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Network Layer: IPv4 Static Routing

Lecture 10 | CSE421 – Computer Networks

Department of Computer Science and Engineering
School of Data & Science

Objectives

- Routing
  - Static Routing
    - Standard Static Routing
      - Directly attached/connected
      - Next Hop/Recursive
      - Fully Specified
    - Summary Static Routing
    - Default Static Routing

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Learning About Networks

A router can learn about remote networks in one of two ways:

- Manually - Remote networks are manually entered into the route table using static routes.
- Dynamically - Remote networks are automatically learned using a dynamic routing protocol.

Static Route

- A static route is created, maintained, and updated by a network administrator, manually.
- A static route to every network must be configured on every router for full connectivity.

Learning About Networks

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Table of R1

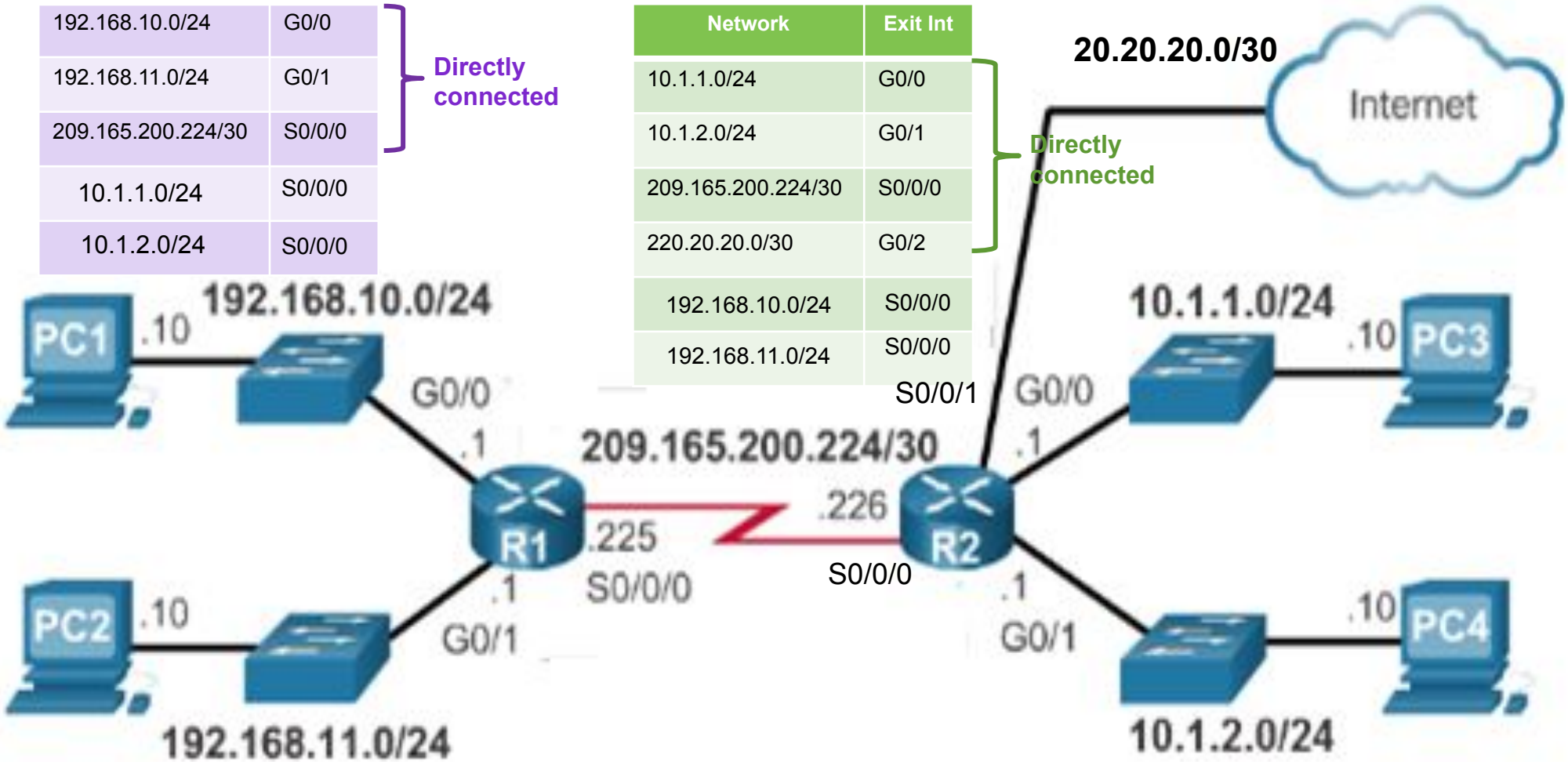
Network	Exit Int
192.168.10.0/24	G0/0
192.168.11.0/24	G0/1
209.165.200.224/30	S0/0/0
10.1.1.0/24	S0/0/0
10.1.2.0/24	S0/0/0

Directly connected

Table of R2

Network	Exit Int
10.1.1.0/24	G0/0
10.1.2.0/24	G0/1
209.165.200.224/30	S0/0/0
220.20.20.0/30	G0/2
192.168.10.0/24	S0/0/0
192.168.11.0/24	S0/0/0

Directly connected



Static Route Advantages

Static routing provides some advantages over dynamic routing, including:

- Static routes are not advertised over the network, resulting in better security.
- Routers not share static routes with each other, thus reducing CPU/RAM overhead and saving bandwidth.

Static Route Disadvantages

Static routing has the following disadvantages:

- Initial configuration and maintenance is time-consuming.
- Configuration is error-prone, especially in large networks.
- Administrator intervention is required to maintain changing route information.
- Does not scale well with growing networks; maintenance becomes cumbersome.
- Requires complete knowledge of the whole network for proper implementation.

Comparison

	Dynamic Routing	Static Routing
Configuration Complexity	Generally independent of the network size	Increases with network size
Topology Changes	Automatically adapts to topology changes	Administrator intervention required
Scaling	Suitable for simple and complex topologies	Suitable for simple topologies
Security	Less secure	More secure
Resource Usage	Uses CPU, memory, link bandwith	No extra resources needed
Predictability	Route depends on the current topology	Route to destination is always the same

Static Route Applications : Types

Static Routes are often used to:

1. Connect to a specific network
2. Provide a Gateway of Last Resort for a stub network – Default Gateway
3. Summarize routing table entries
4. Create a backup route in case a primary route link fails

