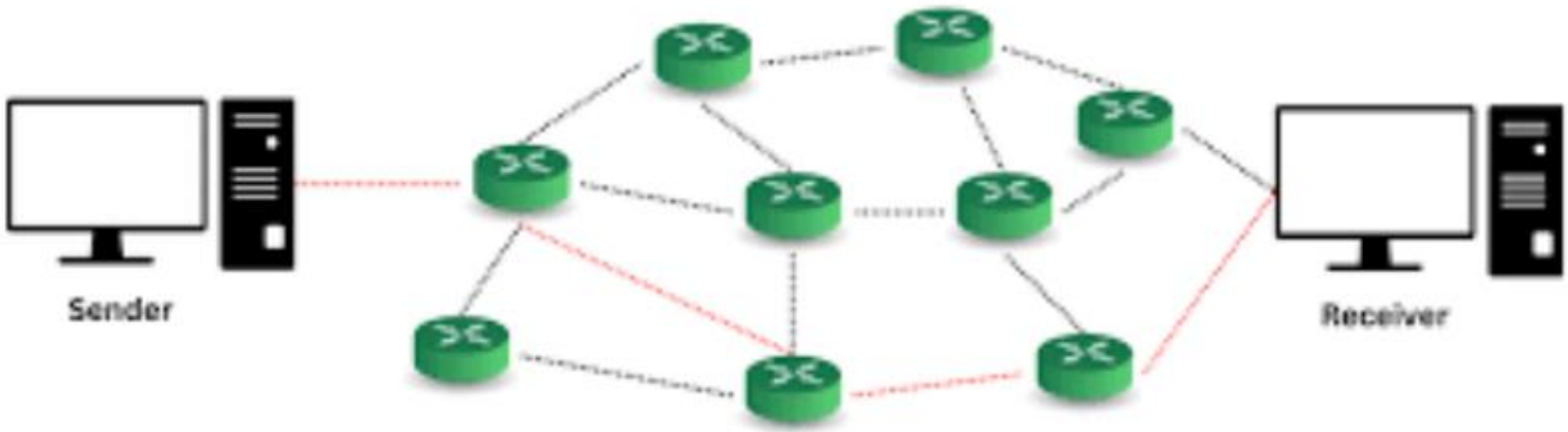
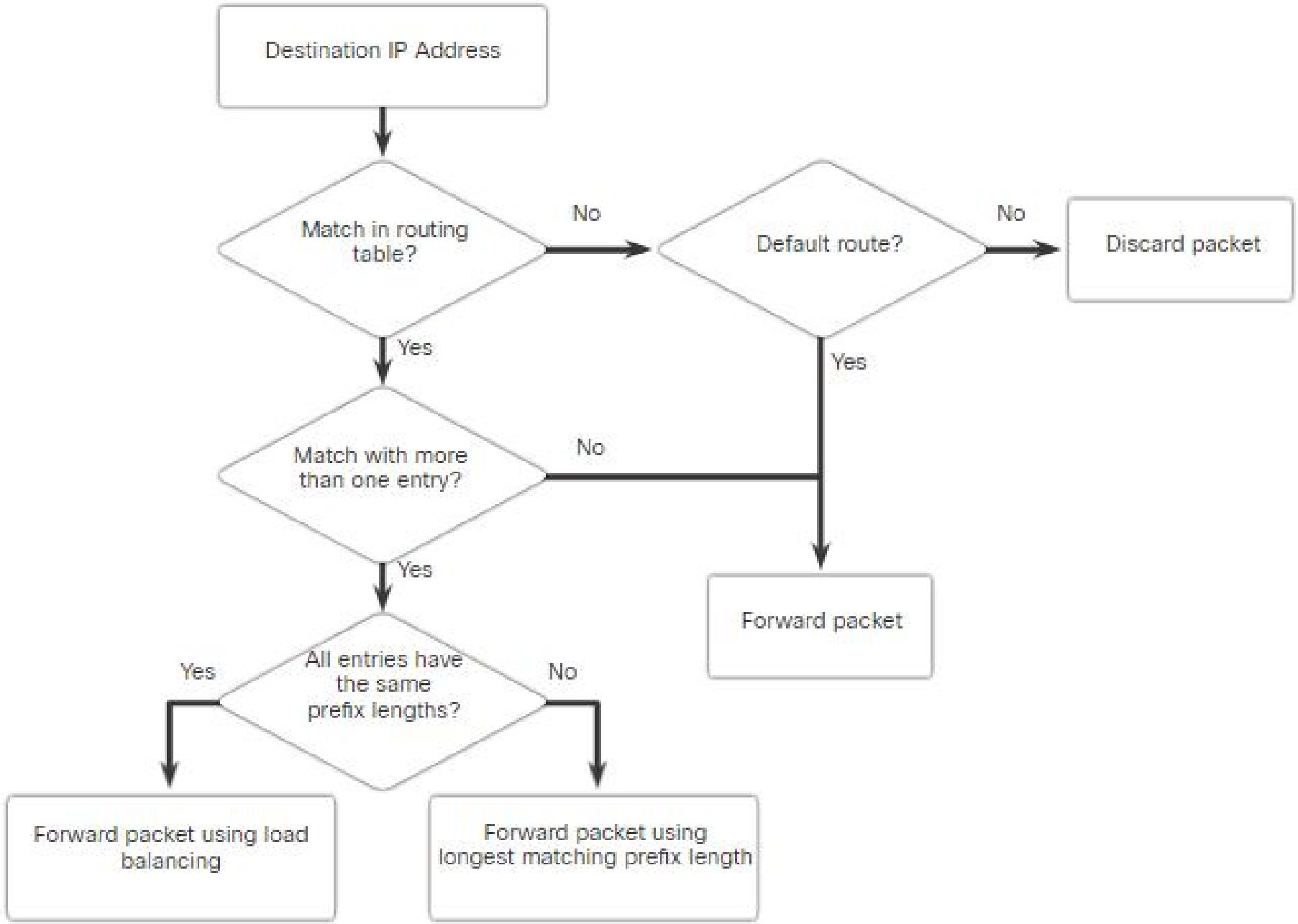
Lecture 4
Routing Types



Routing Working Example


Destination IP Address
Match in routing table?
No
Default route?
No
Discard packet
Yes
Yes
Match with more than one entry?
No
Yes
Forward packet
All entries have the same prefix lengths?
Yes
No
Forward packet using load balancing
Forward packet using longest matching prefix length

