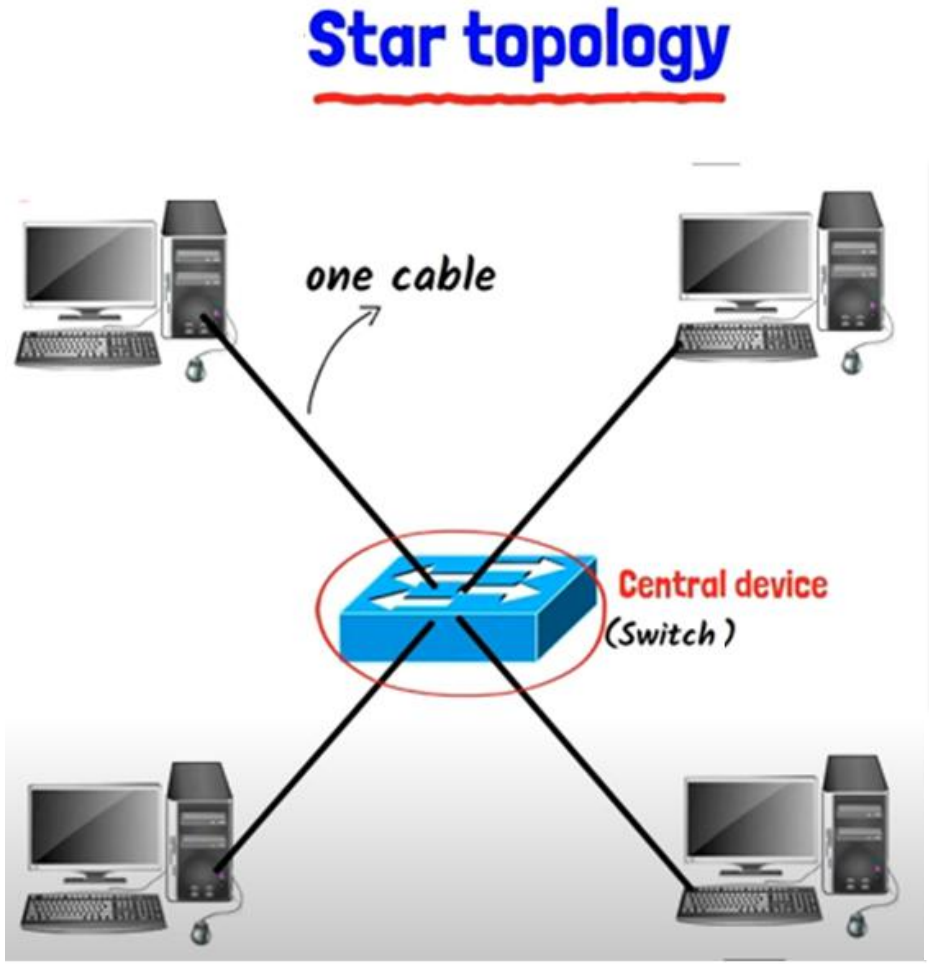