Standard Static Route

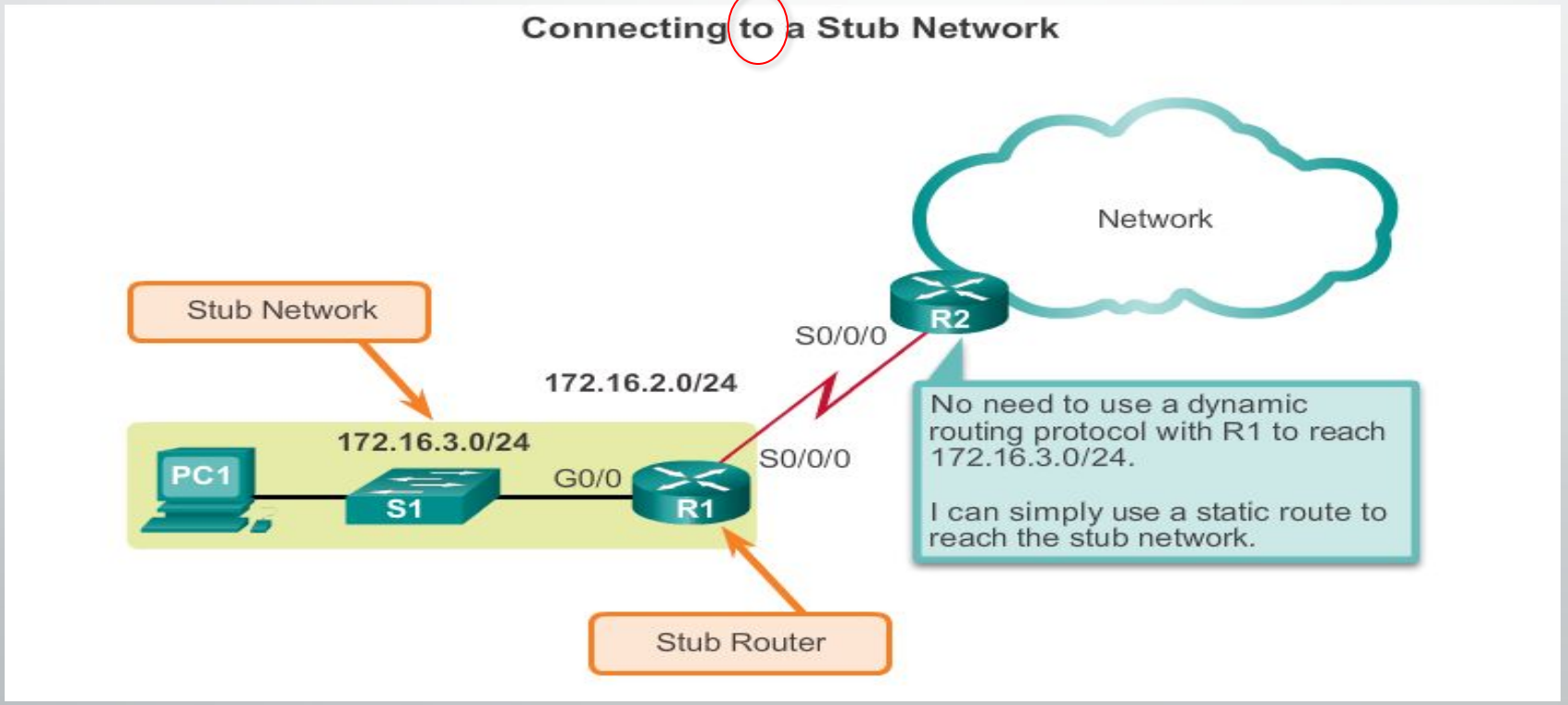
Types of Static Routes

Static Route Applications

Static Routes are often used to:

1. Connect to a specific network
2. Provide a Gateway of Last Resort for a stub network
3. Summarize routing table entries
4. Create a backup route in case a primary route link fails

Static route can be used to connect to a specific network (like for example a stub network)



ip route Command

ip route Command Syntax

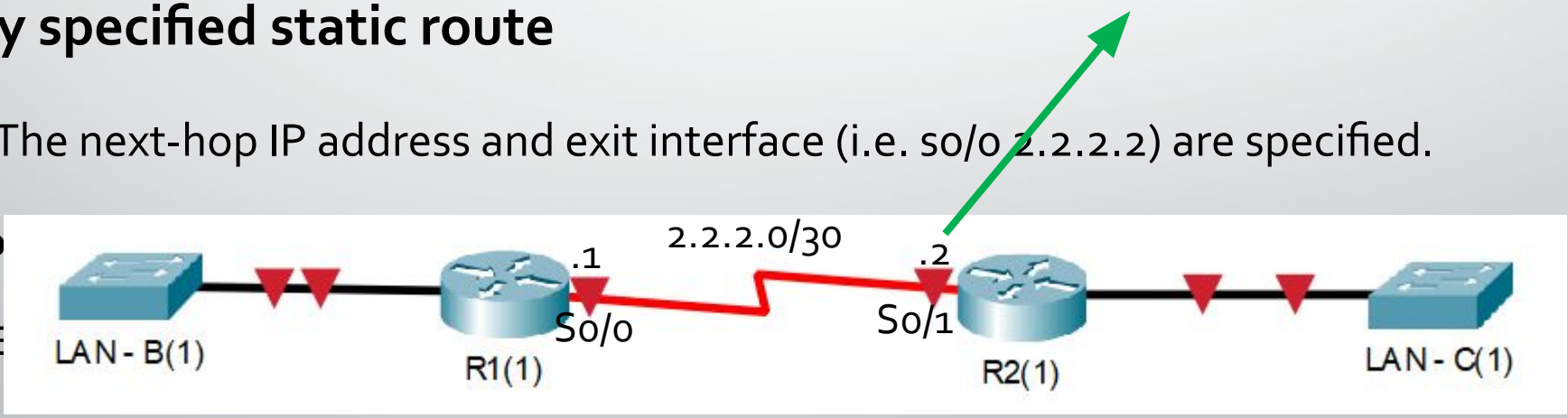
```
Router(config)#ip route network-address subnet-mask
{ip-address | exit-intf}
```

Next hop

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. • Typically used when connecting to a broadcast media (i.e., Ethernet). • Commonly creates a recursive lookup.
exit-intf	• Use the outgoing interface to forward packets to the destination network. • Also referred to as a directly attached static route. • Typically used when connecting in a point-to-point configuration.