Why we need to know the structure of routing table

- As a network administrator, it is important to know the routing table in depth when troubleshooting network issues. Understanding the structure and lookup process of the routing table will help you diagnose any routing table issue, regardless of your level of familiarity with a particular routing protocol. For example, you might encounter a situation in which the routing table has all of the routes you would expect to see, but packet forwarding is not performing as expected. Knowing how to step through the lookup process of a destination IP address for a packet will enable you to determine whether the packet is being forwarded as expected, if and why the packet is being sent elsewhere, or whether the packet has been discarded.

```
R1# show ip route | begin Gateway
Gateway of last resort is 209.165.200.234 to network 0.0.0.0

S*  0.0.0.0/0 [1/0] via 209.165.200.234, Serial0/0/1
                    is directly connected, Serial0/0/1
    172.16.0.0/16 is variably subnetted, 5 subnets, 3 masks
C      172.16.1.0/24 is directly connected, GigabitEthernet0/0
L      172.16.1.1/32 is directly connected, GigabitEthernet0/0
R      172.16.2.0/24 [120/1] via 209.165.200.226, 00:00:12, Serial0/0/0
R      172.16.3.0/24 [120/2] via 209.165.200.226, 00:00:12, Serial0/0/0
R      172.16.4.0/28 [120/2] via 209.165.200.226, 00:00:12, Serial0/0/0
R   192.168.0.0/16 [120/2] via 209.165.200.226, 00:00:03, Serial0/0/0
    209.165.200.0/24 is variably subnetted, 5 subnets, 2 masks
C      209.165.200.224/30 is directly connected, Serial0/0/0
L      209.165.200.225/32 is directly connected, Serial0/0/0
R      209.165.200.228/30 [120/1] via 209.165.200.226, 00:00:12,
                      Serial0/0/0
C      209.165.200.232/30 is directly connected, Serial0/0/1
L      209.165.200.233/30 is directly connected, Serial0/0/1
R1#
```

Destination network (the receiver network) R (RIP)

Destination network/ prefix length



Rout source

Administrative distance (120)

Metric(2)

Next hop 209.165.200.226

Time stamp (duration time of routing path)

Outgoing interface

Route Sourcea	Administrative Distance
Directly connected	0
Static route	1
EIGRP summary route	5
External BGP	20
Internal EIGRP	90
OSPF	110
IS-IS	115
RIP	120
External EIGRP	170
Internal BGP	200

Route Sources

A routing table contains a list of routes to known networks (prefixes and prefix lengths). The source of this information is derived from the following:

- Directly connected networks
- Static routes
- Dynamic routing protocols

The source for each route in the routing table is identified by a code. Common codes include the following:

- **L** - Identifies the address assigned to a router interface.
- **C** - Identifies a directly connected network.
- **S** - Identifies a static route created to reach a specific network.
- **O** - Identifies a dynamically learned network from another router using the OSPF routing protocol.
- ***** - This route is a candidate for a default route.

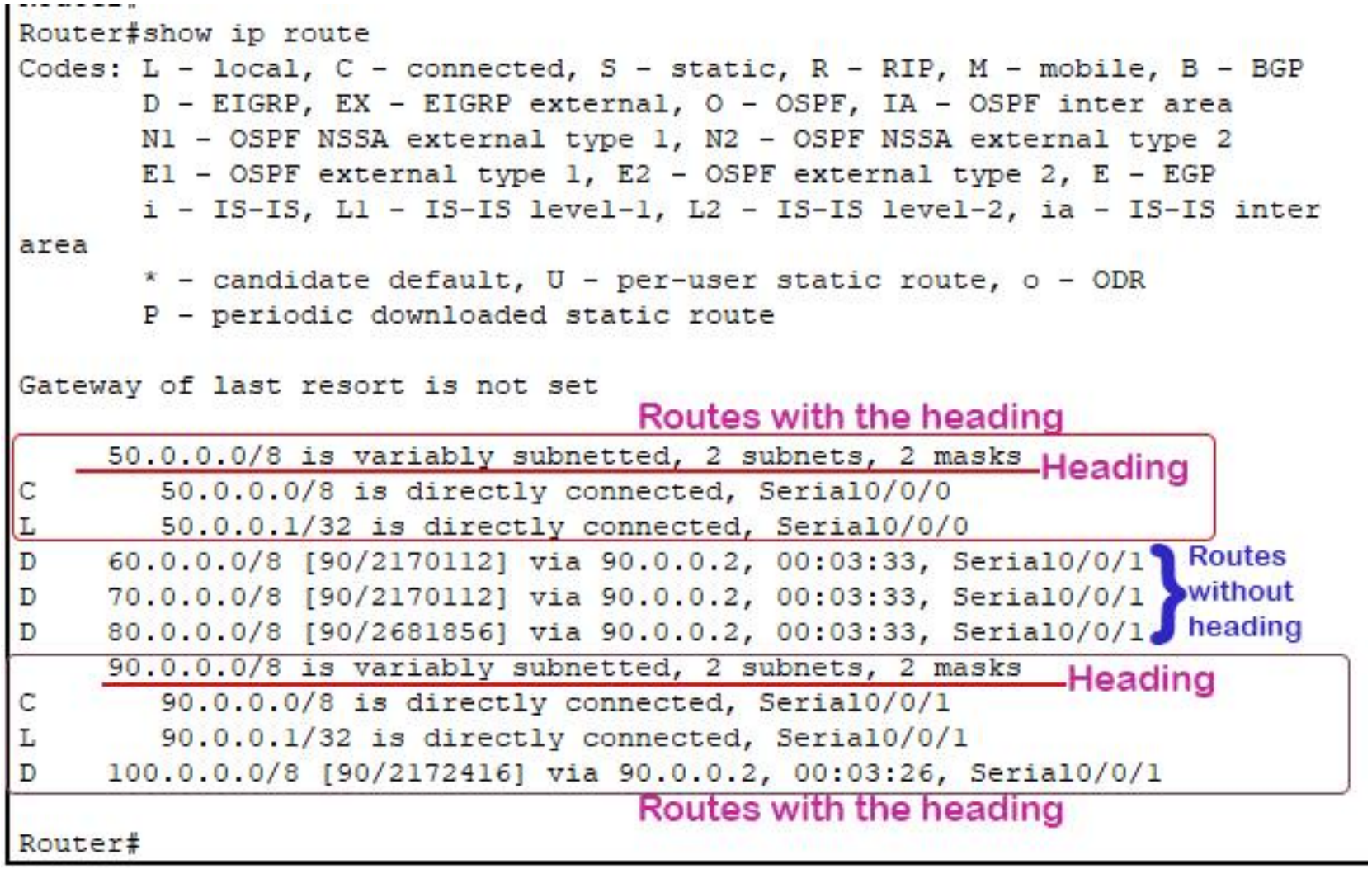
- *Route source : letters in beginning of the line of route table, used to know the used protocol in routing table.*

```
R1# show ip route | begin Gateway
Gateway of last resort is 209.165.200.234 to network 0.0.0.0

S*  0.0.0.0/0 [1/0] via 209.165.200.234, Serial0/0/1
                    is directly connected, Serial0/0/1
      172.16.0.0/16 is variably subnetted, 5 subnets, 3 masks
C       172.16.1.0/24 is directly connected, GigabitEthernet0/0
L       172.16.1.1/32 is directly connected, GigabitEthernet0/0
R       172.16.2.0/24 [120/1] via 209.165.200.226, 00:00:12, Serial0/0/0
R       172.16.3.0/24 [120/2] via 209.165.200.226, 00:00:12, Serial0/0/0
R       172.16.4.0/28 [120/2] via 209.165.200.226, 00:00:12, Serial0/0/0
R     192.168.0.0/16 [120/2] via 209.165.200.226, 00:00:03, Serial0/0/0
      209.165.200.0/24 is variably subnetted, 5 subnets, 2 masks
C       209.165.200.224/30 is directly connected, Serial0/0/0
L       209.165.200.225/32 is directly connected, Serial0/0/0
R       209.165.200.228/30 [120/1] via 209.165.200.226, 00:00:12,
                           Serial0/0/0
C       209.165.200.232/30 is directly connected, Serial0/0/1
L       209.165.200.233/30 is directly connected, Serial0/0/1
R1#
```

