, GigabitEthernet1/0
```

```
C      172.18.0.0/16 is directly connected, GigabitEthernet2/0
```



Default Configuration Example

The default and standard routes use the same syntax, except for one difference:
The default route uses **0.0.0.0** to represent any network address with any subnet mask.

A default route can be set with a next-hop or outgoing interface.

The standard route is denoted by **S**, while the default is denoted by **S***.

Default Route

```
R1(config)#ip route 0.0.0.0 0.0.0.0 gigabitEthernet 2/0
```

```
R1(config)#do show ip route
```

```
10.0.0.0/24 is subnetted, 2 subnets
```

```
S      10.1.0.0 [1/0] via 172.16.0.2
```

```
S      10.2.0.0 is directly connected, GigabitEthernet1/0
```

```
C      172.16.0.0/16 is directly connected, GigabitEthernet0/0
```

```
C      172.17.0.0/16 is directly connected, GigabitEthernet1/0
```

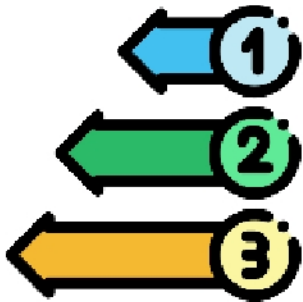
```
C      172.18.0.0/16 is directly connected, GigabitEthernet2/0
```

```
S*     0.0.0.0/0 is directly connected, GigabitEthernet2/0
```



Administrative Distance

Administrative Distance



Administrative Distance (AD) is a predefined value for each routing method. The router selects the path of the lowest AD value in the routing table.

For example, if there are two routes to the same destination network, one via OSPF (a dynamic routing protocol) and the other a static route, the router will select the static route (1 vs. 110).



IPv4 Static Routing

AD Value

AD is a predefined value. The following table lists default AD values for different routing methods.

Default AD Values

Method/Protocol	AD Value
Directly-connected	0
Static Route	1
Internal EIGRP	90
OSPF	110
RIP	120



Additional Types of Static Routing

Floating Static Route



Provides backup paths to primary static routes for situations in which a link failure occurs. This route type is only used when the primary route is not available.

The AD for floating static routes is higher than the AD for primary routes.

Summary Static Route



To reduce the number of routing table entries, multiple static routes can be summarized to a single address.

Host Static Route



Similar to standard route, but instead of configuring a network, it is used to forward traffic to a specific host.

It uses a default mask of 255.255.255.255

Floating Configuration Example

Command

```
ip route <network-address> <subnet-mask> <direction> <AD>
```



The code on the right is an example of a primary and backup route configuration.

The primary route is set with a default AD (1).

The backup route points to the same network but from a different direction, and is set with a higher AD (5).

Note: The backup route will be shown only if the primary route fails.

Code Example

```
R1(config)#ip route 192.168.1.0 255.255.255.0 172.16.0.2
R1(config)#ip route 192.168.1.0 255.255.255.0 10.0.0.2 5

R1(config)#do show ip route
C      10.0.0.0/30 is directly connected, GigabitEthernet0/1
C      172.16.0.0/30 is directly connected, GigabitEthernet0/0
S      192.168.1.0/24 [1/0] via 172.16.0.2
S      192.168.1.0/24 [5/0] via 10.0.0.2
```



Host Configuration Example

Command

```
ip route <ip-address> 255.255.255.255 <direction>
```



Although this type of static route is not very common, it can be useful as a redundant path to a specific resource, such as a server.

This method may be useful for special routing requirements.

Code Example