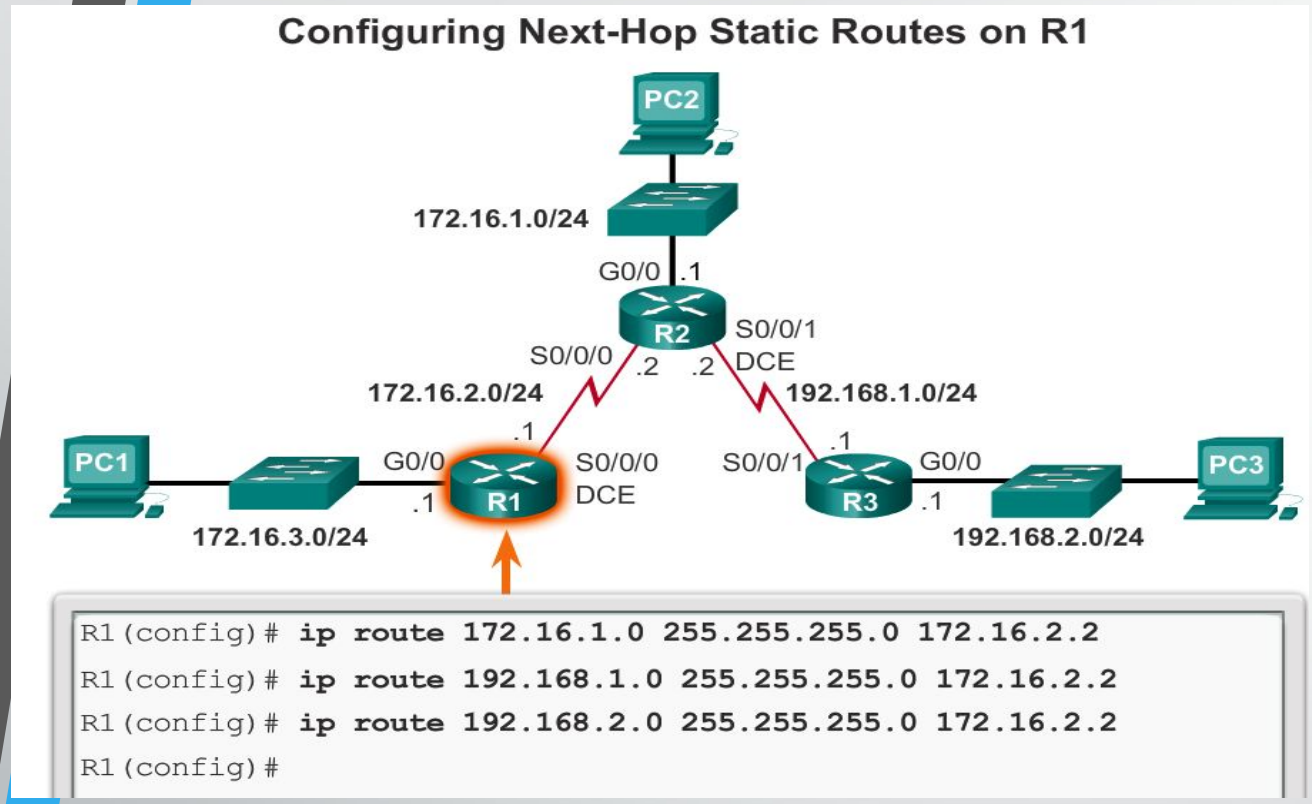
Next Hop Options

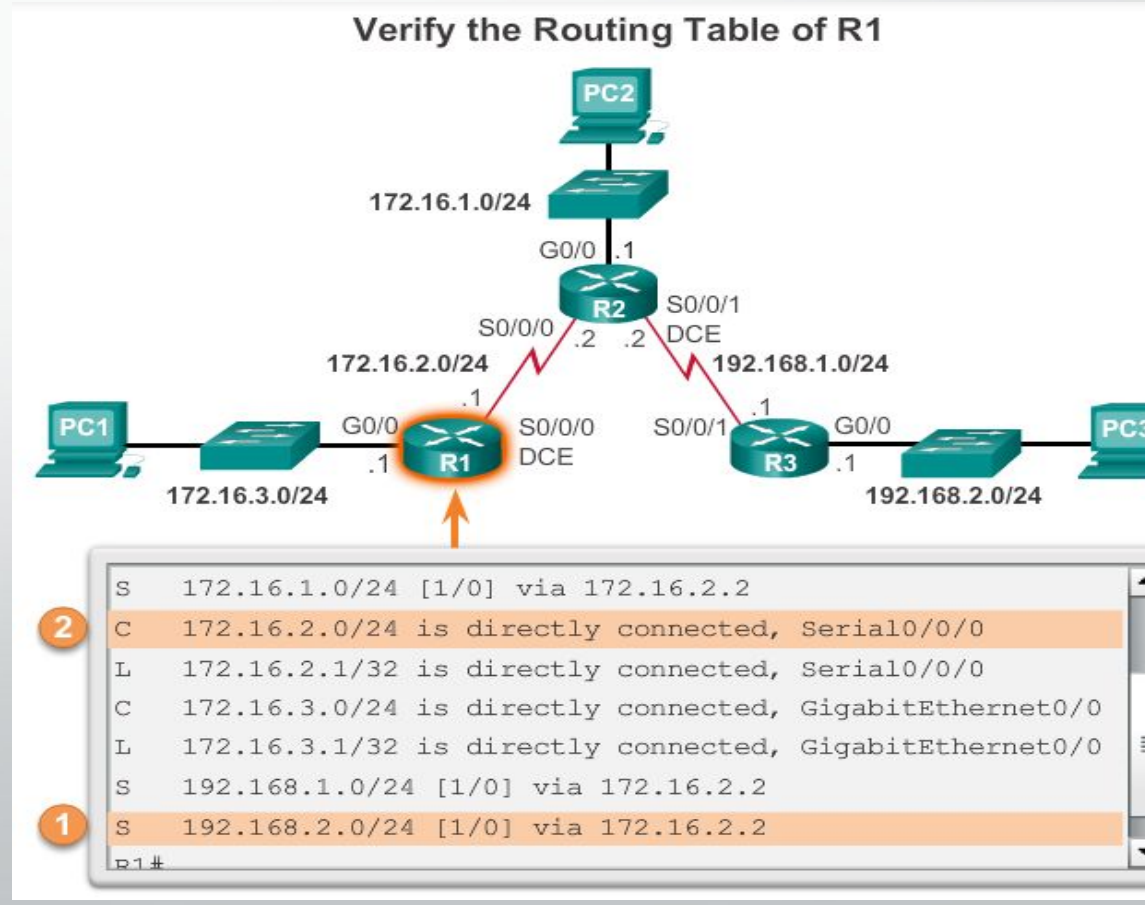
- **Directly attached/connected static route**
  - Only the router **exit interface**/port name (i.e. so/0) is specified.
- **Next-hop/Recursive lookup static route**
  - Only the next-hop IP address (i.e. 2.2.2.2) is specified.
- **Fully specified static route**
  - The next-hop IP address and exit interface (i.e. so/0 2.2.2.2) are specified.
- **No
  - E



