Static Routing

Routing Protocols and Concepts – Chapter 2

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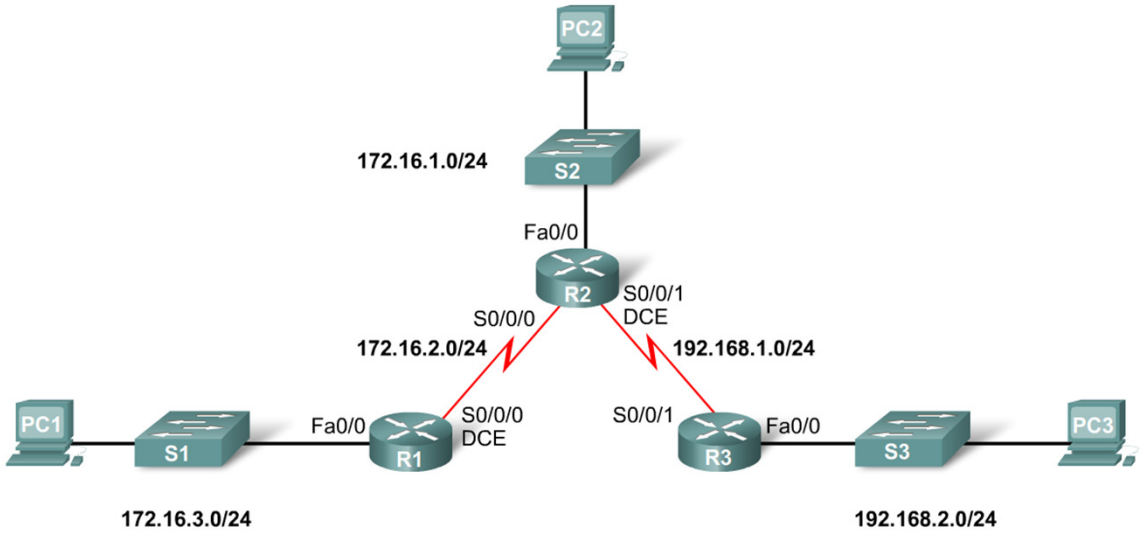
Objectives

- Define the general role a router plays in networks.
- Describe the directly connected networks, different router interfaces
- Examine directly connected networks in the routing table and use the CDP protocol
- Describe static routes with exit interfaces
- Describe summary and default route
- Examine how packets get forwarded when using static routes
- Identify how to manage and troubleshoot static routes

General Role of the Router

- Functions of a Router
  - Best Path Selections
  - Forwarding packets to destination
- Introducing the Topology
  - 3 1800 series routers connected via WAN links
  - Each router connected to a LAN represented by a switch and a PC



General Role of the Router

- Connections of a Router for WAN

  -A router has a DB-60 port that can support 5 different cabling standards

- Connections of a Router for Ethernet

  -2 types of connectors can be used: Straight through and Cross-over

  - Straight through used to connect:

    -Switch-to-Router, Switch-to-PC, Router-to-Server, Hub-to-PC, Hub-to-Server

  - Cross-over used to connect:

    -Switch-to-Switch, PC-to-PC, Switch-to-Hub, Hub-to-Hub, Router-to-Router

Interfaces

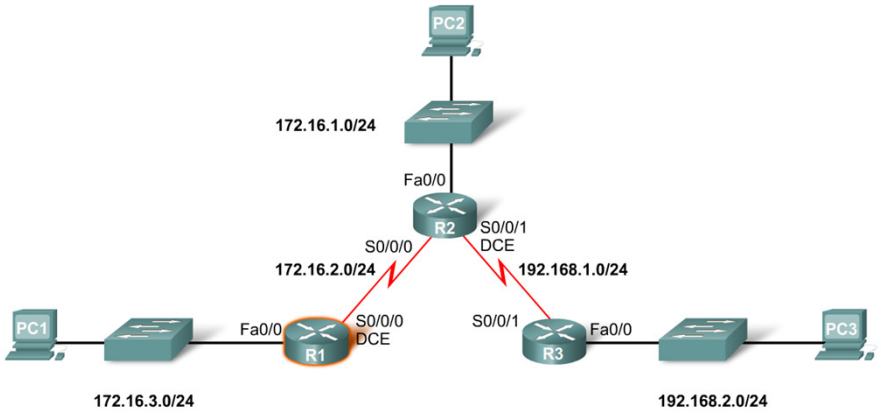
- **Examining Router Interfaces**

-Show IP router command – used to view routing table

-Show Interfaces command – used to show status of an interface

-Show IP Interface brief command – used to show a portion of the interface information

-Show running-config command – used to show configuration file in RAM

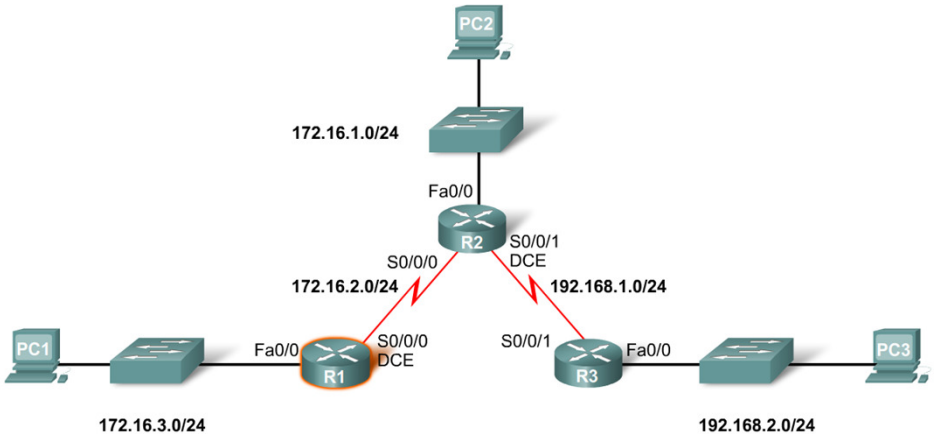


Interfaces

- **Configuring an Ethernet interface**

  -By default all serial and Ethernet interfaces are down

  -To enable an interface use the No Shutdown command




```
R1#show ip route
Codes: C - connected, S - static, I - IGRP, R - RIP, M - mobile, B - BGP
       D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2, E - EGP
       i - IS-IS, L1 - IS-IS level-1, L2 - IS-IS level-2, ia - IS-IS inter area
       * - candidate default, U - per-user static route, o - ODR
       P - periodic downloaded static route

Gateway of last resort is not set

R1#
```