```
R1(config)#ip route 192.168.1.5 255.255.255.255 172.16.0.2
```

```
R1(config)#do show ip route
```

```
C      10.0.0.0/30 is directly connected, GigabitEthernet0/1  
S      192.168.1.5/32 [1/0] via 172.16.0.2
```



Summary Conditions

Contiguous:

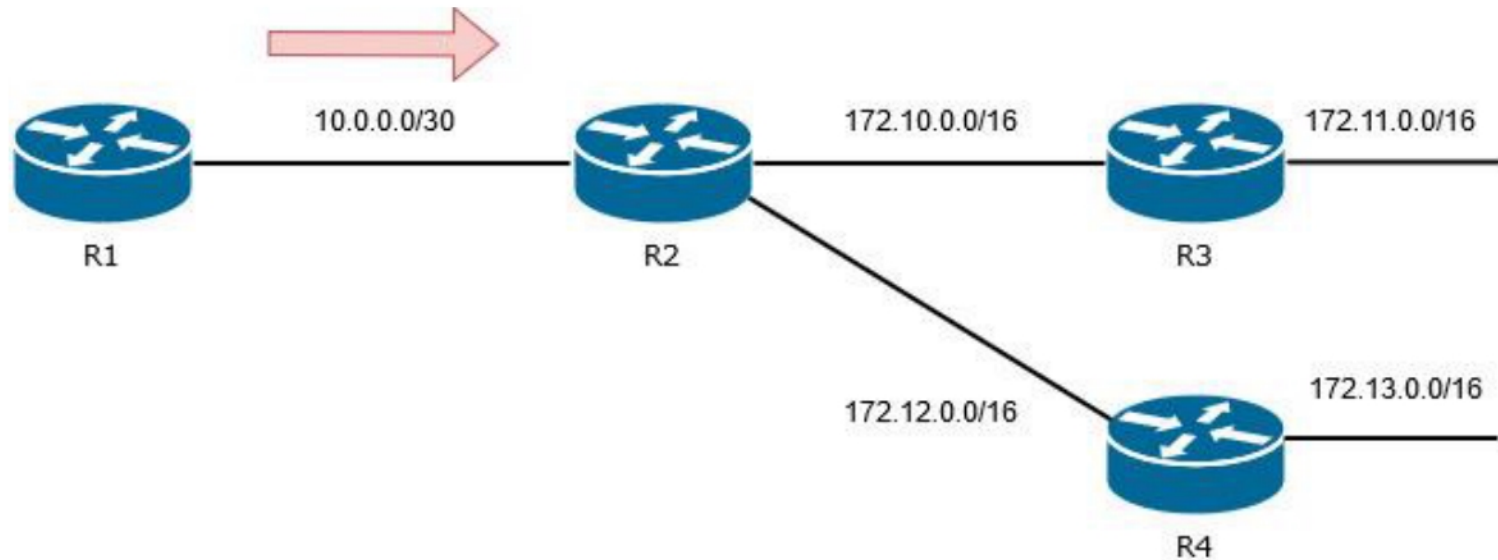
To summarize the network to a single address, the destination networks need to be contiguous.

Same Routing Path:

All networks use the same outgoing interface or next-hop address.

In this example, instead of four standard static routes, a single summarized static route is used, as shown in the next slide.

Network Topology Illustration



Summarizing Steps

Convert IP to Binary

172.10.0.0 – 10101100.00001010.00000000.00000000
172.11.0.0 – 10101100.00001011.00000000.00000000
172.12.0.0 – 10101100.00001100.00000000.00000000
172.13.0.0 – 10101100.00001101.00000000.00000000

1

Compare the Identical Bits

172.10.0.0 – 10101100.00001010.00000000.00000000
172.11.0.0 – 10101100.00001011.00000000.00000000
172.12.0.0 – 10101100.00001100.00000000.00000000
172.13.0.0 – 10101100.00001101.00000000.00000000

2

Create a Summarized Address

Network Address :

172.8.0.0 - 10101100.00001000.00000000.00000000

Subnet Mask:

255.248.0.0 - 11111111.11110000.00000000.00000000

3

Summarizing Configuration Example

Command

```
ip route <summarize-address> <summarize-mask> <direction>
```



The example on the right shows the code for summarizing and verifying the new route. Note the prefix 13.

Code Example

```
R1(config)#ip route 172.8.0.0 255.248.0.0 10.0.0.1  
  
R1(config)#do show ip route  
C 10.0.0.0/24 is directly connected, GigabitEthernet0/0  
S 172.8.0.0/13 [1/0] via 10.0.0.1
```



Lab NET-07-L1

Configuring IPv4 Static and Default Routes
30–60 Min.



Mission

The objective of this exercise is to implement IPv4 standard and default static routes in a full network topology.

Steps

- Configure IPv4 Standard Route
- Configure IPv4 Default Routes
- Configure IPv4 Summary Route

Environment & Tools

- OS: All platforms
- Tools: Cisco Packet Tracer 7.2.2 or higher

Related Files

- Lab document
- NET-07-L1.pka

IPv4 & IPv6 Static Routing

IPV6 STATIC ROUTING

IPv6 Static Routes

IPv6 Static Route Types



Static routing is similar for IPv4 and IPv6, with the exception of how the destination network addresses are formatted.

IPv6 supports the same static routing types, and most of the parameters are identical to those in IPv4 commands.



IPv6 Prerequisites

What's Required for IPv6 Static Routing?



- IPv6 packet forwarding must be enabled on the Cisco router.
Command: **IPv6 unicast-routing**
- The interface must be enabled and configured with an IPv6 address.



Syntax Usage

Command

```
Router(config)# ipv6 route <network-address> / <prefix> <direction>
```

1 2 3



1. Specifies the IPv6 remote network address.
2. Specifies the remote network prefix.
3. Sets the direction of the network, which can be:
Directly-connected - the local outgoing interface.
Next-hop - the IPv6 link-local or global-unicast address of the interconnected router.

Code Example

```
R1(config)#ipv6 route  
2001:abcd:cafe::/64 serial  
0/0/0
```



IPv6 Configuration Example

The code on the right includes examples of all types of IPv6 static routes:

- Standard (next-hop)
- Default (directly-connected)
- Summary
- Floating

Static Route Examples

```
R1(config)#ipv6 route 2001:abcd:cafe::/64 2002:abcd:aaaa::1
```

```
R1(config)#ipv6 route ::/0 serial 0/0/0
```

```
R1(config)#ipv6 route 2001:abcd:cafe::/61 gigabitethernet0/0
```

```
R1(config)#ipv6 route 2001:abcd:cafe::/64 gigabitethernet0/0 5
```



Verify IPv6 Configuration

show ipv6 route displays and verifies the IPv6 routing table.

Remember not to use **show ip route** (displays IPv4 routing table), but rather **show ipv6 route**

Configuration Verification

```
R1(config)#do show ipv6 route
S    2001:ABCD:CAFE::/64 [1/0]
      via 2002:ABCD:AAAA::1
S    ::/0 [1/0]
      via serial 0/0/0
```





QUESTIONS?



THANK YOU