**Configuring R1(1) towards LAN – C
***All settings are done from R1(1)'s perspective

Standard Static Route using next hop IP address

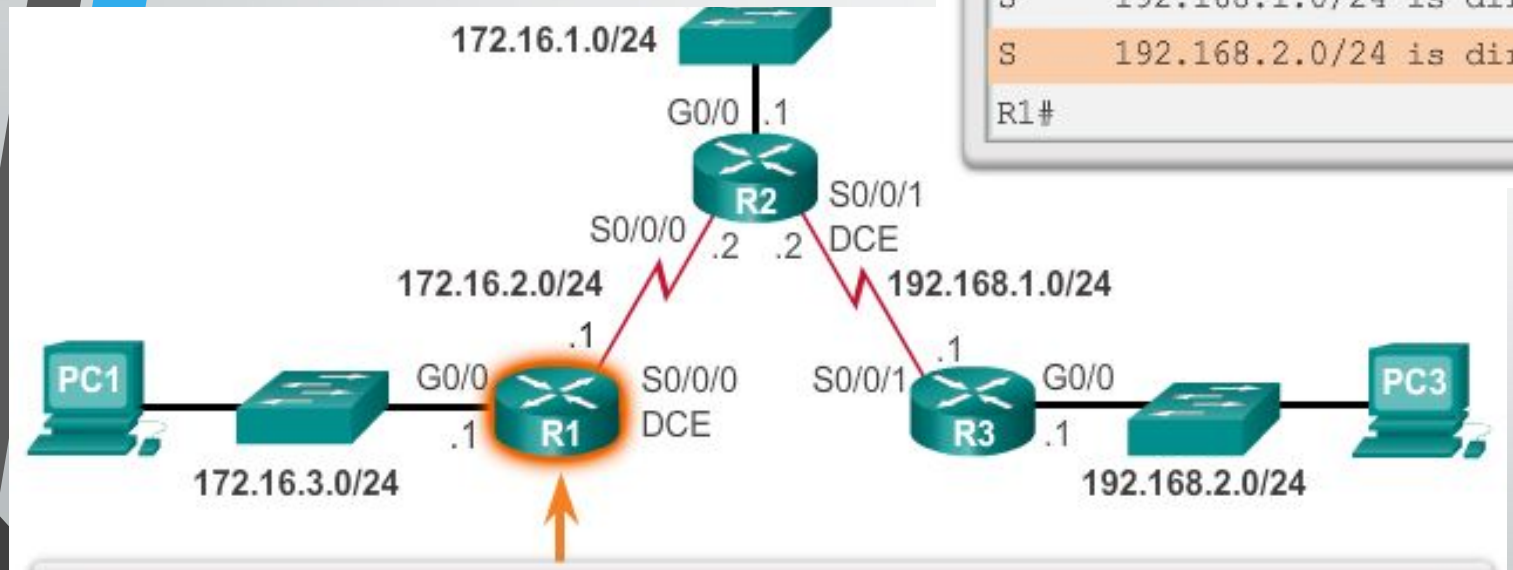




Recursive Lookup

Standard Static Route using Exit Interface

```
S        172.16.1.0/24 is directly connected, Serial0/0/0
C        172.16.2.0/24 is directly connected, Serial0/0/0
L        172.16.2.1/32 is directly connected, Serial0/0/0
C        172.16.3.0/24 is directly connected, GigabitEthernet0/0
L        172.16.3.1/32 is directly connected, GigabitEthernet0/0
S     192.168.1.0/24 is directly connected, Serial0/0/0
S     192.168.2.0/24 is directly connected, Serial0/0/0
R1#
```




```
R1(config)#ip route 172.16.1.0 255.255.255.0 s0/0/0
R1(config)#ip route 192.168.1.0 255.255.255.0 s0/0/0
R1(config)#ip route 192.168.2.0 255.255.255.0 s0/0/0
R1(config)#
```

Static Route : The line and AD explained

```
R1#show ip route
Codes: C - connected, S - Static, I - IGRP, R - RIP,

<output omitted>

Gateway of last resort is not set

     172.16.0.0/24 is subnetted, 3 subnets
S       172.16.1.0 [1/0] via 172.16.2.2
C       172.16.2.0 is directly connected, Serial0/0/0
C       172.16.3.0 is directly connected, FastEthernet0/0
```

Type of route:
S - Static

Destination Network

Administrative Distance

Cost of Path

Next Hop IP
Or, Exit Interface
Or, Fully Specified

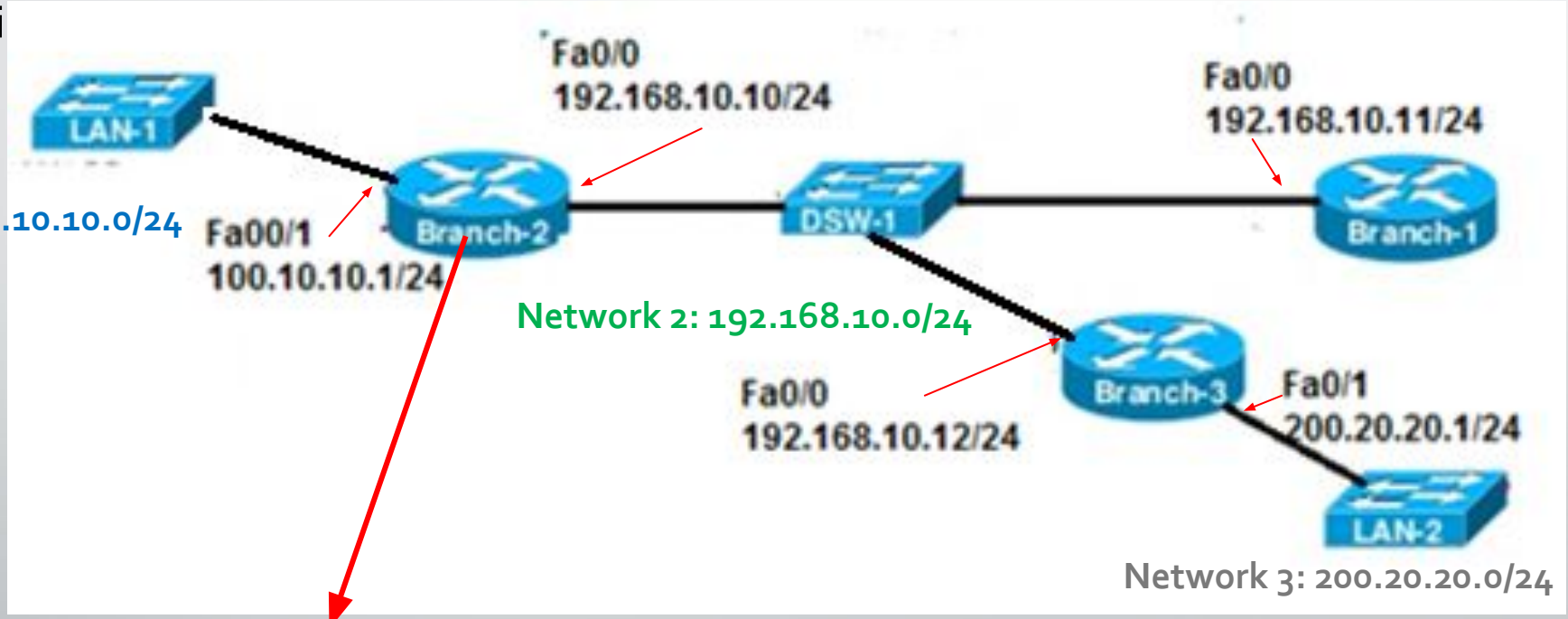
Static Routing table record if it was configured with Exit Interface

```
S     192.168.1.0/24 is directly connected, Serial0/0/0
S     192.168.2.0/24 is directly connected, Serial0/0/0
```

NOTE : AD of Static Routes is 1 and AD of Directly Connected Routes is 0

Configuring a Fully Specified Static Route

- Both the **output interface** and the **next-hop IP** address are specified.
- It's used when the output interface is a **multi-access interface** and it is necessary to explicitly identify the next hop else, the Router will have difficulty determining the desti




```
Branch-2(config)#ip route 200.20.20.0 255.255.255.0 fa0/0 192.168.10.12
```