Interfaces

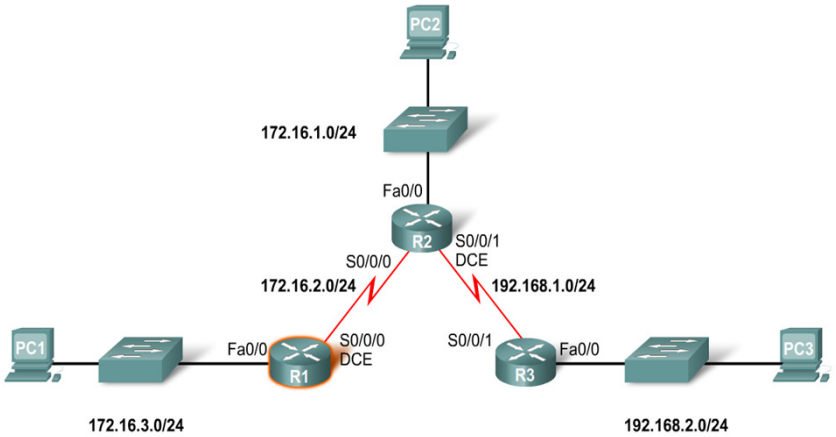
- **Verifying Ethernet interface**

  -Show interfaces for fastEthernet 0/0 – command used to show

  -Show ip interface brief

  -Show running-config

- Ethernet interfaces participate in ARP

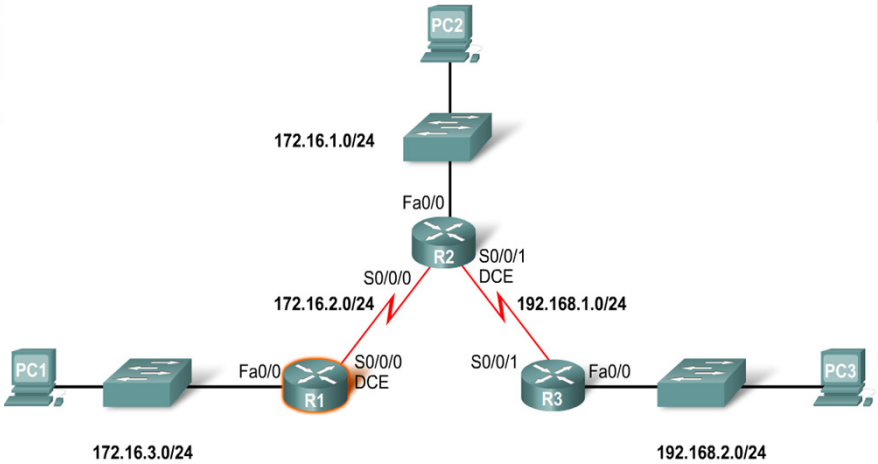


Verifying MAC Addresses on Ethernet Interfaces

```
R1#show interfaces fastethernet 0/0
FastEthernet0/0 is up, line protocol is up
  Hardware is AmdFE, address is 000c.3010.9260 (bia 000c.3010.9260)
  Internet address is 172.16.3.1/24
  <output omitted>
R1#
```

Ethernet interfaces have MAC addresses.

Interfaces



- **Configuring a Serial interface**
  - -Enter interface configuration mode
  - -Enter in the ip address and subnet mask
  - -Enter in the no shutdown command
- Example:
  - -R1(config)#interface serial 0/0
  - -R1(config-if)#ip address 172.16.2.1 255.255.255.0
  - -R1(config-if)#no shutdown

Serial interface with down and down

```
R1#show interfaces serial 0/0/0
Serial0/0/0 is administratively down, line protocol is down
  Hardware is PowerQUICC Serial
  Internet address is 172.16.2.1/24
  MTU 1500 bytes, BW 1544 Kbit, DLY 20000 usec,
<output omitted>
```

Serial interface is down and down even though it has an IP address and was enabled with no shutdown command.

Interfaces

- **Examining Router Interfaces**

  -Physically connecting a WAN Interface.

  -A WAN Physical Layer connection has sides:

  - Data Circuit-terminating Equipment (DCE) – This is the service provider. CSU/DSU is a DCE device.
  - Data Terminal Equipment (DTE) – Typically the router is the DTE device.

Interfaces

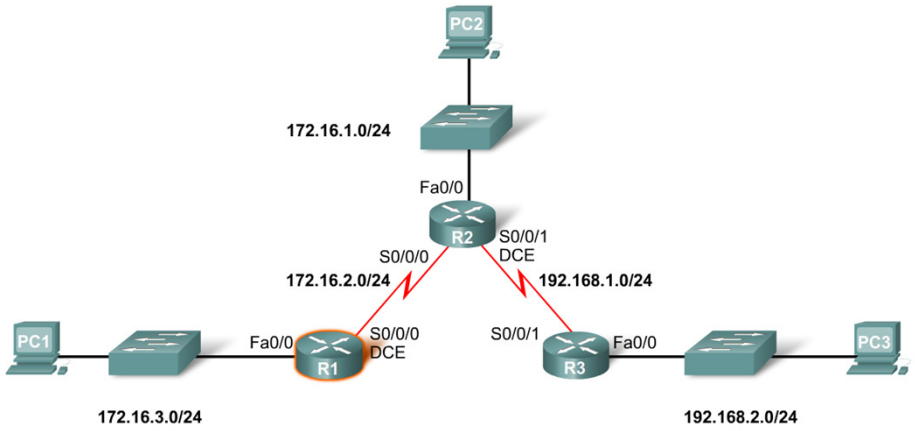
- **Configuring serial links in a lab environment**
  - One side of a serial connection must be considered a DCE
  - This requires placing a clocking signal – use the clock rate command.
  - Example:
    - -R1(config)#interface serial 0/0
    - -R1(config-if)#clockrate 64000
  - Serial Interfaces require a clock signal to control the timing of the communcations.

Routing Table and CDP Protocol

- **Purpose of the debug ip routing command**
  - Allows you to view changes that the router performs when adding or removing routes
  - Example:
    - -R2#debug ip routing
    - -IP routing debugging is on

Routing Table and CDP Protocol

- To **configure an Ethernet interface**
  - Example:
    - -R2(config)#interface fastethernet 0/0
    - -R2(config-if)#ip address 172.16.1.1 255.255.255.0
    - -R2(config-if)#no shutdown

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R1#show ip route
Codes: C - connected, S - static, I - IGRP, R - RIP, M - mobile, B - BGP
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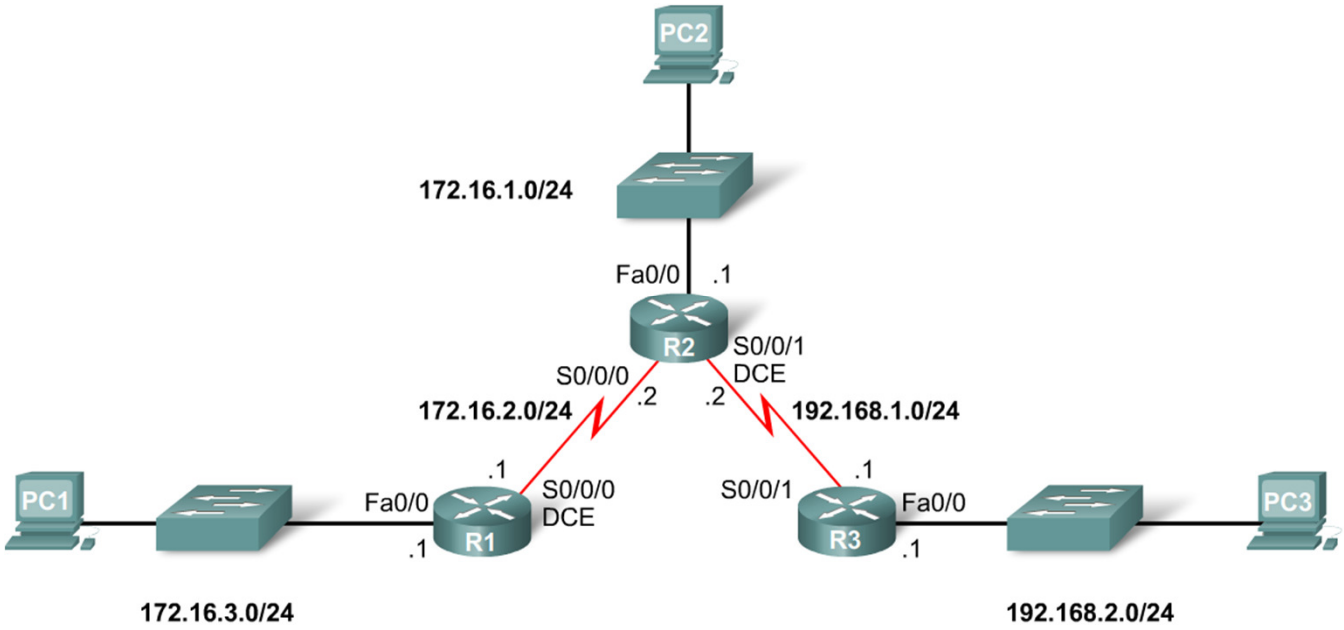
       i - IS-IS, L1 - IS-IS level-1, L2 - IS-IS level-2, ia - IS-IS inter area
       * - candidate default, U - per-user static route, o - ODR
       P - periodic downloaded static route

Gateway of last resort is not set

R1#
```

Routing Table and CDP Protocol

- When a router only has its interfaces configured & no other routing protocols are configured then:
  - -The routing table contains only the directly connected networks
  - -Only devices on the directly connected networks are reachable



Routing Table and CDP Protocol

Summary of interface status with `show ip interface brief`