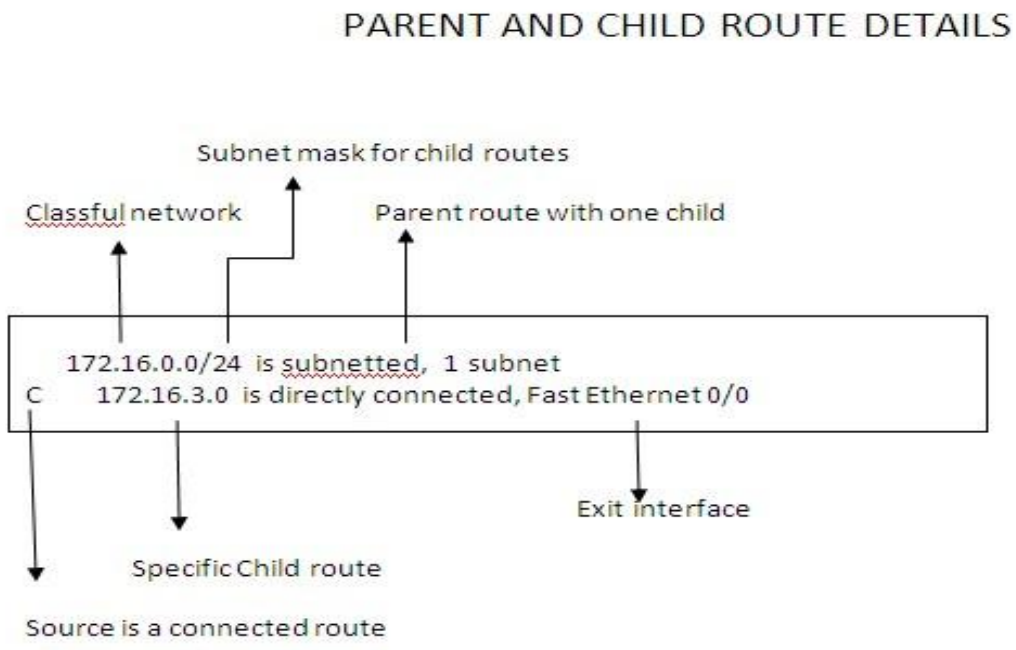
```
L - local, C - connected, S - static, R - RIP, M - mobile, B -
D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
E1 - OSPF external type 1, E2 - OSPF external type 2
i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS
ia - IS-IS inter area, * - candidate default, U - per-user sta
o - ODR, P - periodic downloaded static route, + - replicated
```

The heading includes three things: **the classful network**, the **total number of subnets**, and the **total number of masks used to create** the **subnets**.



- # Classful addressing (IPv4)

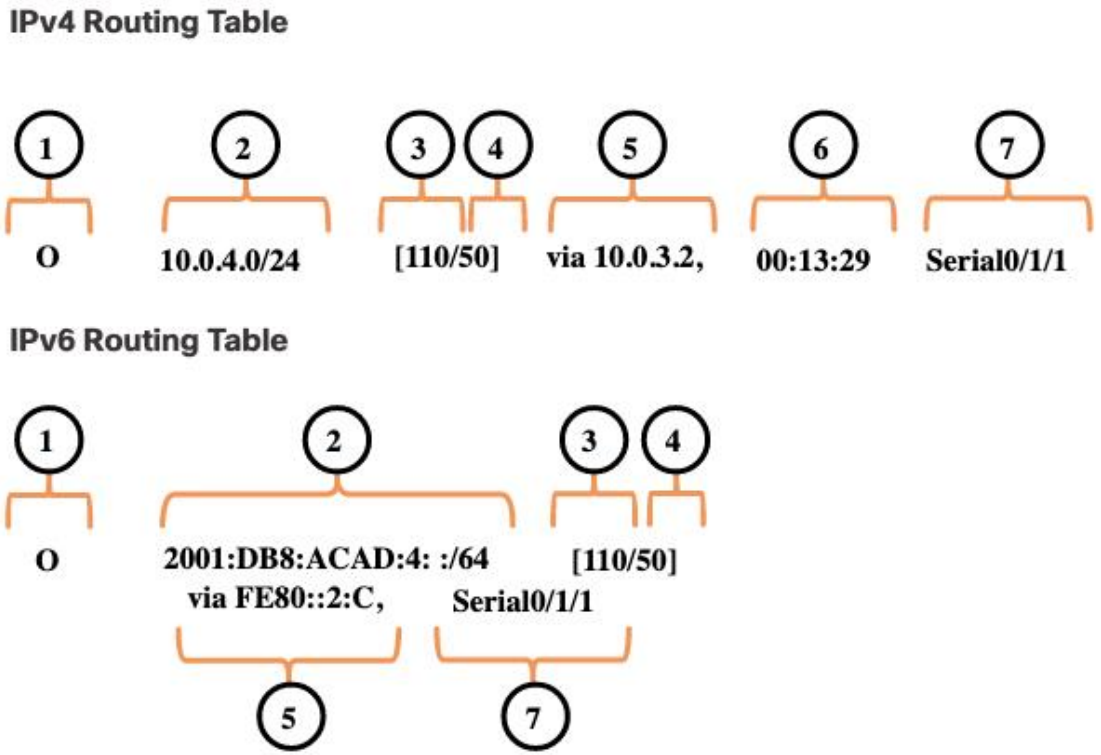
- An indented entry is known as a **child route**. A route entry is indented if it is the subnet of a classful address (class A, B or C network).
- Directly connected networks will always be indented (child routes)
- The child route will include the route source and all the forwarding information such as the next-hop address.
- The classful network address of this subnet will be shown above the route entry, less indented, and without a source code. That route is known as a **parent route.**