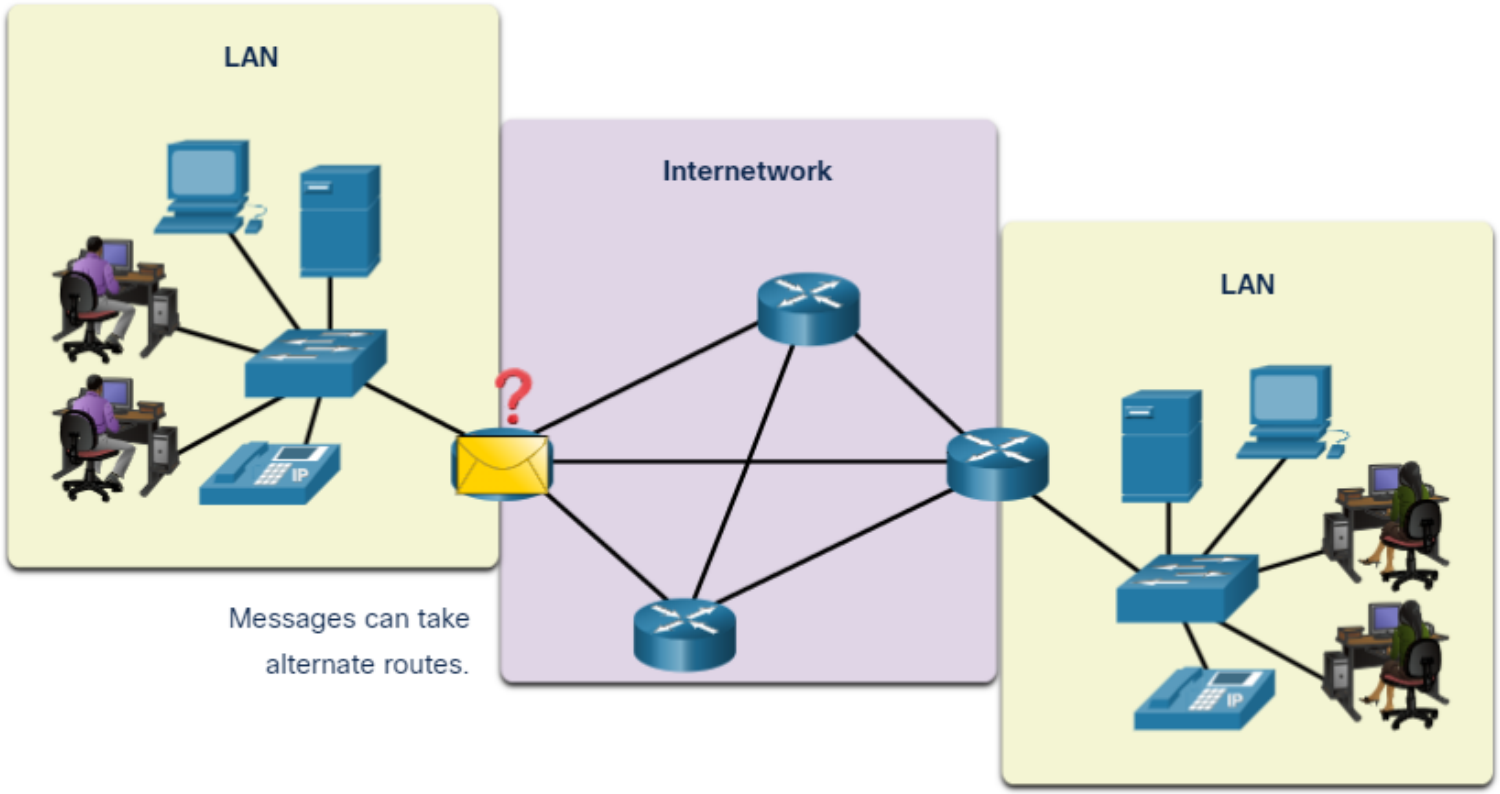
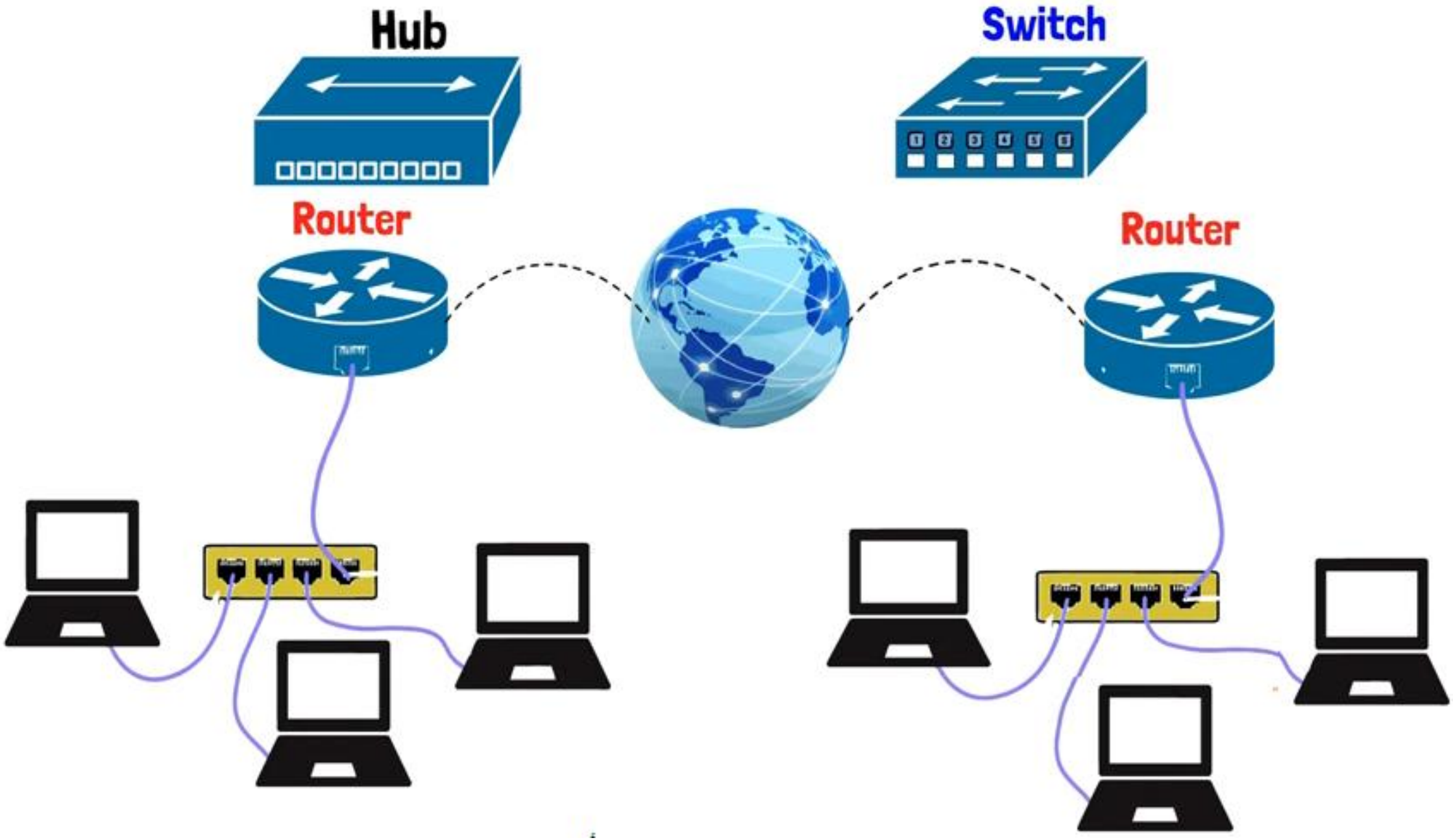
Lecture 3
Introduction to Routing