```
R1#show ip interface brief
Interface                  IP-Address      OK? Method Status                Protocol
FastEthernet0/0            unassigned      YES manual administratively down down
Serial0/0/0                unassigned      YES unset  administratively down down
FastEthernet0/1            unassigned      YES unset  administratively down down
Serial0/0/1                unassigned      YES unset  administratively down down
```

Routing table has no routes

```
R1#show ip route
Codes: C - connected, S - static, I - IGRP, R - RIP, M - mobile, B - BGP
       D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
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       P - periodic downloaded static route

Gateway of last resort is not set

R1#
```

```
R1#show running-config
!
version 12.3
!
hostname R1
!
!
enable secret 5 $1$.3RO$VLUOdBF2OqNBn0EjQBvR./
!
!
interface FastEthernet0/0
 mac-address 000c.3010.9260
 no ip address
 duplex auto
 speed auto
 shutdown
!
interface FastEthernet0/1
```

```
R2(config)#interface serial 0/0/1
R2(config-if)#ip address 192.168.1.2 255.255.255.0
R2(config-if)#clock rate 64000
R2(config-if)#no shutdown
```

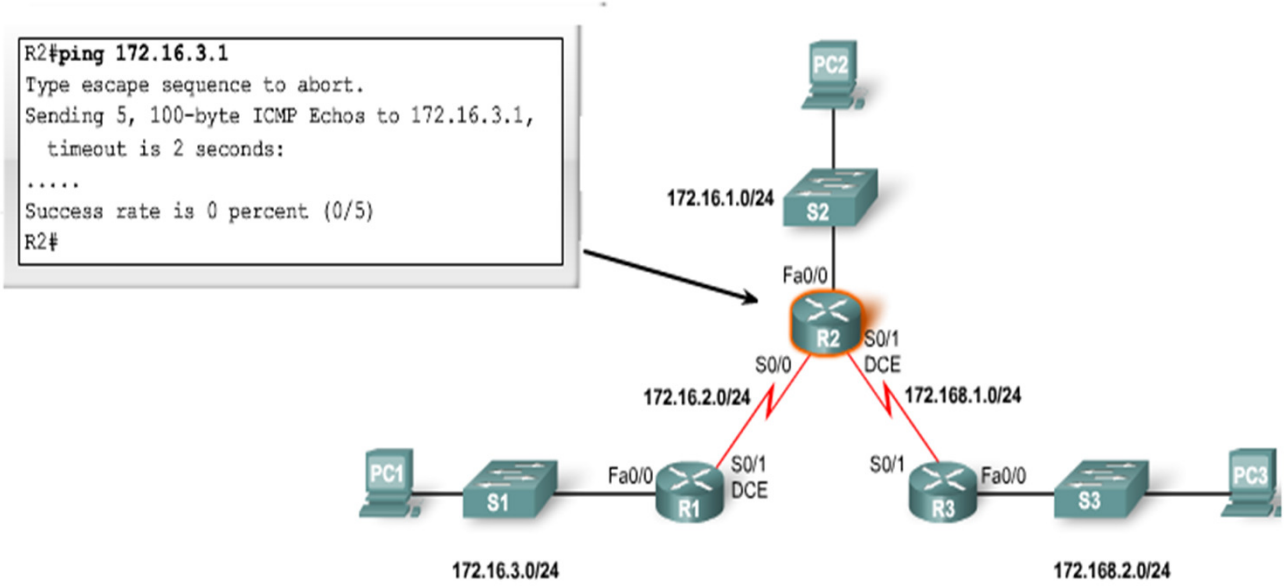
```
R3(config)#interface fastethernet 0/0
R3(config-if)#ip address 192.168.2.1 255.255.255.0
R3(config-if)#no shutdown
R3(config-if)#interface serial 0/0/1
R3(config-if)#ip address 192.168.1.1 255.255.255.0
R3(config-if)#no shutdown
```

Routing Table and CDP Protocol

- Checking each route in turn

  The ping command is used to check end to end connectivity

```
R2#ping 172.16.3.1
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 172.16.3.1,
  timeout is 2 seconds:
.....
Success rate is 0 percent (0/5)
R2#
```