Routing Table Entries

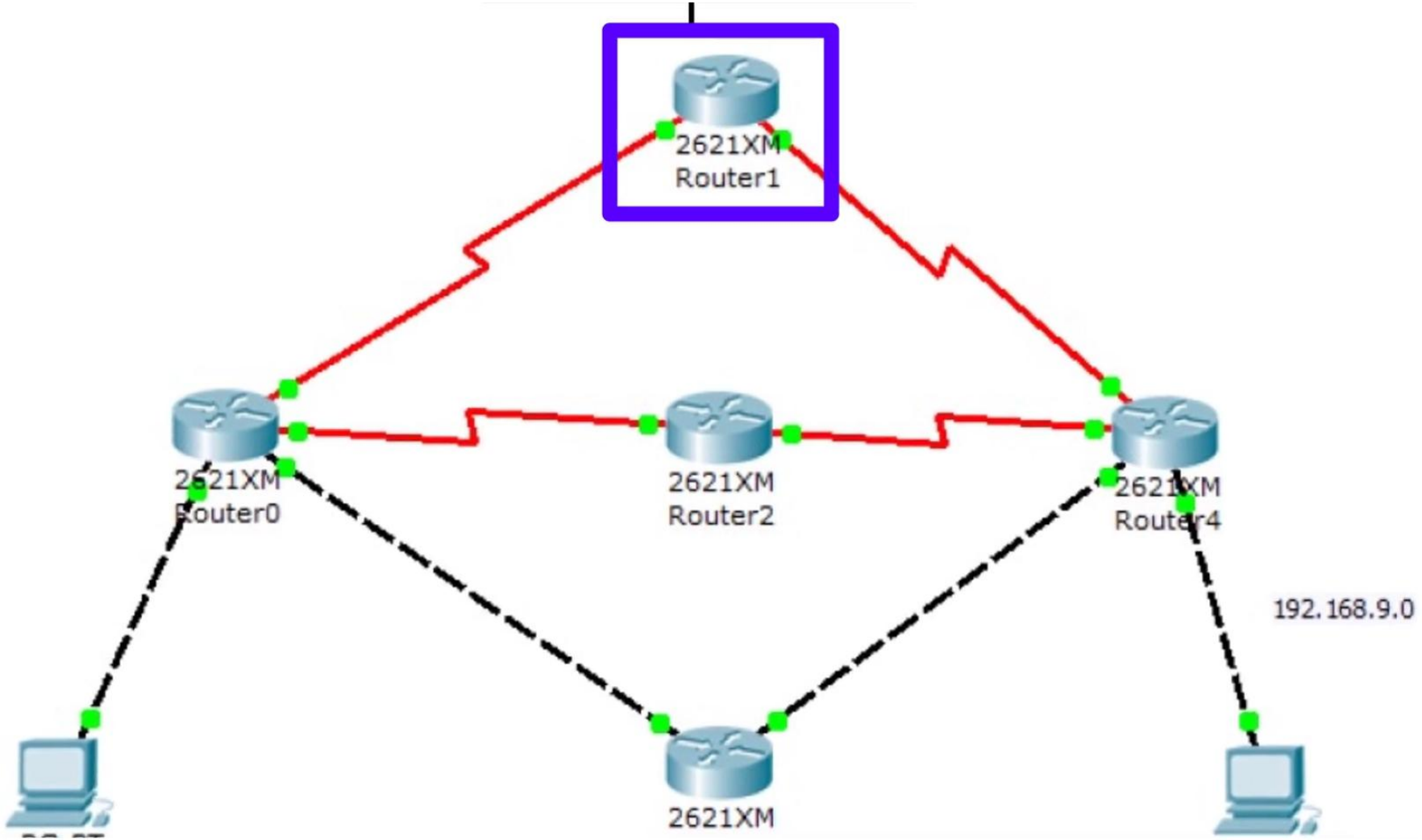
In the figure, the numbers identify the following information:

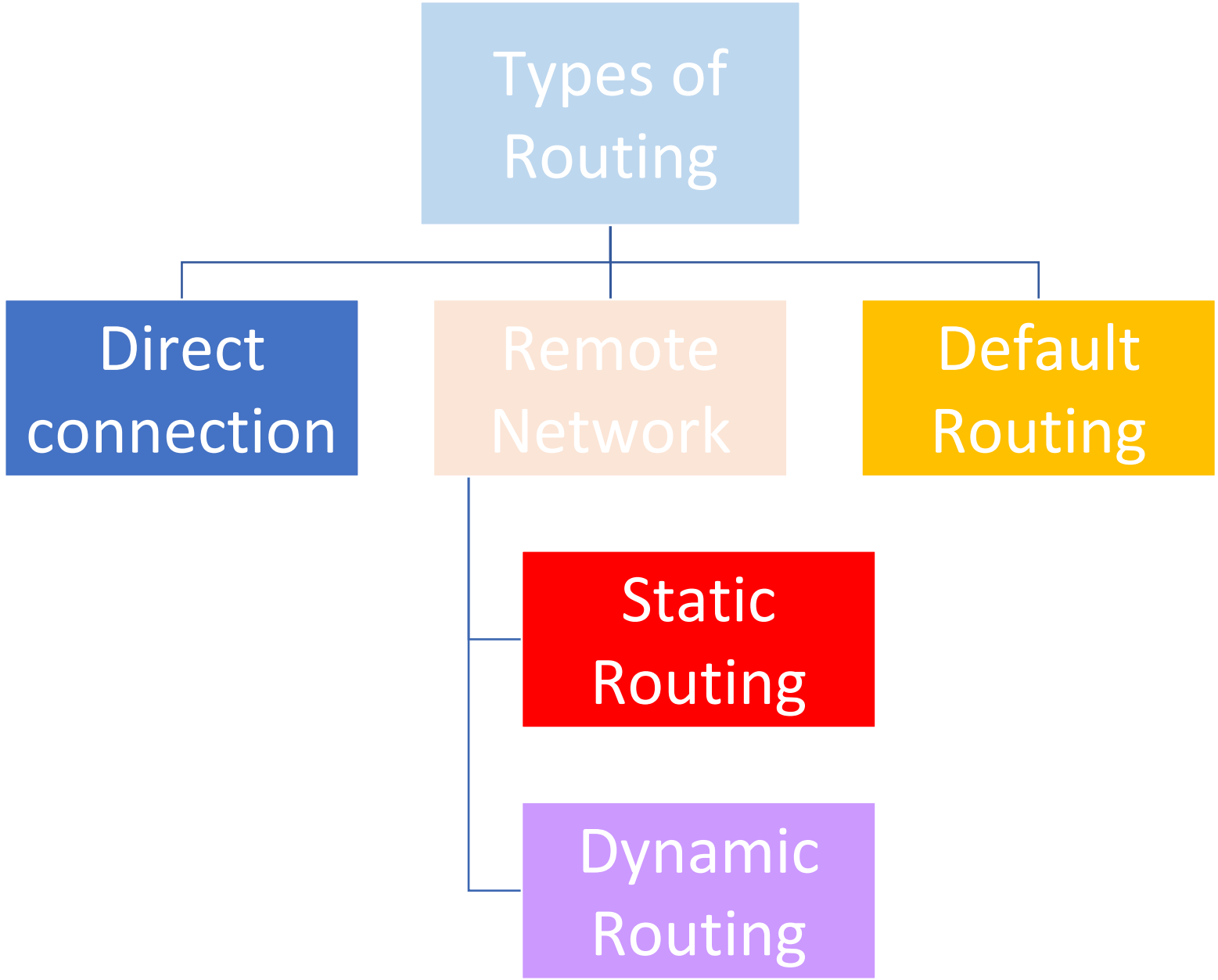
1. **Route source** - This identifies how the route was learned.
2. **Destination network (prefix and prefix length)** - This identifies the address of the remote network.
3. **Administrative distance** - This identifies the trustworthiness of the route source. Lower values indicate preferred route source.
4. **Metric** - This identifies the value assigned to reach the remote network. Lower values indicate preferred routes.
5. **Next-hop** - This identifies the IP address of the next router to which the packet would be forwarded.
6. **Route timestamp** - This identifies how much time has passed since the route was learned.
7. **Exit interface** - This identifies the egress interface to use for outgoing packets to reach their final destination.