Switching Vs Routing






Hub
Switch
Router
Router

Switching	Routing
Hop to hop	End to end
Layer 2 data link	Layer 3 network layer
Mac address	IP address
Mac table	Routing table

Interface	Mac Address

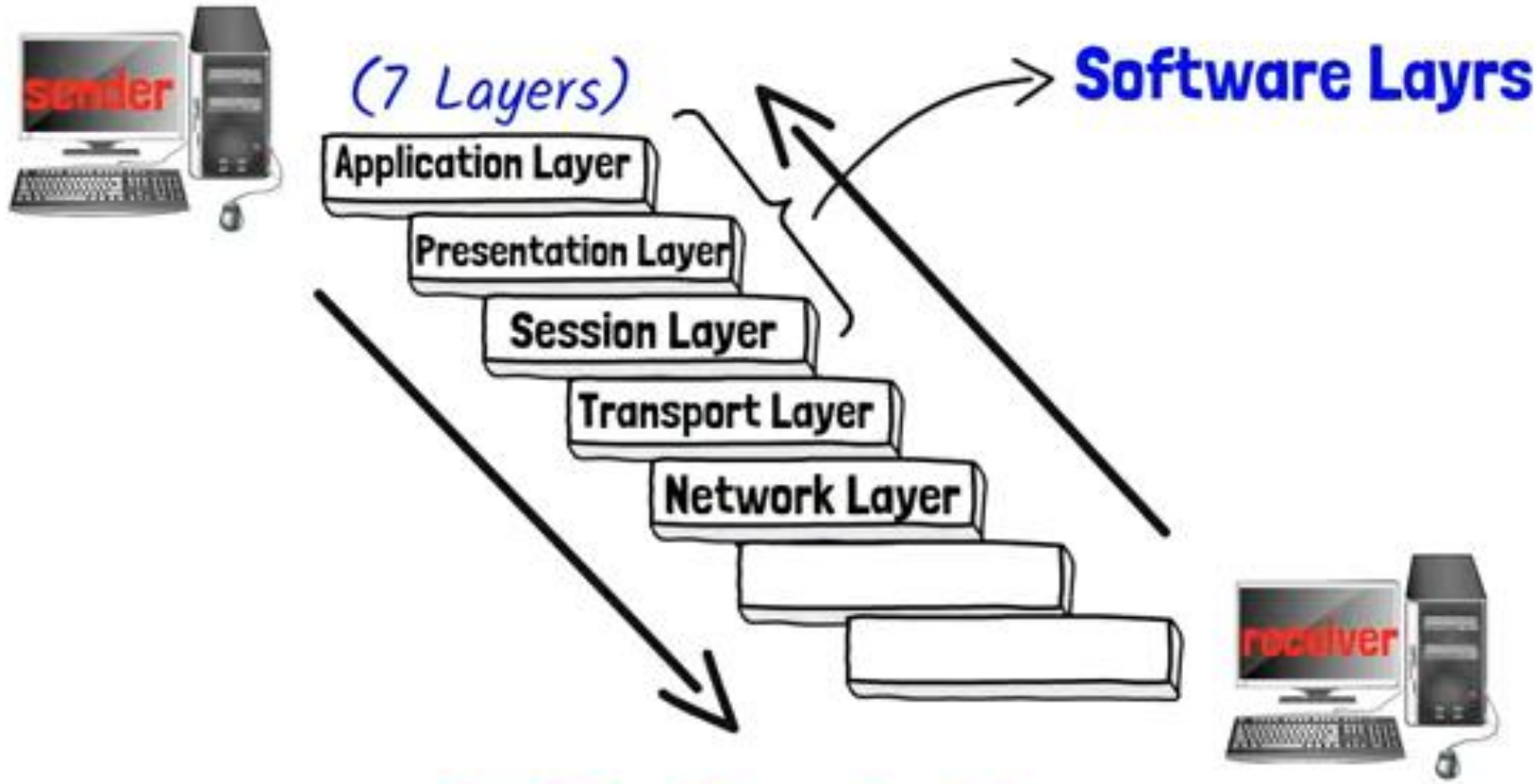
Interface	IP Network

Module Objectives

Module Title: Routing Concepts

Module Objective: Explain how routers use information in packets to make forwarding decisions.

Topic Title	Topic Objective
Path Determination	Explain how routers determine the best path.
Packet Forwarding	Explain how routers forward packets to the destination.
Basic Router Configuration Review	Configure basic settings on a router.
IP Routing Table	Describe the structure of a routing table.
Static and Dynamic Routing	Compare static and dynamic routing concepts.