```
R2#show ip route
<output omitted>
     172.16.0.0/24 is subnetted, 2 subnets
C    172.16.1.0 is directly connected, FastEthernet0/0
C    172.16.2.0 is directly connected, Serial0/0
C    192.168.1.0/24 is directly connected, Serial0/1
R2#
```

Destination IP Address	172.16.3.1	0101100.00010000.00000011.00000001	No Match
First route in routing table	172.16.1.0	10101100.00010000.00000001.00000000	
Destination IP Address	172.16.3.1	10101100.00010000.00000011.00000001	No Match
Second route in routing table	172.16.1.0	10101100.00010000.00000001.00000000	
Destination IP Address	172.16.3.1	10101100.00010000.00000011.00000001	No Match
Third route in routing table	172.16.1.0	10101100.00010000.00000001.00000000	

Routing Table and CDP Protocol

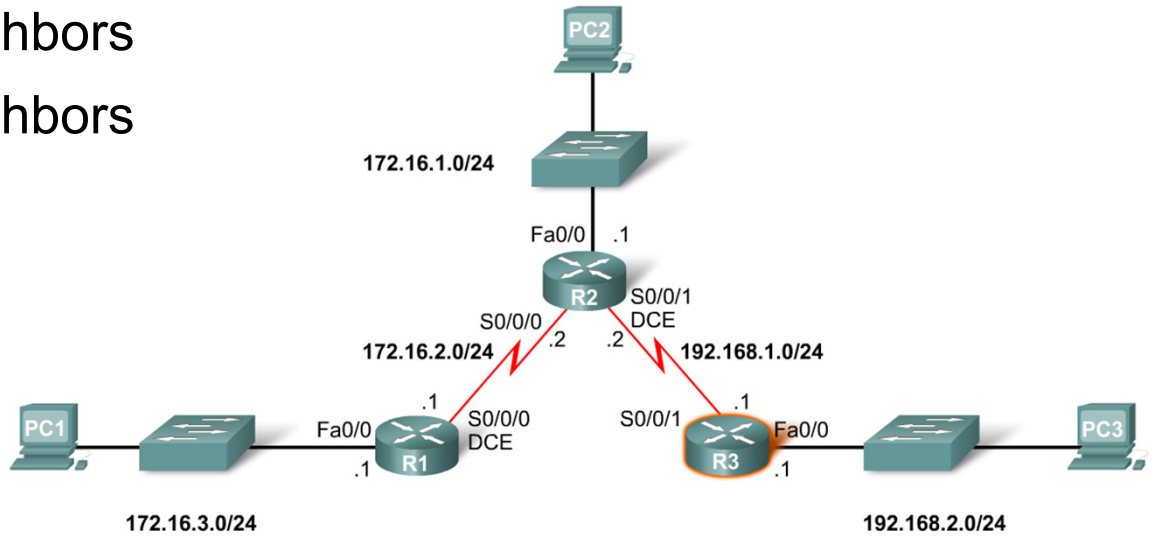
- **Purpose of CDP**

  A layer 2 cisco proprietary tool used to gather information about other directly connected Cisco devices.

- Concept of neighbors

  -2 types of neighbors

  - Layer 3 neighbors
  - Layer 2 neighbors



Routing Table and CDP Protocol

- CDP show commands
  - Show cdp neighbors command
    - -Displays the following information:
      - Neighbor device ID
      - Local interface
      - Holdtime value, in seconds
      - Neighbor device capability code
      - Neighbor hardware platform
      - Neighbor remote port ID
  - Show cdp neighbors detail command
    - -Useful in determining if an IP address configuration error

Routing Table and CDP Protocol

- Disabling CDP

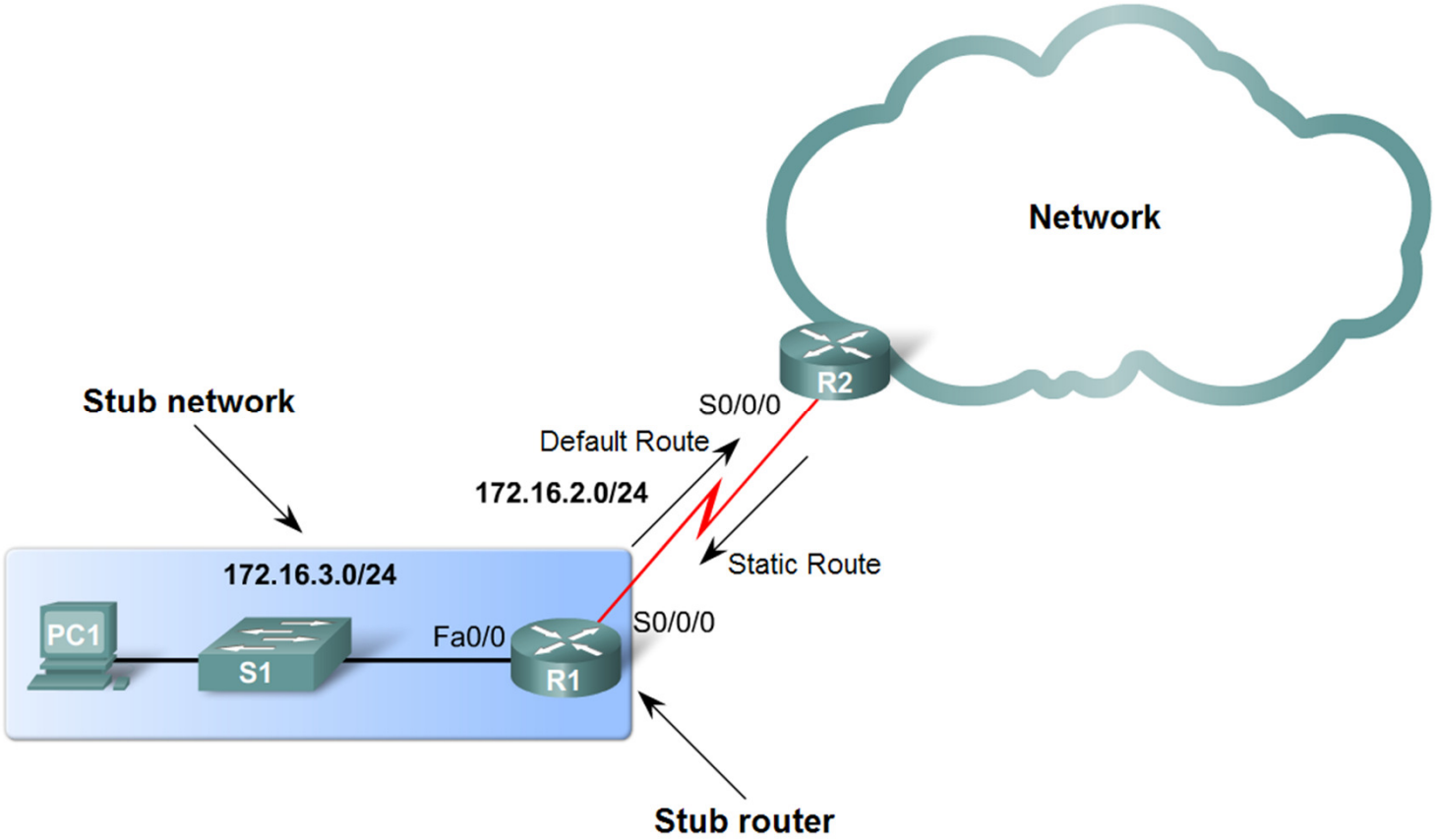
  To disable CDP globally use the following command

  Router(config)#no cdp run

Static Routes with Exit Interfaces

- **Purpose of a static route**

  A manually configured route used when routing from a network to a stub network



Static Routes with Exit Interfaces

- **IP route command**
  - To configure a static route use the following command: ip route
  - Example:

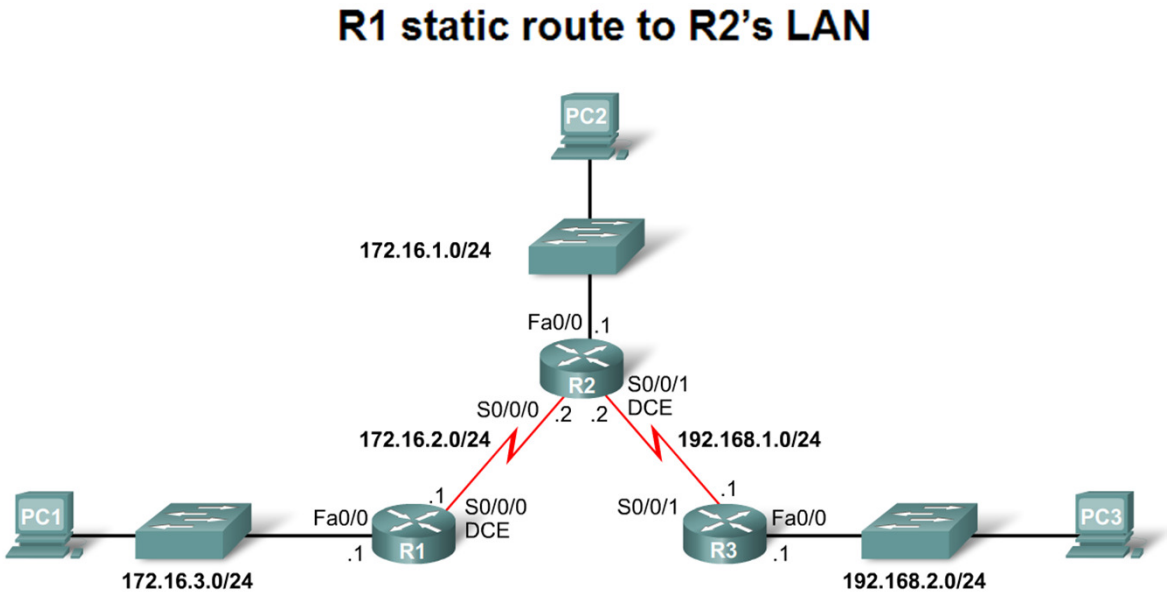
-Router(config)# ip route network-address subnet-mask {ip-address | exit-interface }