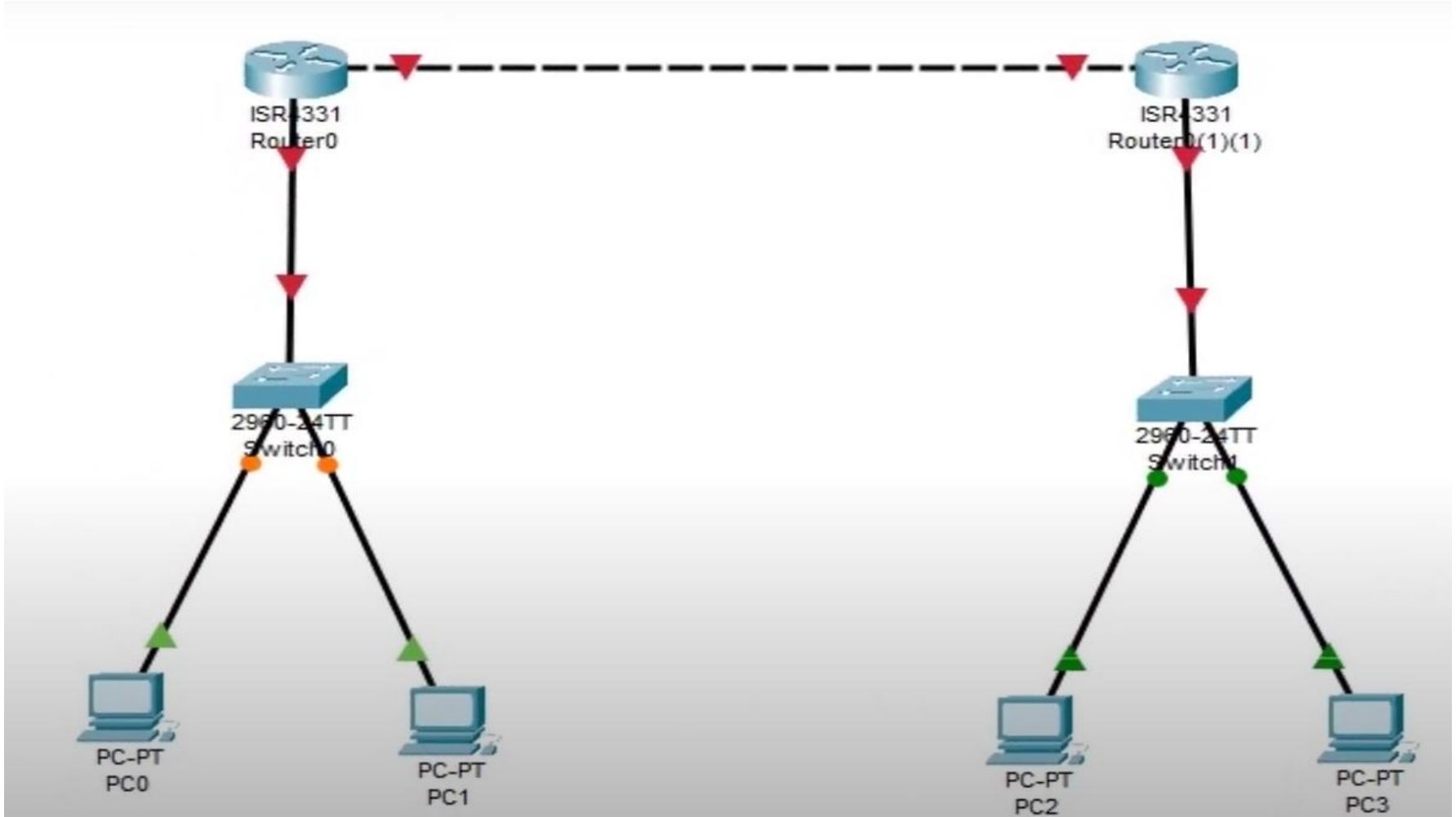
Note: The prefix length of the destination network specifies the minimum number of far-left bits that must match between the IP address of the packet and the destination network (prefix) for this route to be used.

Routing means determine the path to send the packet




Types of Routing
Direct connection
Remote Network
Default Routing
Static Routing
Dynamic Routing

Direct connected network: only one network connect to router recorded in routing table without any configuration



Directly Connected Networks

- The router must have at least one active interface configured with an IP address and subnet mask (prefix length). [192.186.10.0/24]

- This is known as a directly connected network or a directly connected route.
- Routers add a directly connected route to its routing table when an interface is configured with an IP address and is activated.