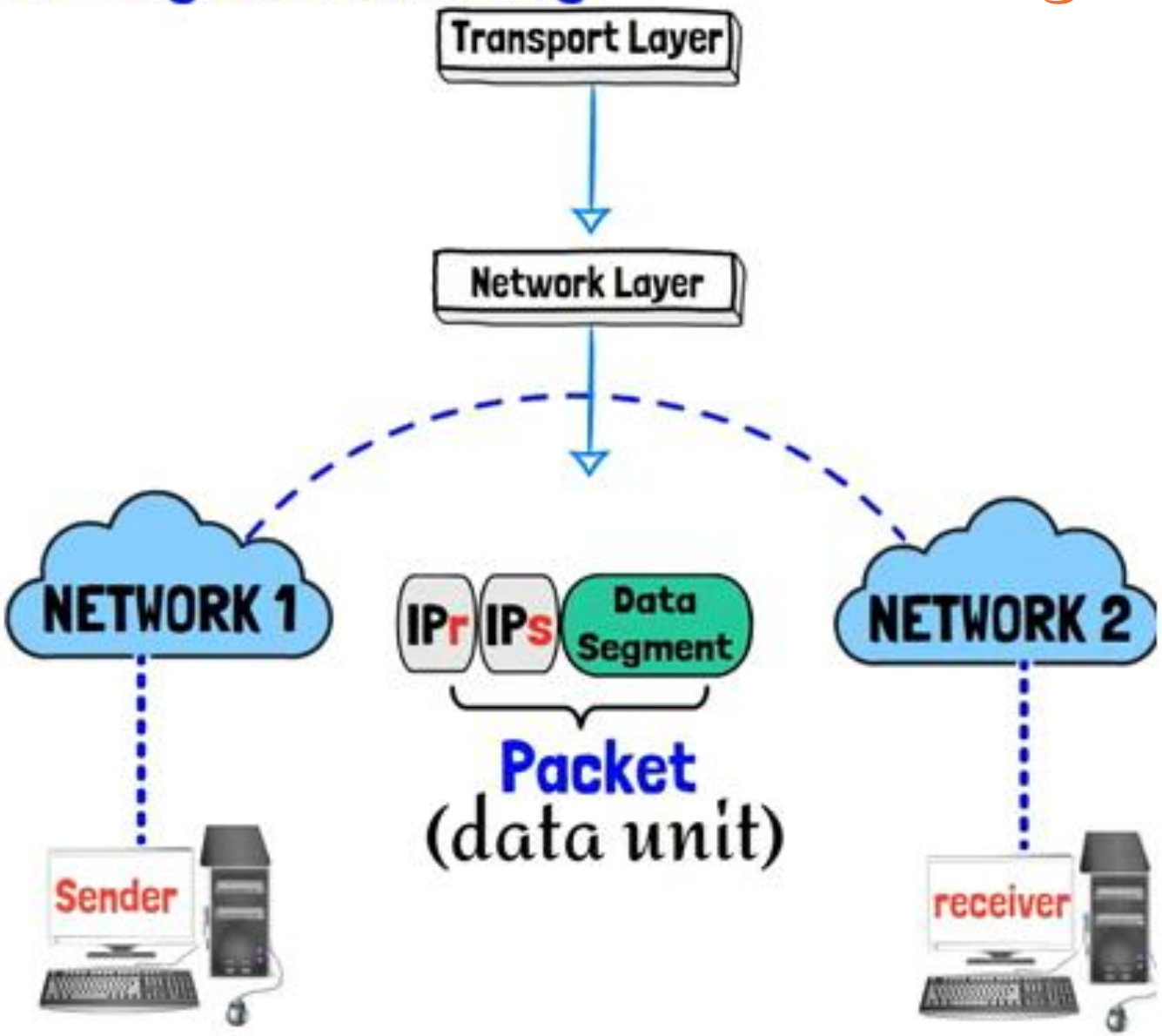


OSI Model

(Open Systems Interconnection)