Recommended

Types of Static Routes

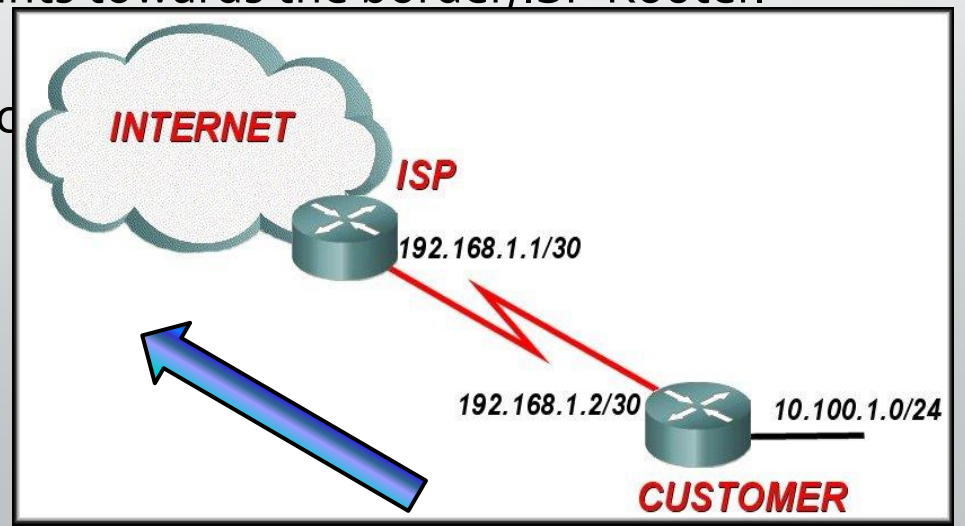
Static Route Applications

Static Routes are often used to:

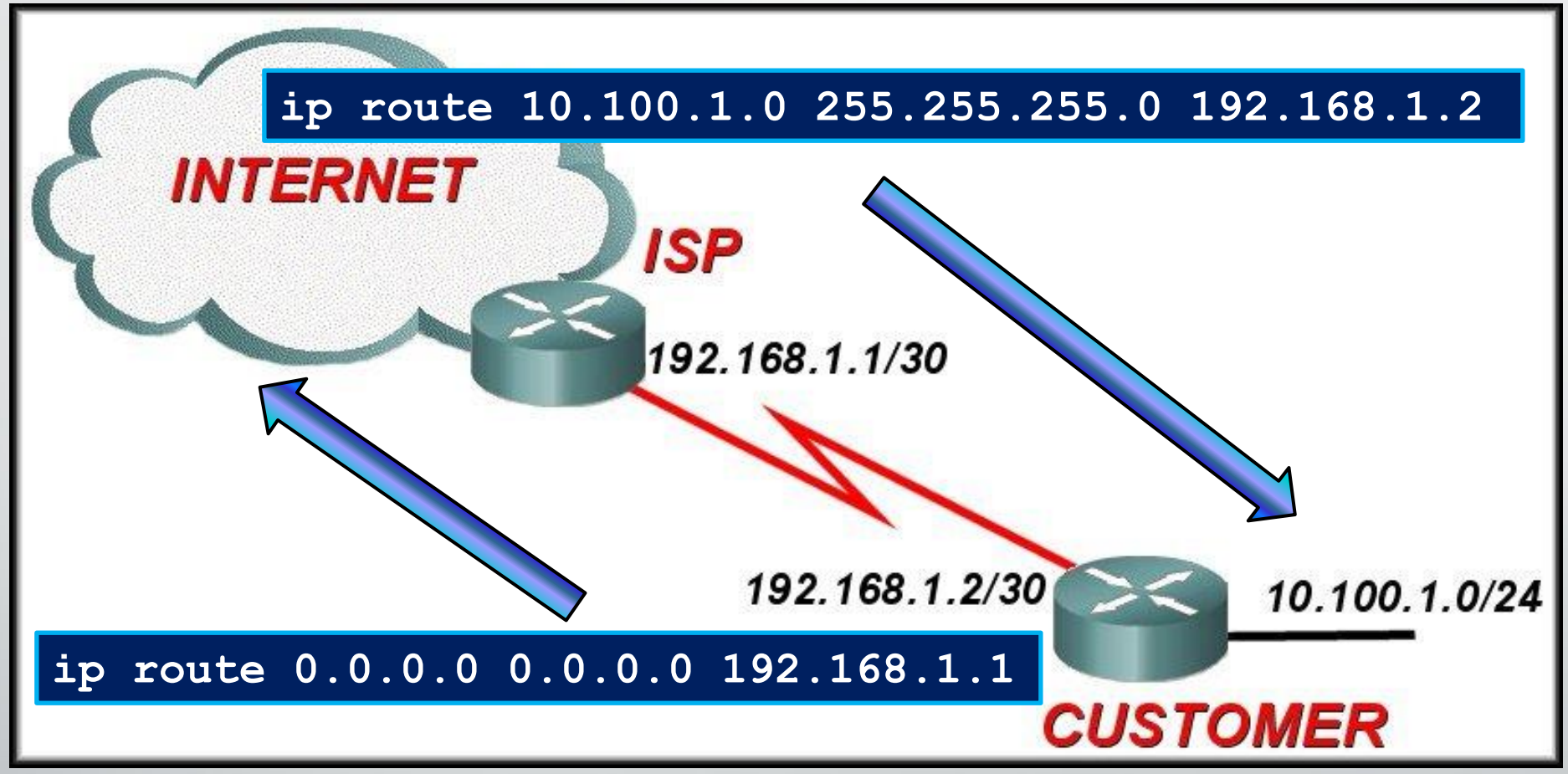
1. Connect to a specific network
2. Provide a Gateway of Last Resort for a stub network
3. Summarize routing table entries
4. Create a backup route in case a primary route link fails

Default Static Routing

- A **default path** to send all IP packets
  - when no other routes in the routing table match the packet destination IP address.
  - when a router has only one other router to which it is connected. This condition is known as a stub router.
- Uses a special network address as destination: **0.0.0.0/0**
  - Has a subnet mask of 0. Meaning, it will check zero bits and hence it will match all IPs!
- Conventionally, always points towards the border/ISP Router.
- Configuring a default static



Configuring Default Static Route



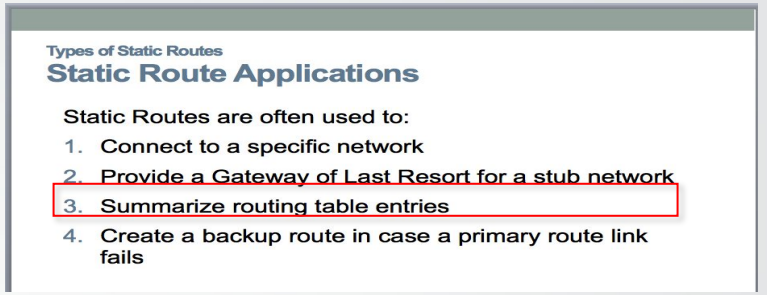
- **Note: A static route usually always points towards the specific network, while default static route points towards outside the network where a border router is connected to the internet