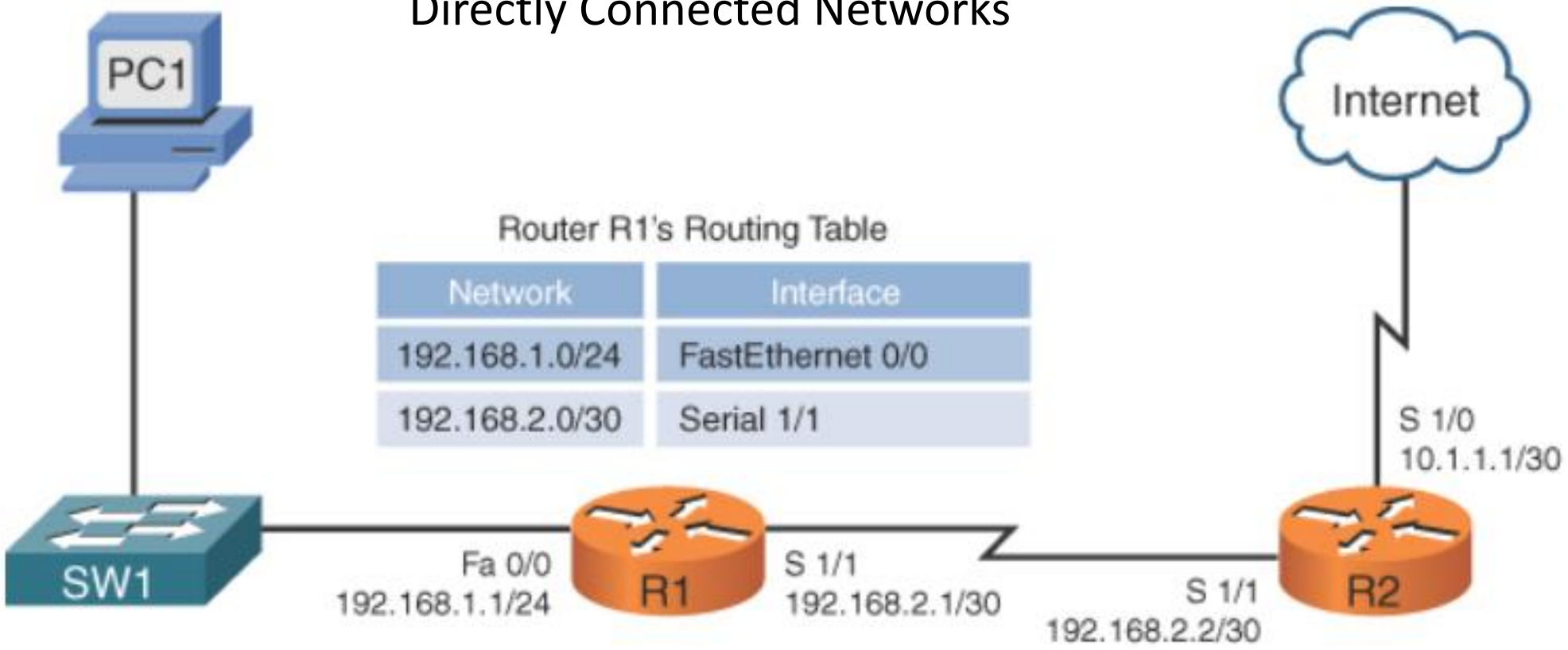
IP Routing Table

Directly Connected Networks (C, L)

- A directly Connected network is denoted by a status code of **C** in the routing table. The route contains a network prefix and prefix length.
- The routing table also contains a local route for each of its directly connected networks, indicated by the status code of **L**.
- For IPv4 local routes the prefix length is /32 and for IPv6 local routes the prefix length is /128.

IP Routing Table

Directly Connected Networks



Router R1's Routing Table

Network	Interface
192.168.1.0/24	FastEthernet 0/0
192.168.2.0/30	Serial 1/1

Router R2's Routing Table

Network	Interface
10.1.1.0/30	Serial 1/0
192.168.2.0/30	Serial 1/1



What is the correct path?

Longest Prefix Match

When a packet destined for the IP address 192.168.2.10:

THE SHORTEST RANGE THAT CONTAINS THE DESTINATION IP

Routing Table:

192.168.0.0/16 (192.168.0.0 – 192.168.255.255)
192.168.1.0/24 (192.168.1.0 – 192.168.1.255)
192.168.1.0/26 (192.168.1.0 – 192.168.1.63)
192.168.1.0/28 (192.168.1.0 – 192.168.1.15)
192.168.1.0/29 (192.168.1.0 – 192.168.1.7)

Default Routing

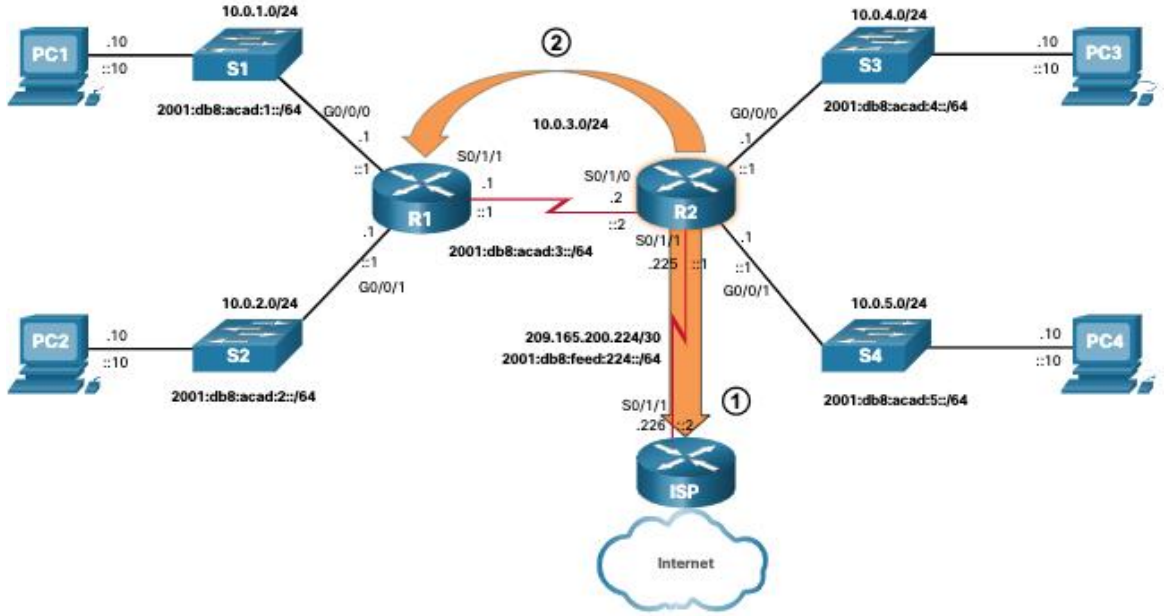
Default Routing - Default Routing is something called gateway of last resort, when a specific route to a particular network does not exist, a router will drop all the packets destined to that specific network. Router forward packets using a default route when there is no specific routes that match a packet's destination IP address in the routing table. The default route can be identified by all zeros in both the network and subnet mask (0.0.0.0 0.0.0.0).