```
Router(config)# ip route network-address subnet-mask
{ip-address | exit-interface }
```

Parameter	Description
network-address	Destination network address of the remote network to be added to the routing table.
subnet-mask	Subnet mask of the remote network to be added to the routing table. The subnet mask can be modified to summarize a group of networks.
ip-address	Commonly referred to as the next-hop router's IP address.
exit-interface	Outgoing interface that is used to forward packets to the destination network.

Static Routes with Exit Interfaces

- **Dissecting static route syntax**
  - ip route - Static route command
  - 172.16.1.0 – Destination network address
  - 255.255.255.0 - Subnet mask of destination network
  - 172.16.2.2 - Serial 0/0/0 interface IP address on R2, which is the "next-hop" to this network



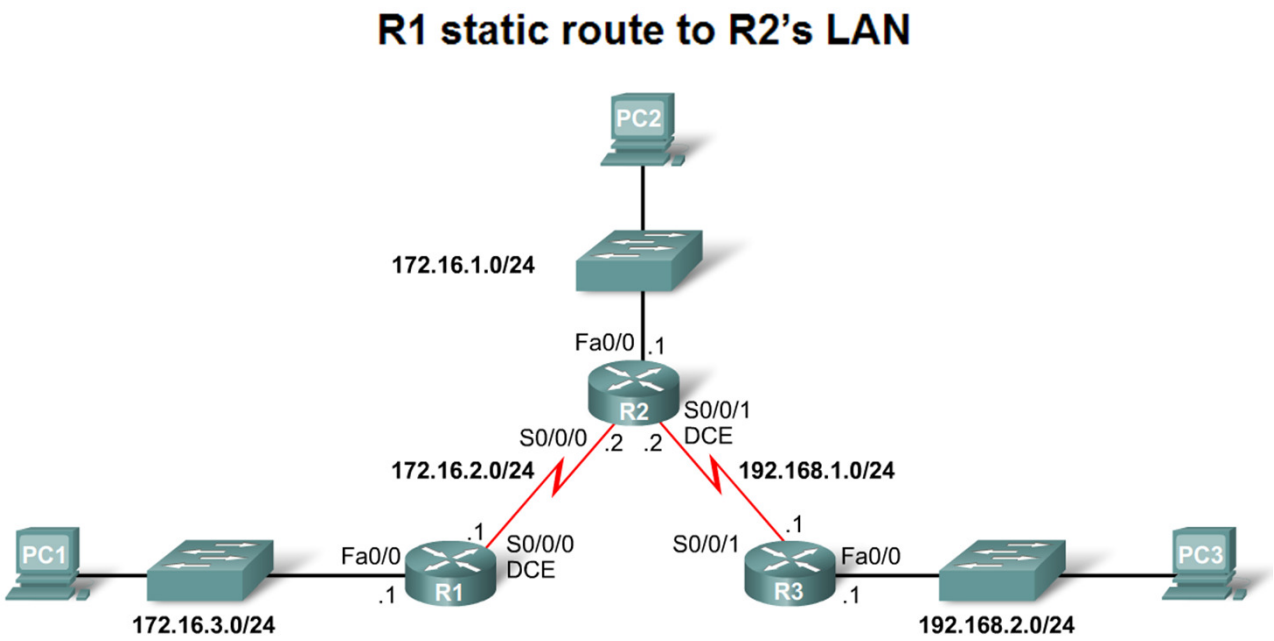
Static Routes with Exit Interfaces

- **Configuring routes to 2 or more remote networks**

  Use the following commands for R1

  -R1(config)#ip route 192.168.1.0 255.255.255.0 172.16.2.2

  -R1(config)#ip route 192.168.2.0 255.255.255.0 172.16.2.2



Static Routes with Exit Interfaces

- **Zinin's 3 routing principles**
  - **Principle 1**: "Every router makes its decision alone, based on the information it has in its own routing table."
  - **Principle 2**: "The fact that one router has certain information in its routing table does not mean that other routers have the same information."
  - **Principle 3**: "Routing information about a path from one network to another does not provide routing information about the reverse, or return path."

Static Routes with Exit Interfaces

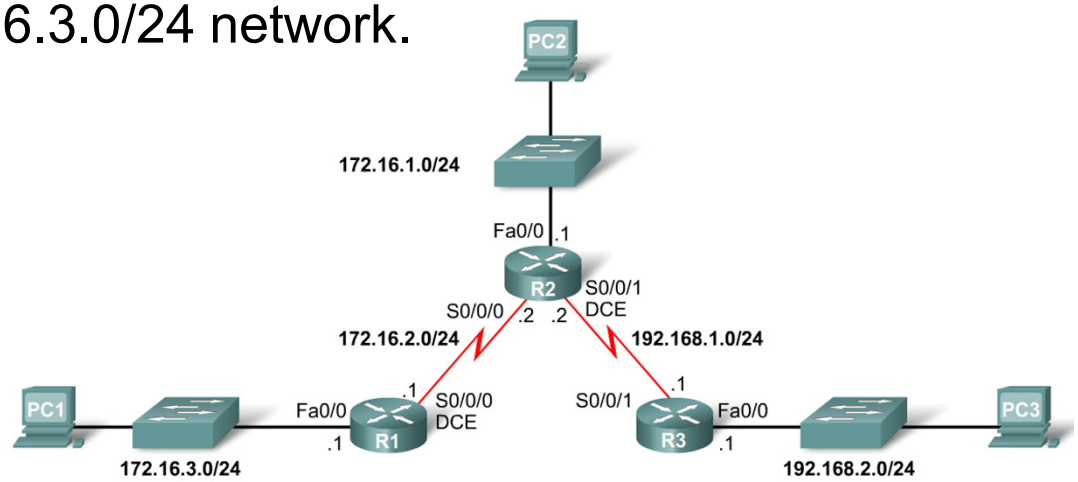
- Using Zinin's 3 routing principles, how would you answer the following?

  -Would packets from PC1 reach their destination?

  Yes, packets destined for 172.16.1.0/24 and 192.168.1.0/24 networks would reach their destination.

  -Does this mean that any packets from these networks destined for 172.16.3.0/24 network will reach their destination?

  No, because neither R2 nor R3 router has a route to the 172.16.3.0/24 network.



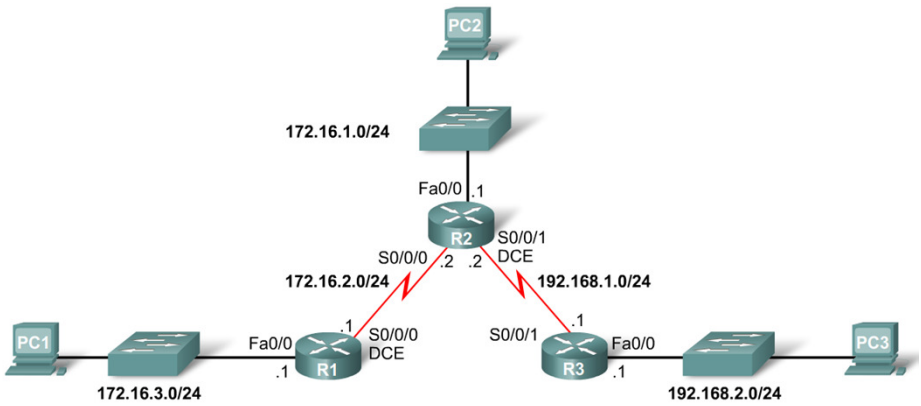
Static Routes with Exit Interfaces

- **Resolving to an Exit Interface**

  -**Recursive route lookup** - Occurs when the router has to perform multiple lookups in the routing table before forwarding a packet. A static route that forwards all packets to the next-hop IP address goes through the following process (reclusive route lookup)

  - The router first must match static route's destination IP address with the Next hop address
  - The next hop address is then matched to an exit interface

R1 does a recursive lookup



Static Routes with Exit Interfaces

- Configuring a Static route with an Exit Interface

-Static routes configured with an exit interface are more efficient because the routing

–The routing table can resolve the exit interface in a single search instead of 2 searches

-Example of syntax require to configure a static route with an exit interface

R1 routes depend on exit interface

```
R1#debug ip routing
IP routing debugging is on
R1#config t
Enter configuration commands, one per line.  End with CNTL/Z.
R1(config)#int s0/0/0
R1(config-if)#shutdown
R1(config-if)#end

is_up: 0 state: 6 sub state: 1 line: 0
RT: interface Serial0/0/0 removed from routing table
RT: del 172.16.2.0/24 via 0.0.0.0, connected metric [0/0]
RT: delete subnet route to 172.16.2.0/24
RT: del 192.168.1.0 via 172.16.2.2, static metric [1/0]
RT: delete network route to 192.168.1.0
RT: del 172.16.1.0/24 via 172.16.2.2, static metric [1/0]
RT: delete subnet route to 172.16.1.0/24

R1#show ip route
<output omitted>
```

Four routes are removed.
Only one route is left in the table.

Static Routes with Exit Interfaces

- **Modifying Static routes**
  - Existing static routes cannot be modified. The old static route must be deleted by placing **no** in front of the **ip route**
  - Example:
    - -no ip route 192.168.2.0 255.255.255.0 172.16.2.2
  - A **new static route** must be rewritten in the configuration

```
R1(config)#no ip route 172.16.1.0 255.255.255.0 172.16.2.2
R1(config)#ip route 172.16.1.0 255.255.255.0 serial 0/0/0
R1(config)#no ip route 192.168.1.0 255.255.255.0 172.16.2.2
R1(config)#ip route 192.168.1.0 255.255.255.0 serial 0/0/0
```