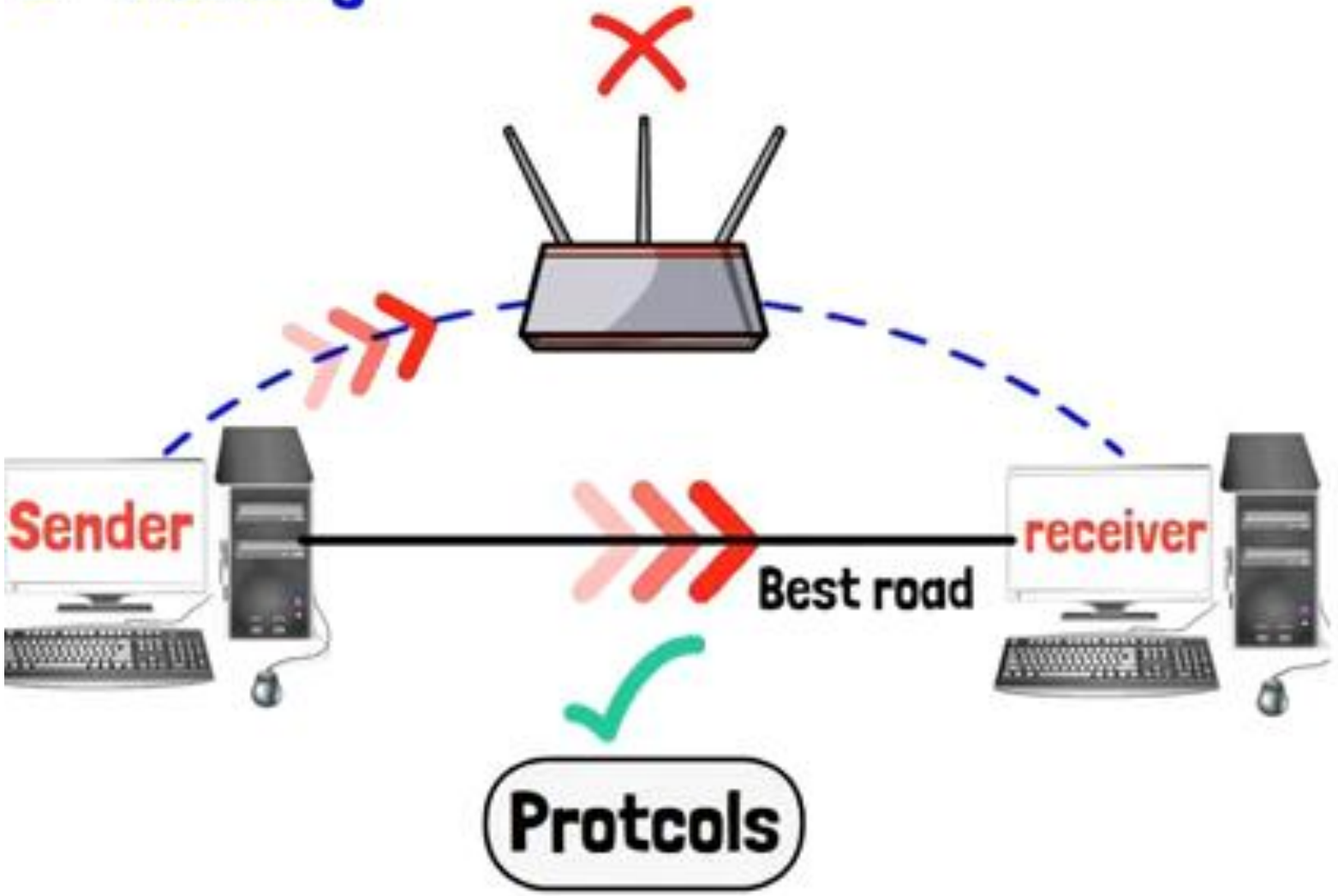
1- Logical Addresing

IP Addressing



2- Routing

Select the best path for signal



Path Determination

© 2016 Cisco and/or its affiliates. All rights reserved. Cisco Confidential

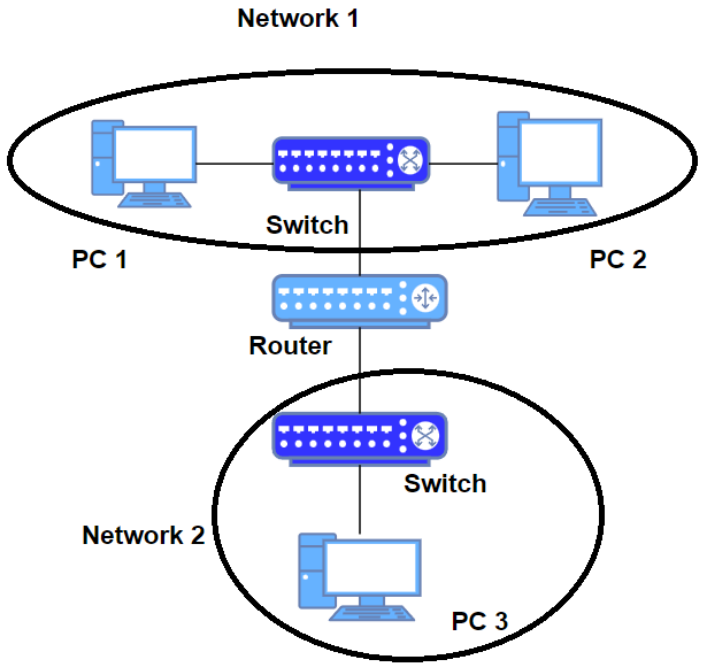
Routing is the process of path determination in any network. A computer network is made of many machines, called ***nodes***, and paths or links that connect those nodes. Communication between two nodes in an interconnected network can take place through many different paths

The primary functions of a router are to determine the best path to forward packets based on the information in its routing table, and to forward packets toward their destination.

عملية اختيار مسار لحركة البيانات
ضمن شبكة ما، وبين أو عبر عدّة شبكات

A router

- **is a device that acts as a gateway to a network and is also responsible for forwarding packets or messages to destination addresses. In addition, a router determines the best routes for forwarding packets *based on the information stored in its routing table:***
  - Router select best path
  - Router forward the packet
  - Router has processor, memory and operating system
  - Rerouting the packet in case failing the routing path
  - Act as simple firewall
  - Monitor network traffic



How Router Select The Best Path?