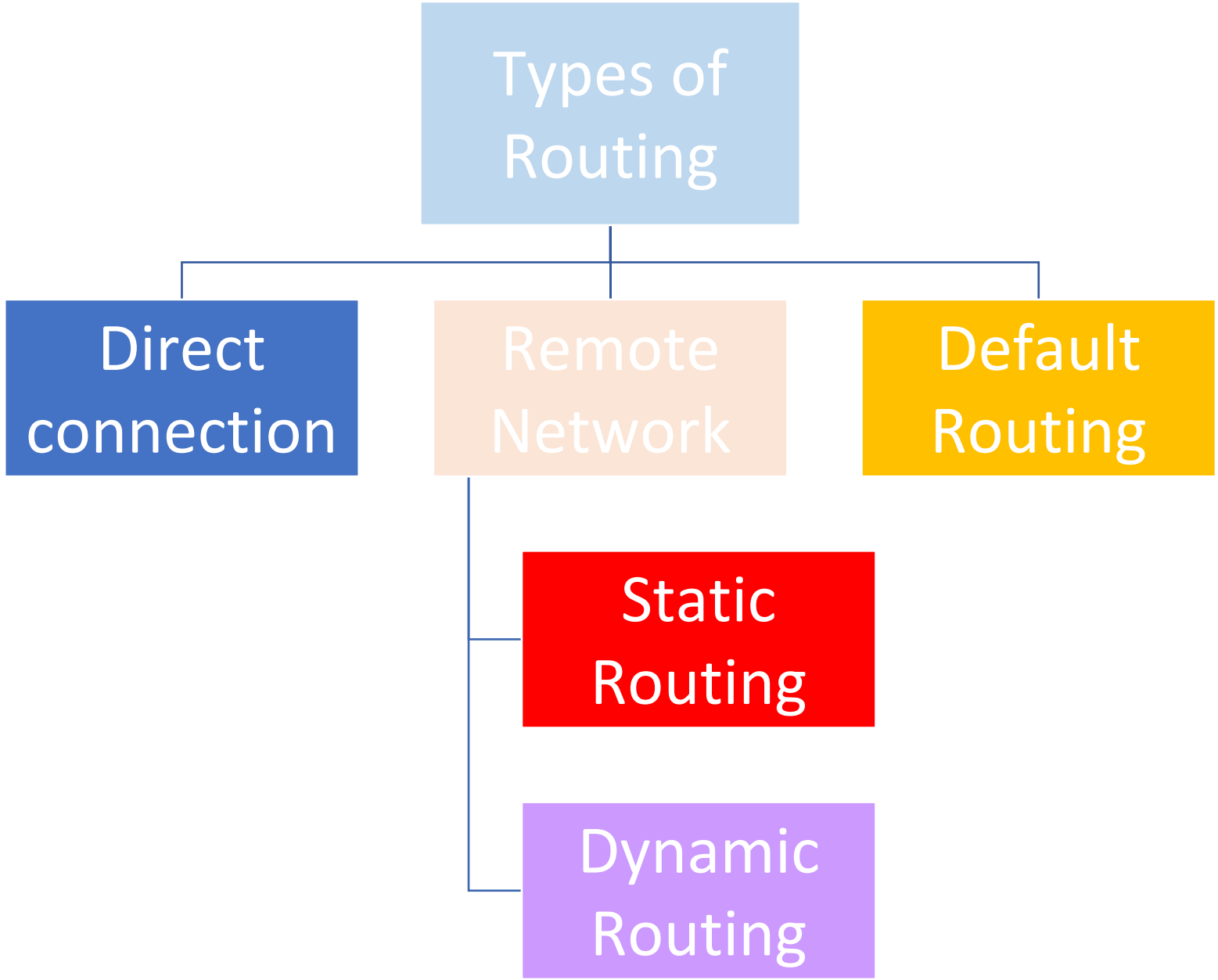
Example routing table contents

Network destination	Netmask	Gateway	Interface	Metric
0.0.0.0	0.0.0.0	192.168.0.1	192.168.0.100	10
127.0.0.0	255.0.0.0	127.0.0.1	127.0.0.1	1
192.168.0.0	255.255.255.0	192.168.0.100	192.168.0.100	10

Default Route

The default route specifies a next-hop router to use when the routing table does not contain a specific route that matches the destination IP address. A default route can be either a static route or learned automatically from a dynamic routing protocol. A default route has an IPv4 route entry of 0.0.0.0/0 or an IPv6 route entry of ::/0. This means that zero or no bits need to match between the destination IP address and the default route.




Types of Routing
Direct connection
Remote Network
Default Routing
Static Routing
Dynamic Routing

Remote networks

- Routing table entries to remote networks may be either **dynamic** or **static**.
  - Dynamic routes are routes to remote networks that were learned automatically by the router through a dynamic routing protocol.
  - Static routes are routes that a network administrator manually configured.

Static Routes

After directly connected interfaces are configured and added to the routing table, static or dynamic routing can be implemented for accessing remote networks. Static routes are manually configured. They define an explicit path between two networking devices. They are not automatically updated and must be manually reconfigured if the network topology changes.

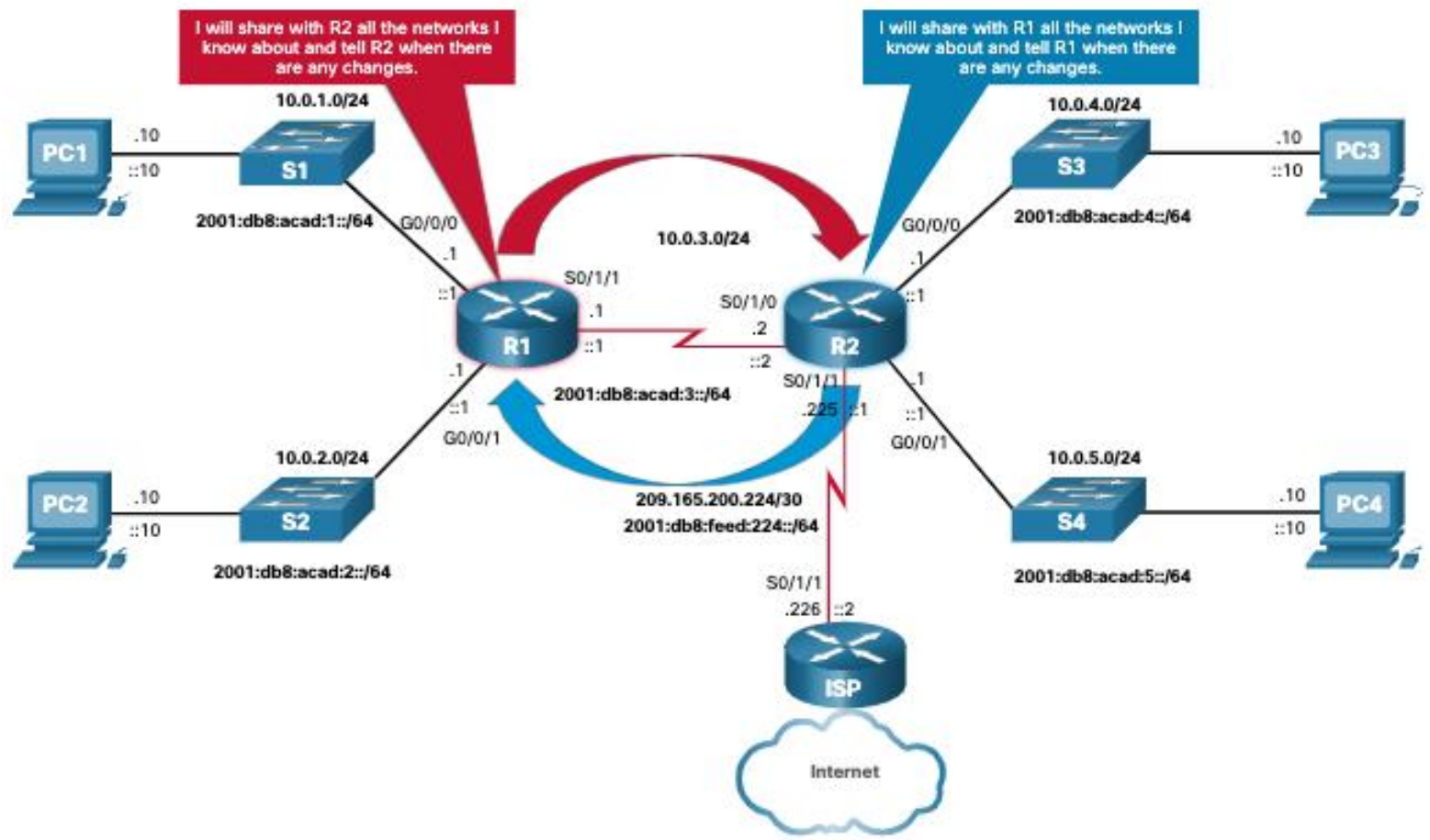
IP Routing Table
Static Routes

Static routing has primary uses:

1. It provides ease of routing table maintenance in smaller networks that are not expected to grow significantly.
2. It uses a single default route to represent a path to any network that does not have a more specific match with another route in the routing table. Default routes are used to send traffic to any destination beyond the next upstream router.