```
R2(config)#no ip route 172.16.3.0 255.255.255.0 172.16.2.1
R2(config)#ip route 172.16.3.0 255.255.255.0 serial 0/0/0
R2(config)#no ip route 192.168.2.0 255.255.255.0 192.168.1.1
R2(config)#ip route 192.168.2.0 255.255.255.0 serial 0/0/1
```

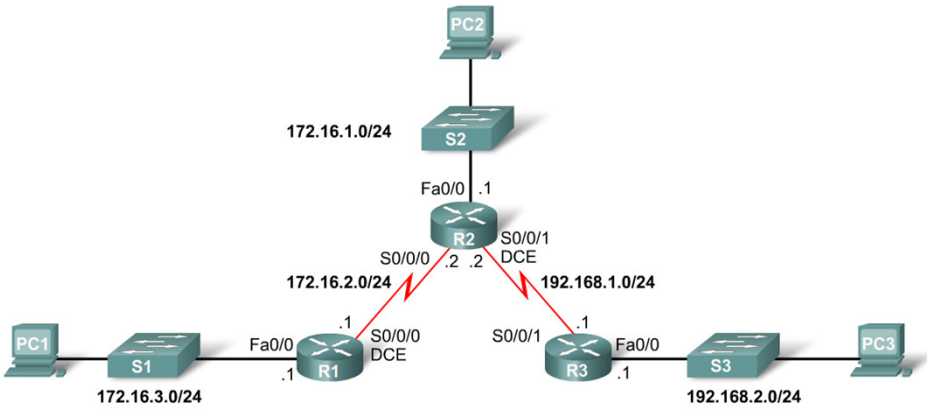
```
R3(config)#no ip route 172.16.1.0 255.255.255.0 192.168.1.2
R3(config)#ip route 172.16.1.0 255.255.255.0 serial 0/0/1
R3(config)#no ip route 172.16.2.0 255.255.255.0 192.168.1.2
R3(config)#ip route 172.16.2.0 255.255.255.0 serial 0/0/1
R3(config)#no ip route 172.16.3.0 255.255.255.0 192.168.1.2
R3(config)#ip route 172.16.3.0 255.255.255.0 serial 0/0/1
```

Static Routes with Exit Interfaces

- **Verifying the Static Route Configuration**

-Use the following commands

- Step 1 show running-config
- Step 2 verify static route has been entered correctly
- Step 3 show ip route
- Step 4 verify route was configured in routing table
- Step 5 issue ping command to verify packets can reach destination and that Return path is working



Static Routes with Exit Interfaces

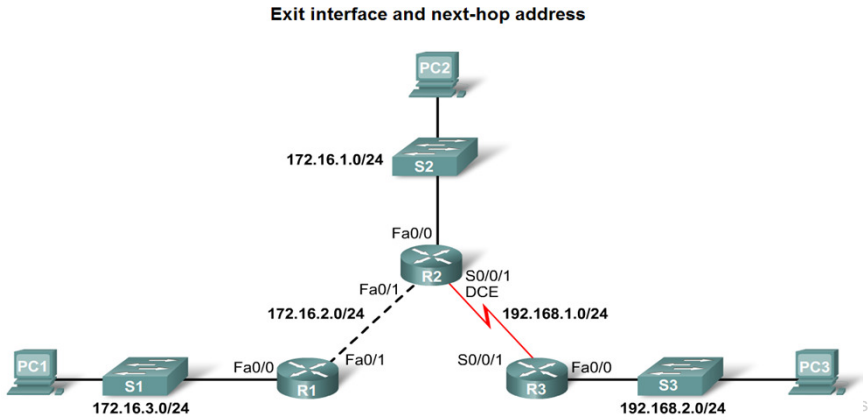
- **Ethernet interfaces and ARP.**
  - **If a static route is configured on an Ethernet link**

-If the packet is sent to the next-hop router then…

the destination MAC address will be the address of the next hop's Ethernet interface

This is found by the router consulting the ARP table.

If an entry isn't found then an ARP request will be sent out



Summary and Default Route

- **Summarizing routes** reduces the size of the routing table.
- **Route summarization** is the process of combining a number of static routes into a single static route.

Summary and Default Route

- **Configuring a summary route**

  Step 1: Delete the current static route

  Step 2: Configure the summary static route

  Step 3: Verify the new static route

```
R3#show ip route
<output omitted>

Gateway of last resort is not set

 172.16.0.0/24 is subnetted, 3 subnets
S       172.16.1.0 is directly connected, Serial0/0/1
S       172.16.2.0 is directly connected, Serial0/0/1
S       172.16.3.0 is directly connected, Serial0/0/1
C    192.168.1.0/24 is directly connected, Serial0/0/1
C    192.168.2.0/24 is directly connected, FastEthernet0/0
```

```
R3#show ip route
<output omitted>

Gateway of last resort is not set

     172.16.0.0/22 is subnetted, 1 subnets
S       172.16.0.0 is directly connected, Serial0/0/1
C    192.168.1.0/24 is directly connected, Serial0/1
C    192.168.2.0/24 is directly connected, FastEthernet0/0
```

```
R3#ping 172.16.1.1

Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 172.16.1.1, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 28/29/32 ms
R3#ping 172.16.2.1

Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 172.16.2.1, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 56/56/60 ms
R3#ping 172.16.3.1

Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 172.16.3.1, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 56/56/60 ms
R3#
```

Summary and Default Route

- **Default Static Route**
  - This is a route that will match all packets. Stub routers that have a number of static routes all exiting the same interface are good candidates for a default route.
    - -Like route summarization this will help reduce the size of the routing table
- **Configuring a default static route**
  - Similar to configuring a static route. Except that destination IP address and subnet mask are all zeros
  - Example:
    - -Router(config)#ip route 0.0.0.0 0.0.0.0 [exit-interface | ip-address]

Summary and Default Route

- **Static routes and subnet masks**

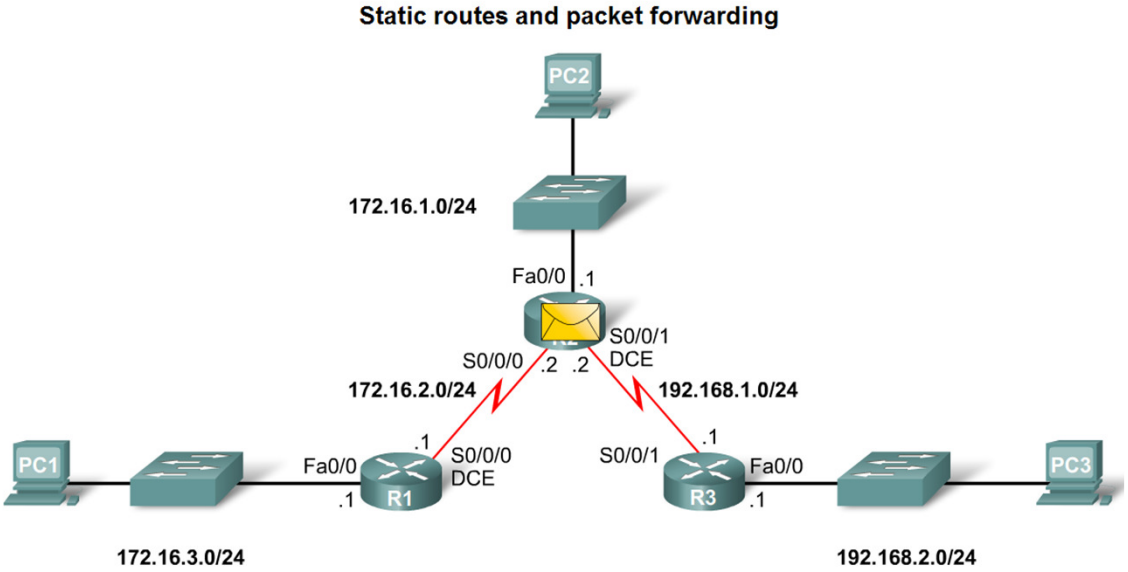
  The routing table lookup process will use the most specific match when comparing destination IP address and subnet mask

- **Default static routes and subnet masks**

  Since the subnet mask used on a default static route is 0.0.0.0 all packets will match.

Static Routes and Packet Forwarding

- Packet forwarding with static routes. (recall Zinin's 3 routing principles)
- Router 1
  - Packet arrives on R1's Fastethernet 0/0 interface
    - R1 does not have a route to the destination network, 192.168.2.0/24
      - R1 uses the default static route.



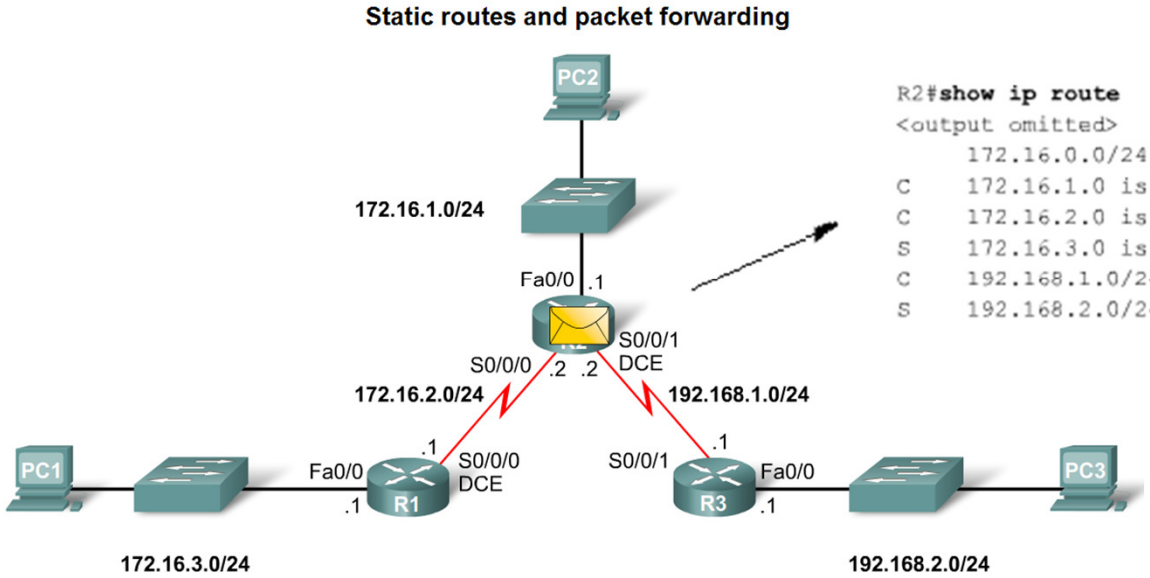