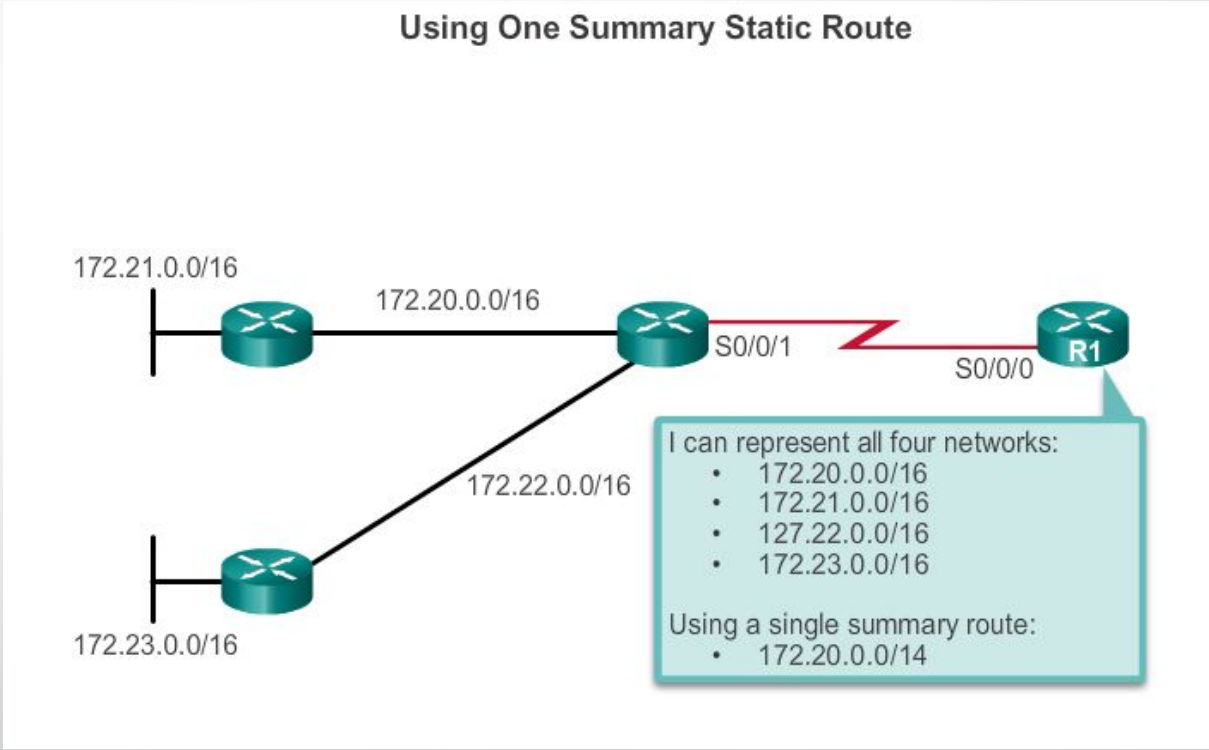
Verifying Default Static Route

```
CUSTOMER#show ip route
Codes: C - connected, S - static, I - IGRP, R - RIP, M - mobile, B - BGP
<output omitted>
       * - candidate default, U - per-user static route, o - ODR
       P - periodic downloaded static route

Gateway of last resort is 192.168.1.1 to network 0.0.0.0

   10.0.0.0/8 is subnetted, 1 subnets
C     10.100.1.0/24 is directly connected, FastEthernet0/0
C     192.168.1.0/24 is directly connected, Serial0/0/1
S*    0.0.0.0/0 [1/0] via 192.168.1.1
```

Summary Static Routing

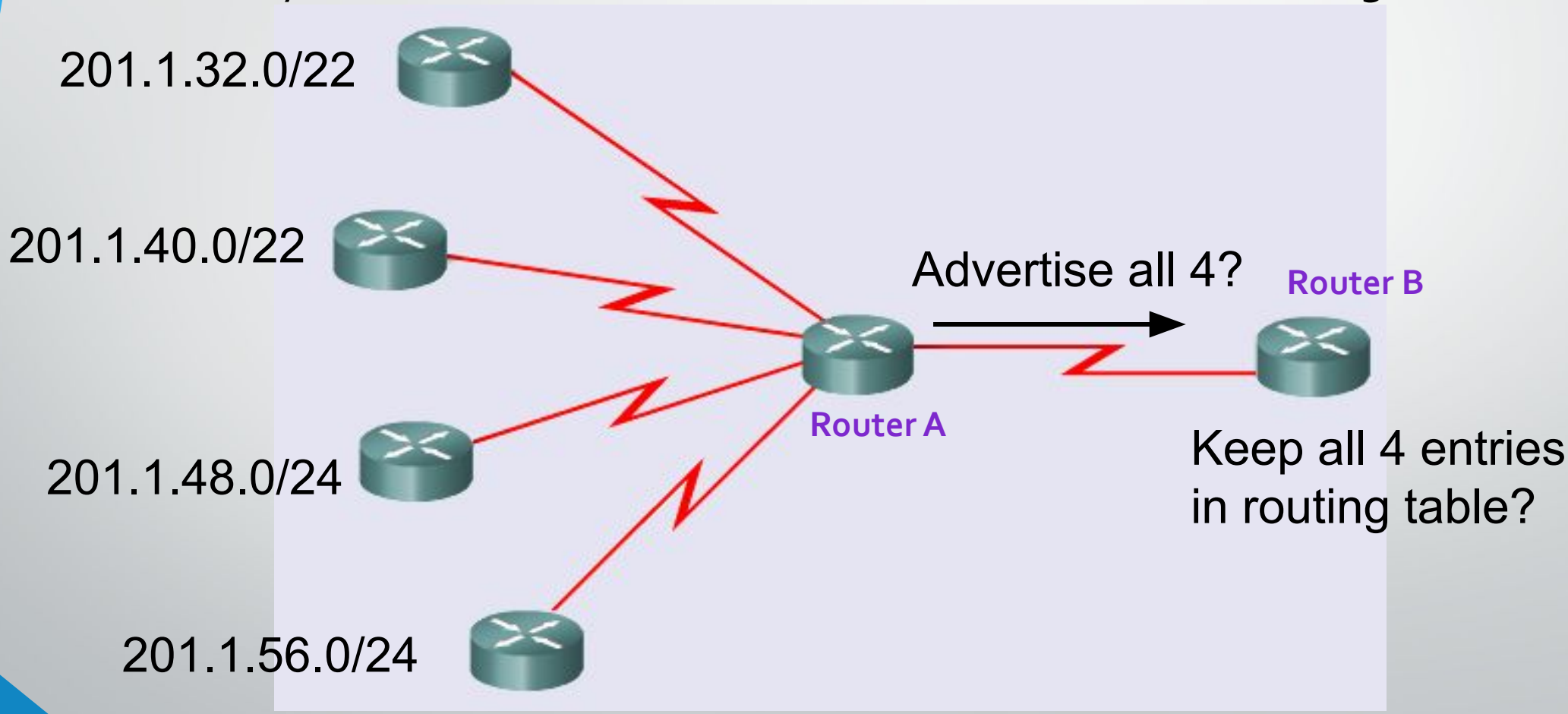
- A summary route is a single route that can be used to represent multiple routes.
  - Creates smaller routing tables
  - More efficient routing table lookup process.
  - Reduce the number of routes advertise
  - Have the same exit interface or next-hop IP address.
  - Generally a set of contiguous networks.





Route Summarization

- How many entries does Router A and Router B have in it's routing table?