Dynamic Routing Protocols

Dynamic routing protocols are used by routers to automatically share information about the reachability and status of remote networks. Dynamic routing protocols perform several activities, including network discovery and maintaining routing tables.



Static or Dynamic?

Static and dynamic routing are not mutually exclusive. Rather, most networks use a combination of dynamic routing protocols and static routes.

Static routes are commonly used in the following scenarios:

1. As a default route forwarding packets to a service provider
2. For routes outside the routing domain and not learned by the dynamic routing protocol
3. When the network administrator wants to explicitly define the path for a specific network

Static routes are useful for smaller networks with only one path to an outside network. They also provide security in a larger network for certain types of traffic, or links to other networks that need more control.

Static or Dynamic? (Cont.)

Dynamic routing protocols are implemented in any type of network consisting of more than just a few routers. Dynamic routing protocols are scalable and automatically determine better routes if there is a change in the topology.

Dynamic routing protocols are commonly used in the following scenarios:

1. In networks consisting of more than just a few routers
2. When a change in the network topology requires the network to automatically determine another path
3. For scalability. As the network grows, the dynamic routing protocol automatically learns about any new networks.

Static or Dynamic? (Cont.)

The table shows a comparison of some the differences between dynamic and static routing.

Feature	Dynamic Routing	Static Routing
Configuration complexity	Independent of network size	Increases with network size
Topology changes	Automatically adapts to topology changes	Administrator intervention required
Scalability	Suitable for simple to complex network topologies	Suitable for simple topologies
Security	Security must be configured	Security is inherent
Resource Usage	Uses CPU, memory, and link bandwidth	No additional resources needed
Path Predictability	Route depends on topology and routing protocol used	Explicitly defined by the administrator

Types Of Dynamic Routing

	Interior Gateway Protocols				Exterior Gateway Protocols
	Distance Vector		Link-State		Path Vector
IPv4	RIPv2	EIGRP	OSPFv2	IS-IS	BGP-4
IPv6	RIPng	EIGRP for IPv6	OSPFv3	IS-IS for IPv6	BGP-MP

How The Dynamic Routing Protocols Determine The Networks

1. ***Router send to all connected networks ask about the network use same protocol and other tables reply to it.***

2. Router exchange the routing tables with other connected networks.

Quiz

Section 1: Routing Tables and Route Sources

Q1. What is the main purpose of routing?

A) Assigning MAC addresses B) Determining the path used to forward packets C) Creating user accounts D) Encrypting network traffic

Q2. Which of the following can provide routes to a routing table?

A) Directly connected networks B) Static routes C) Dynamic routing protocols D) All of the above

Q3. Which routing table code identifies a directly connected network?

A) L B) C C) S D) O

Q4. Which routing table code identifies a local interface address?

A) L B) C C) S D) *

Q5. Which routing table code identifies a static route?

A) O B) C C) S D) L

Q6. Which routing table code identifies a route learned through OSPF?

A) O B) S C) C D) L

Q7. What does administrative distance indicate?

A) Route bandwidth B) Trustworthiness of the route source C) Packet size D) Number of router interfaces

Q8. What is the administrative distance of a static route according to the lecture?

A) 0 B) 1 C) 90 D) 120

Q9. What is the administrative distance of OSPF?

A) 20 B) 90 C) 110 D) 120

Q10. What is the administrative distance of RIP?

A) 1 B) 90 C) 110 D) 120

Section 2: Routing Table Entries and Direct Connections

Q11. What does a route metric help determine?

A) The preferred route based on the routing protocol's metric B) Router username C) Destination MAC address D) Number of interfaces

Q12. What is the next-hop address?

A) The final user's address B) The IP address of the next router to which a packet is forwarded C) Router hostname D) Subnet mask

Q13. What does the exit interface identify?

A) The interface used to send packets toward their destination B) A disabled interface C) The destination network name D) The routing protocol version

Q14. What does the destination network prefix length specify?

A) The number of far-left bits that must match B) Number of routers C) Number of packets D) Route metric value

Q15. When does a router add a directly connected route to its routing table?

A) When a file is created B) When an interface has an IP address and is activated C) When RIP is disabled D) Only after a static route is added

Q16. What prefix length is used for an IPv4 local route?

A) /24 B) /16 C) /32 D) /128

Q17. What prefix length is used for an IPv6 local route?

A) /32 B) /64 C) /128 D) /0

Section 3: Default, Static, and Dynamic Routing

Q18. What is the purpose of a default route?

A) Forwarding packets when no specific matching route exists B) Removing routing table entries C) Assigning IP addresses automatically D) Replacing directly connected routes

Q19. Which IPv4 prefix represents a default route?

A) 192.168.1.0/24 B) 127.0.0.1/8 C) 0.0.0.0/0 D) 255.255.255.255/32

Q20. A default route is also known as the:

A) Child route B) Gateway of last resort C) Local route D) Loopback route

Q21. How are static routes configured?

A) Automatically by routers B) Manually by a network administrator C) Only by end users D) By DNS servers

Q22. What happens when a static route's network topology changes?

A) It always updates automatically B) It may need to be manually reconfigured C) It deletes all routes D) It becomes an OSPF route automatically

Q23. What is a key benefit of dynamic routing protocols?

A) Automatically sharing reachability information about remote networks B) Requiring no CPU or memory C) Working with only one router D) Never responding to topology changes

Q24. Which routing method can automatically adapt to topology changes?

A) Static routing B) Dynamic routing C) Direct connection only D) Manual addressing

Q25. Which is a common use of static routing?

A) Explicitly defining a path to a specific network B) Automatically discovering every new network C) Continuously exchanging routing tables D) Automatically adapting to every topology change

Q26. Which routing approach is generally more scalable for networks with many routers?

A) Static routing B) Dynamic routing C) Direct connection only D) No routing

Q27. Which resources can dynamic routing protocols use?

A) No CPU or memory B) CPU, memory, and link bandwidth C) Disk space only D) Printer resources only

Section 4: Dynamic Routing Protocols

Q28. Which protocol is classified as a link-state protocol in the lecture?

A) RIPv2 B) OSPFv2 C) BGP-4 D) RIPng

Q29. Which protocol is listed as an exterior gateway protocol in the lecture?

A) OSPFv2 B) RIPv2 C) BGP-4 D) IS-IS

Q30. How do dynamic routing protocols learn about remote networks?

A) Routers exchange routing information with neighboring routers B) Routers rename their interfaces C) Routers delete their routing tables D) Routers use text editors

Answer Key

Question	Answer	Question	Answer	Question	Answer
1	B	11	A	21	B
2	D	12	B	22	B
3	B	13	A	23	A
4	A	14	A	24	B
5	C	15	B	25	A
6	A	16	C	26	B
7	B	17	C	27	B
8	B	18	A	28	B
9	C	19	C	29	C
10	D	20	B	30	A