```
R1#show ip route
<output omitted>
     172.16.0.0/24 is subnetted, 2 subnets
C    172.16.2.0 is directly connected, Serial0/0
C    172.16.3.0 is directly connected, FastEthernet0/0
S*   0.0.0.0/0 is directly connected, Serial0/0
```

Static Routes and Packet Forwarding

- Packet forwarding with static routes. (recall Zinin's 3 routing principles)
- Router 2

  The packet arrives on the Serial 0/0/0 interface on R2.

  R2 has a static route to 192.168.2.0/24 out Serial0/0/1.



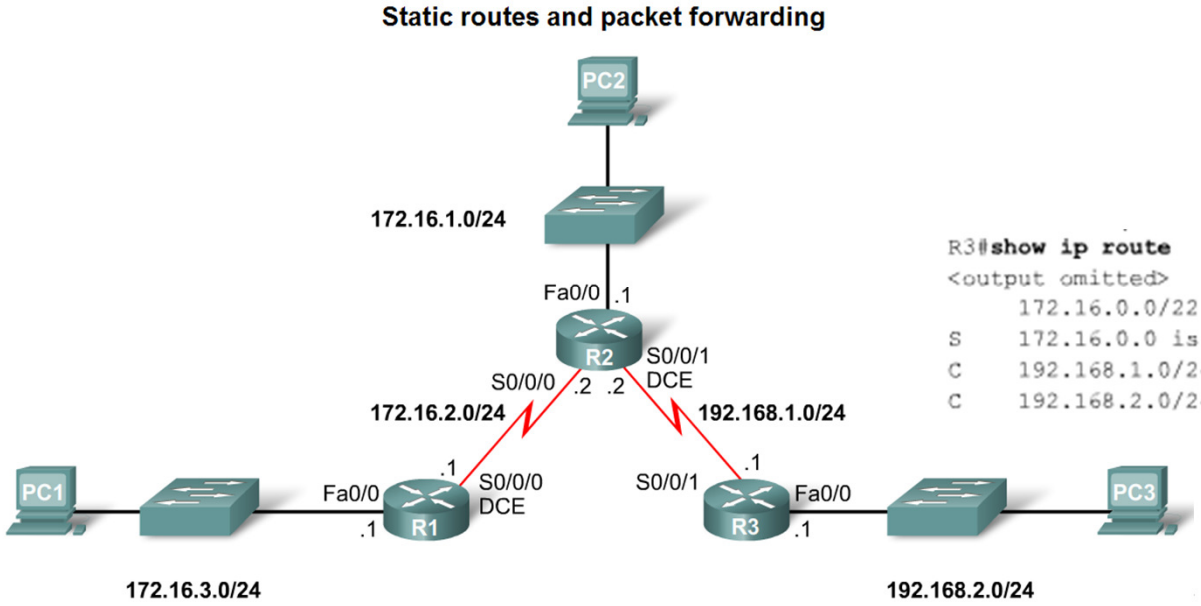

```
R2#show ip route
<output omitted>
     172.16.0.0/24 is subnetted, 3 subnets
C    172.16.1.0 is directly connected, FastEthernet0/0
C    172.16.2.0 is directly connected, Serial0/0
S    172.16.3.0 is directly connected, Serial0/0
C    192.168.1.0/24 is directly connected, Serial0/1
S    192.168.2.0/24 is directly connected, Serial0/1
```

Static Routes and Packet Forwarding

- Packet forwarding with static routes. (recall Zinin's 3 routing principles)
- Router 3

  The packet arrives on the Serial0/0/1 interface on R3.

  R3 has a connected route to 192.168.2.0/24 out Fastethernet 0/1.