Route Summarization

- 201.1.32.0/22
- 201.1.40.0/22
- 201.1.48.0/24
- 201.1.56.0/24

Same

Difference starts in this octet (Octet 3)

Octet 3 in binary

00100000
00101000
00110000
00111000

Same

Difference starts here

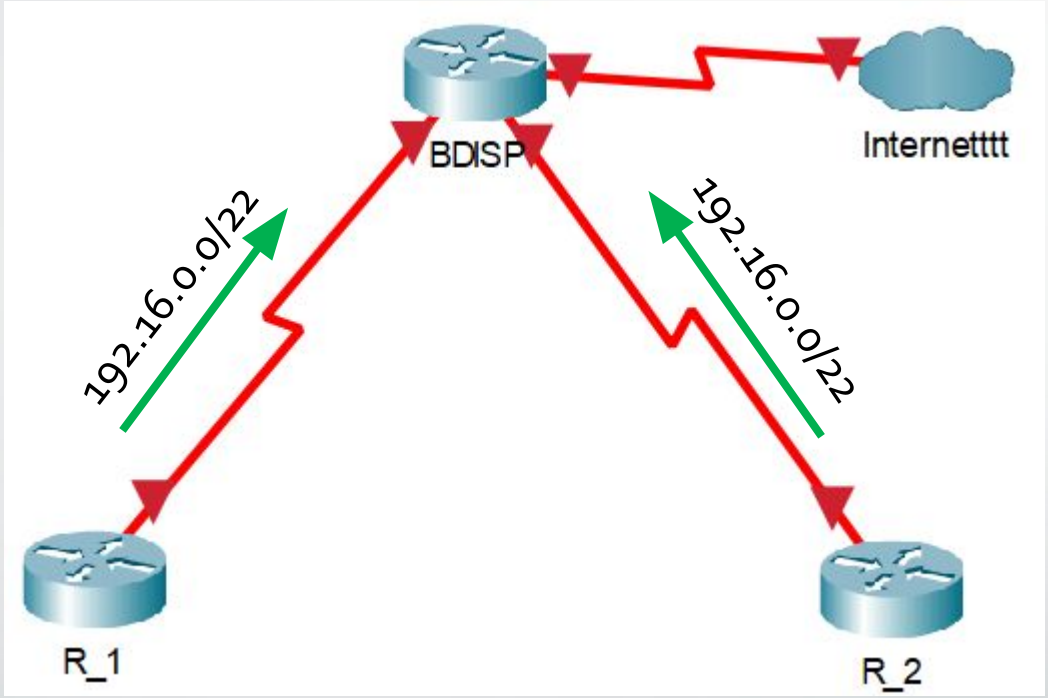
Summarized Network Address

201.1.32.0/19

201.1.00100000.0/19

19 bits the same so use /19 for summary

Problem of Summary Static Routing

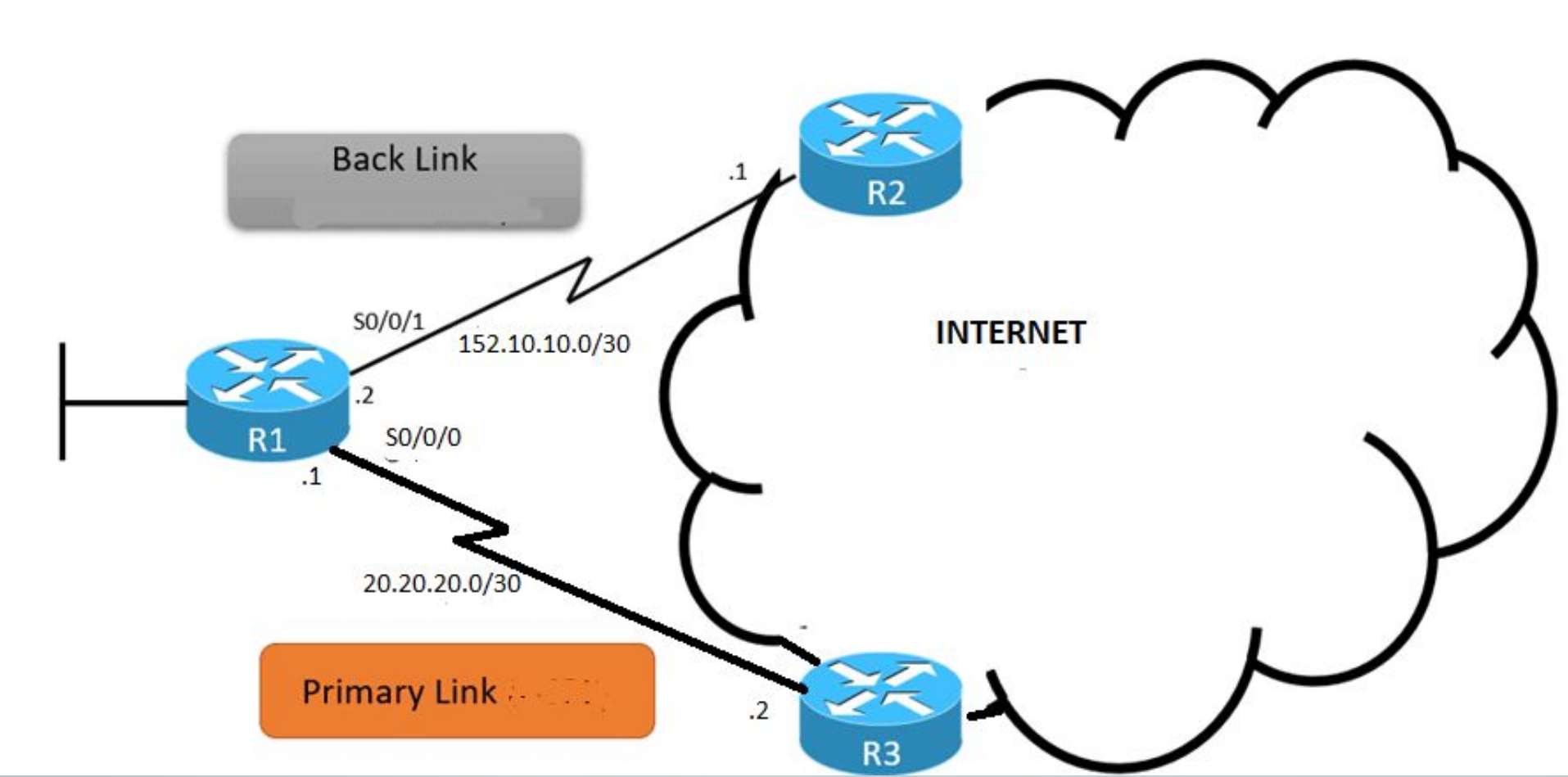


192.16.0.0/24
192.16.2.0/24

192.16.1.0/24
192.16.3.0/24

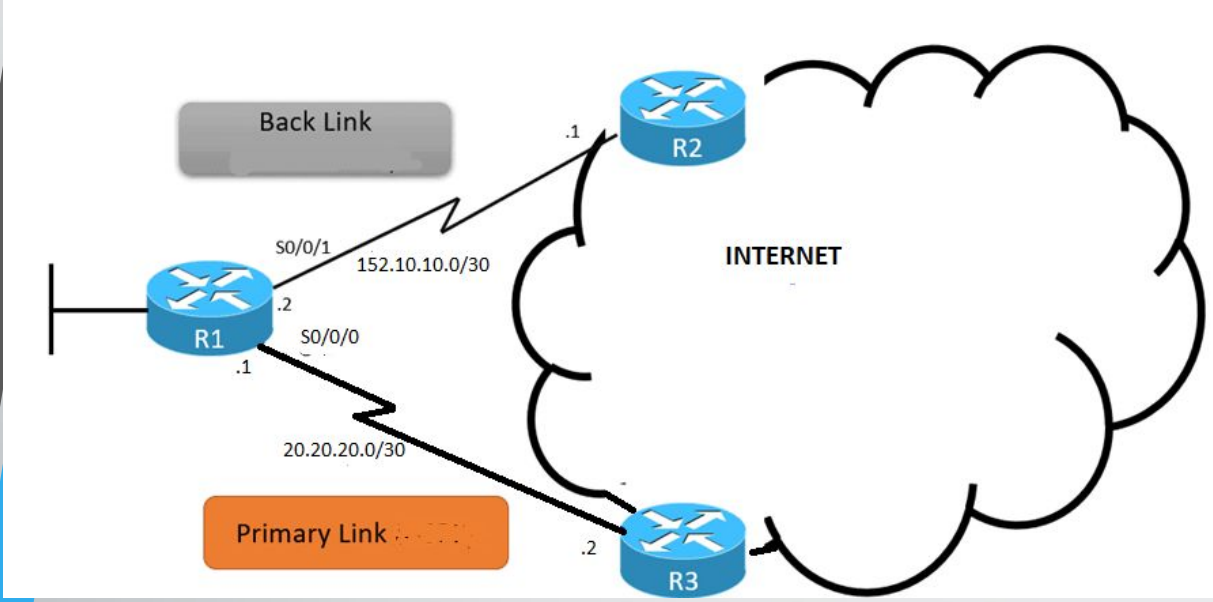
Discontiguous Networks

Floating Static Routing



Source : https://study-ccna.com/floating-static-route/

Floating Default Static Routing



- R1 Routing Table (Partial)

```
S* 0.0.0.0/0 is directly connected, S0/0/
S* 0.0.0.0/0 is directly connected, S0/0/
```

- Both has same cost same AD. Which one to use?

- `R1(config)#ip route 0.0.0.0 0.0.0.0 S0/0/0`
- `R1(config)#ip route 0.0.0.0 0.0.0.0 S0/0/1 5`

Present in Routing Table

AD > default Value

Present in Router Configuration File

Floating Static Routing

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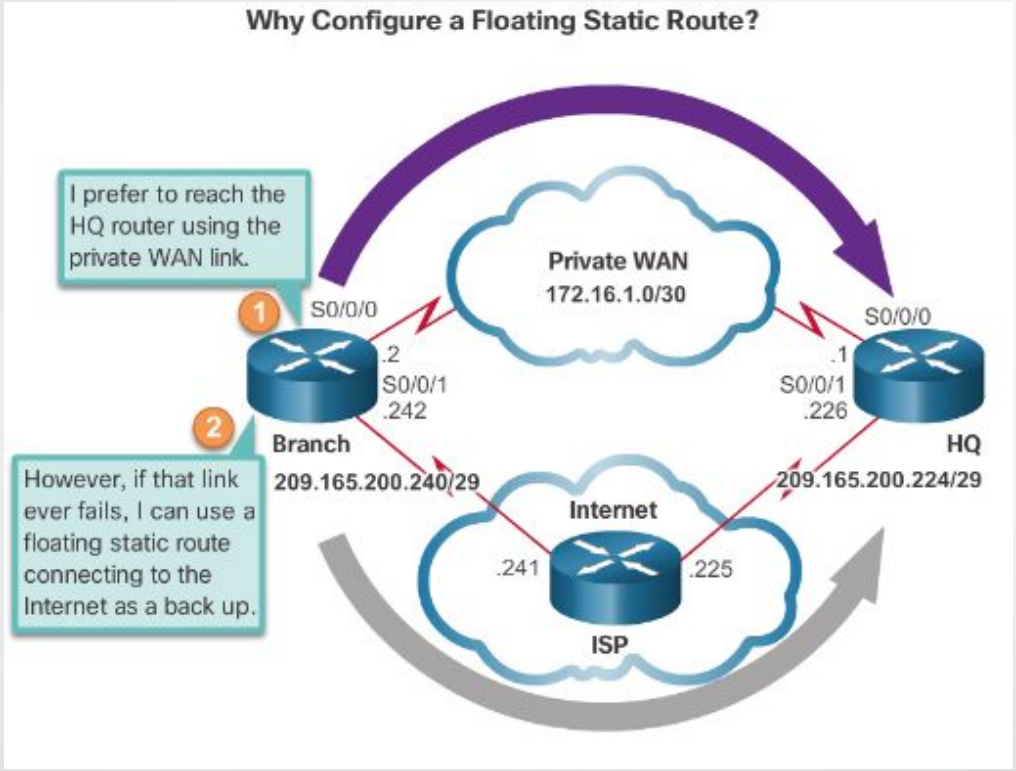
- Create a **backup route** in case a primary route link fails
- Uses **Administrative Distance** (AD)
  - The primary path has the default AD of 1 (but, may be configured to have a higher value)
  - The value of AD of back up path is greater than the AD of primary path/route.
  - Since the AD of primary path is lower, it means that primary path is more trustworthy and hence ignore the back up path unless the primary path is down.
- The static route "floats" and is not used when the route with the better administrative distance is active.
- If the preferred route is lost then the floating static route can take over