1. Longest prefix match
2. Metrics
3. Administrative distance

Longest prefix match

192.168.0.0/20



Network Address
Prefix
Class C

Prefix length

Best path means
longest prefix

Longest Prefix Match

When a packet destined for the IP address 192.168.1.10:

THE SHORTEST RANGE THAT CONTAINS THE DESTINATION IP

Routing Table:

Contain the range of IP 192.168.1.10

Not contain the range of IP

```
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)
```

The best path

IPv4 Longest Match Example

In the table, an IPv4 packet has the destination IPv4 address 172.16.0.10. The router has three route entries in its IPv4 routing table that match this packet: 172.16.0.0/12, 172.16.0.0/18, and 172.16.0.0/26. Of the three routes, 172.16.0.0/26 has the longest match and would be chosen to forward the packet. For any of these routes to be considered a match there must be at least the number of matching bits indicated by the subnet mask of the route.

Destination IPv4 Address		**Address in Binary**
172.16.0.10		**10101100.00010000.00000000.00**001010
Route Entry	Prefix/Prefix Length	Address in Binary
1	172.16.0.0**/12**	**10101100.0001**0000.00000000.00001010
2	172.16.0.0**/18**	**10101100.00010000.00**000000.00001010
3	172.16.0.0**/26**	**10101100.00010000.00000000.00**001010

IPv6 Longest Match Example

An IPv6 packet has the destination IPv6 address 2001:db8:c000::99. This example shows three route entries, but only two of them are a valid match, with one of those being the longest match. The first two route entries have prefix lengths that have the required number of matching bits as indicated by the prefix length. The third route entry is not a match because its /64 prefix requires 64 matching bits.

Destination	**2001:db8:c000::99/48**	
Route Entry	Prefix/Prefix Length	Does it match?
1	**2001:db8:c0**00::**/40**	Match of 40 bits
2	**2001:db8:c000**::**/48**	Match of 48 bits (longest match)
3	**2001:db8:c000**:5555::**/64**	Does not match 64 bits

Metric

- If there are two paths with *same prefix* and *same protocol*
- We can select one of them by **metric**
- Metric is number represent the ***cost of the path***
- The metric number is determined by protocols
- In case metric is equal for two paths then make load balance

Routing protocol	The way to calculate the metric	The best value
RIP	Counting hops	minimum
OSPF	BW	maximum
EIGRP	BW, Load and Reliability	Maximum

Best Path

The best path is selected by a routing protocol based on the value or metric it uses to determine the distance to reach a network. A metric is the quantitative value used to measure the distance to a given network. The best path to a network is the path with the lowest metric.

Dynamic routing protocols typically use their own rules and metrics to build and update routing tables. The following table lists common dynamic protocols and their metrics.

Routing Protocol	Metric
Routing Information Protocol (RIP)	•The metric is "hop count". •Each router along a path adds a hop to the hop count. •A maximum of 15 hops allowed.
Open Shortest Path First (OSPF)	•The metric is "cost" which is the based on the cumulative bandwidth from source to destination. •Faster links are assigned lower costs compared to slower (higher cost) links.
Enhanced Interior Gateway Routing Protocol (EIGRP)	•It calculates a metric based on the bandwidth and delay values. •It could also include load and reliability into the metric calculation.

Administrative distance (AD)

- If there are two paths with *same prefix* and *same protocol*
- The metric is calculated in different way related to its protocol
- AD is number value represent trustworthiness or priority to the best path
- The best path is assign to the lowest value of AD
- In case AD is equal for two paths then make load balancing

Administrative Distance (Cont.)

The table lists various routing protocols and their associated ADs.

Route Source	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

Load Balancing

When a router has two or more paths to a destination with equal cost metrics, then the router forwards the packets using both paths equally. This is called equal cost load balancing.

- The routing table contains the single destination network, but has multiple exit interfaces, one for each equal cost path. The router forwards packets using the multiple exit interfaces listed in the routing table.
- If configured correctly, load balancing can increase the effectiveness and performance of the network.
- Equal cost load balancing is implemented automatically by dynamic routing protocols. It is enabled with static routes when there are multiple static routes to the same destination network using different next-hop routers.

Note: Only EIGRP supports unequal cost load balancing.

sheet

Put True or false

1. routing table is very important for switch ()
2. Mac address is unique and used in switch ()
3. Router used in layer 2 data link layer ()
4. Administrative address represents the priority of routing ()
5. Using the cost to determine the best path is done by load balancing ()
6. Metric is different by used protocol ()
7. The minimum bandwidth is the best path ()
8. Equal the metric although using different protocol means need to use AD ()