```
R3#show ip route
<output omitted>
     172.16.0.0/22 is subnetted, 1 subnets
S    172.16.0.0 is directly connected, Serial0/1
C    192.168.1.0/24 is directly connected, Serial0/1
C    192.168.2.0/24 is directly connected, FastEthernet0/0
```

Static Routes and Packet Forwarding

- Troubleshooting a Missing Route
- Tools that can be used to isolate routing problems include:

  -Ping– tests end to end connectivity

  -Traceroute– used to discover all of the hops (routers) along the path between 2 points

  -Show IP route– used to display routing table & ascertain forwarding process

  -Show ip interface brief- used to show status of router interfaces

  -Show cdp neighbors detail– used to gather configuration information about directly connected neighbors

Static Routes and Packet Forwarding

- Solving a Missing Route
- Finding a missing or mis-configured route requires methodically using the correct tools

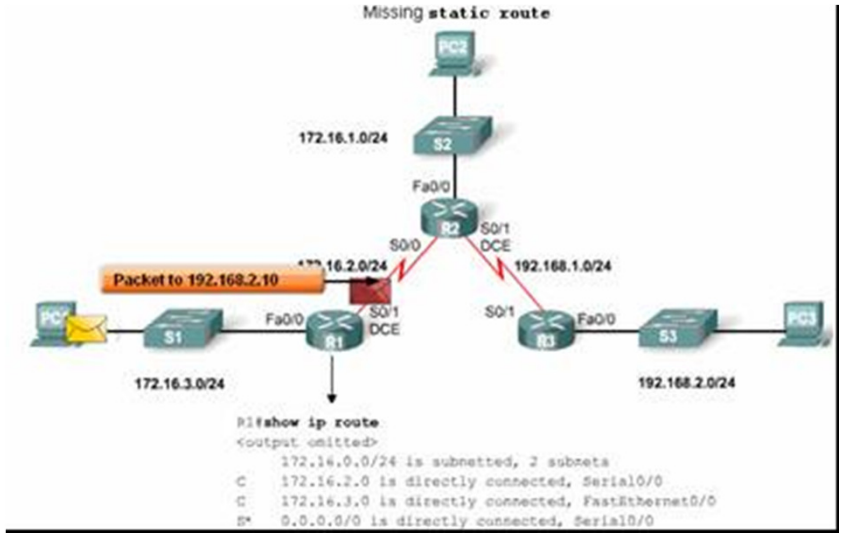
  -Start with PING. If ping fails then use traceroute to determine where packets are failing to arrive

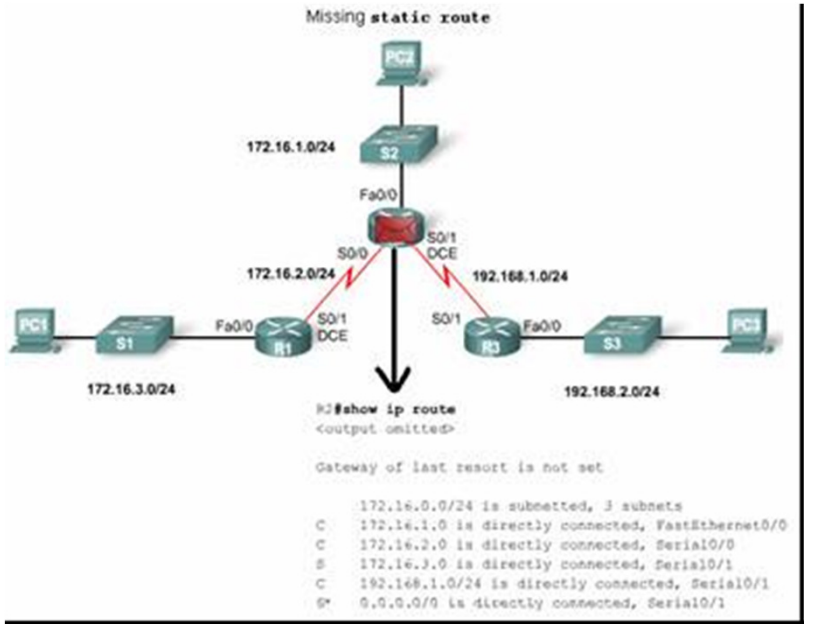
- Issue: show ip route to examine routing table.

  -If there is a problem with a mis-configured static route remove the static route then reconfigure the new static route

Static Routes and Packet Forwarding

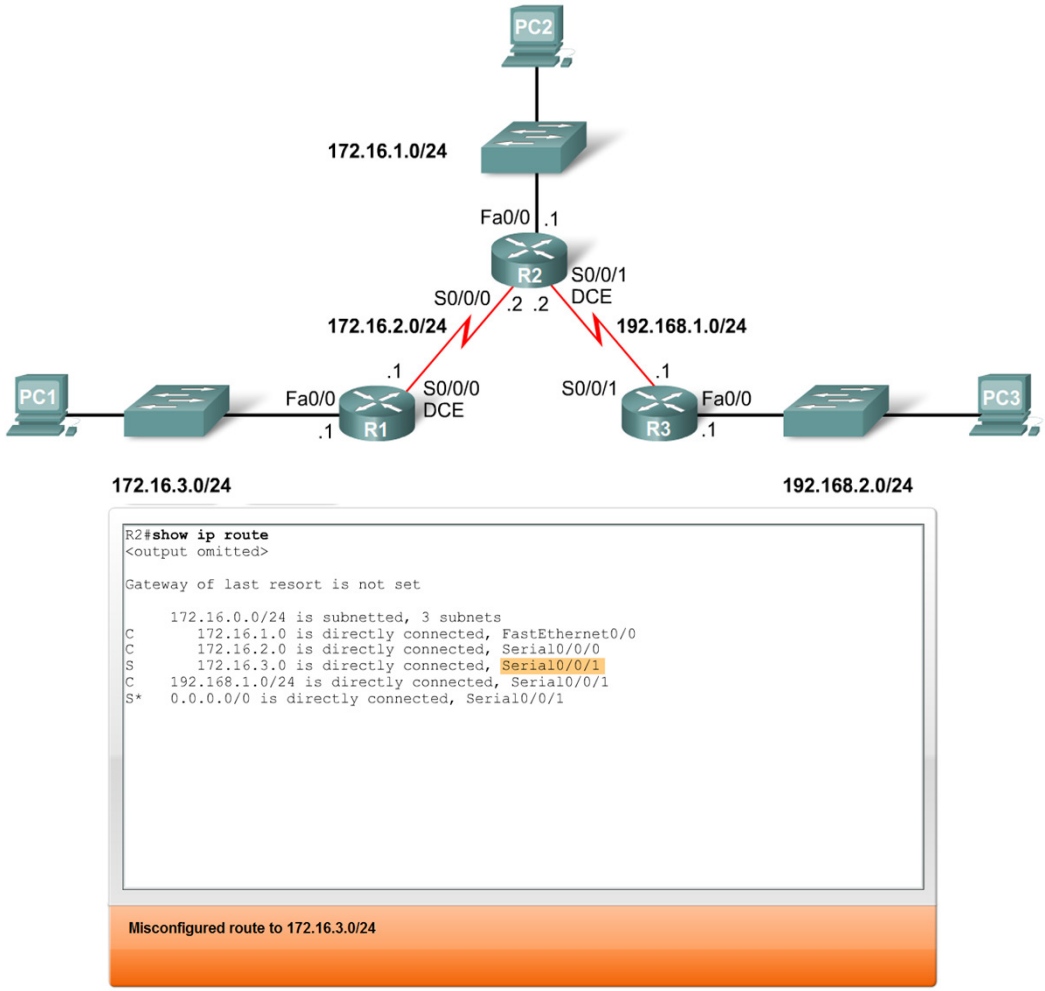
- Solving a Missing Route

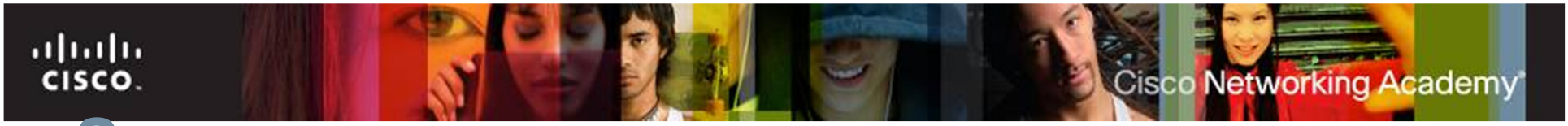




Static Routes and Packet Forwarding

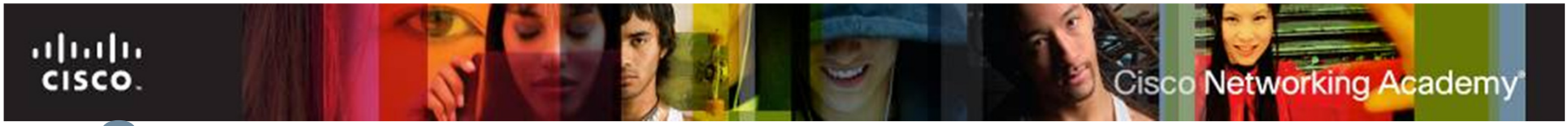
- Solving a Missing Route





Summary

- **Routers**
  - -Operate at layer 3
  - -Functions include best path selection & forwarding packets
- **Connecting Networks**
  - **WANs**
    - Serial cables are connected to router serial ports.
    - In the lab environment clock rates must be configured for DCE
  - **LANs**
    - Straight through cables or cross over cables are used to connect to fastethernet port. (The type of cable used depends on what devices are being connected)
- **Cisco Discovery Protocol**
  - A layer 2 proprietary protocol
  - Used to discover information about directly connected Cisco devices



Summary

- **Static Routes**

  -This is a manually configured path that specifies how the router will get to a certain point using a certain path.

- **Summary static routes**

  -This is several static routes that have been condensed into a single static route.

- **Default route**

  -It is the route packets use if there is no other possible match for their destination in the routing table.

- **Forwarding of packets when static route is used**

  -Zinin's 3 routing principles describe how packets are forwarded

- **Troubleshooting static routes** may require some of the following commands:

  -Ping

  -Traceroute

  -Show IP route

  -Show ip interface brief

  -Show cdp neighbors detail