Configuring a Floating Static Route



- `Branch(config)#ip route 209.165.200.224 255.255.255.240 S0/0/0`
- `Branch(config)#ip route 209.165.200.224 255.255.255.240 S0/0/1 5`
  - *In other words, the AD has to be **more than** the AD of sthe primary route.

    ** A primary route may be set to have other AD values

`AD > 1`

Automatically Installed Host Routes

Branch IPv4 Routing Table


```
Branch# show ip route
Codes: L - local, C - connected, S - static, 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
       i - IS-IS, su - IS-IS summary, 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, H - NHRP, l - LISP
       a - application route
       + - replicated route, % - next hop override
Gateway of last resort is not set

      198.51.100.0/24 is variably subnetted, 2 subnets, 2 masks
C        198.51.100.0/30 is directly connected, Serial0/0/0
L        198.51.100.1/32 is directly connected, Serial0/0/0
Branch#
```

Configure IPv4 Static Host Routes


```
Branch(config)# ip route 209.165.200.238 255.255.255.255 198.51.100.2
Branch(config)# ipv6 route 2001:db8:acad:2::99/128 2001:db8:acad:1::2
Branch(config)# end
Branch# show ip route | begin Gateway
Gateway of last resort is not set

      198.51.100.0/24 is variably subnetted, 2 subnets, 2 masks
C        198.51.100.0/30 is directly connected, Serial0/0/0
L        198.51.100.1/32 is directly connected, Serial0/0/0
      209.165.200.0/32 is subnetted, 1 subnets
S        209.165.200.38 [1/0] via 198.51.100.2
```

Commands to Verify Static Routes

- Along with **ping** and **traceroute**, useful commands to verify static routes include:
  - **`show ip route`**
  - **`show ip route static`**
  - **`show ip route network`**

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The End