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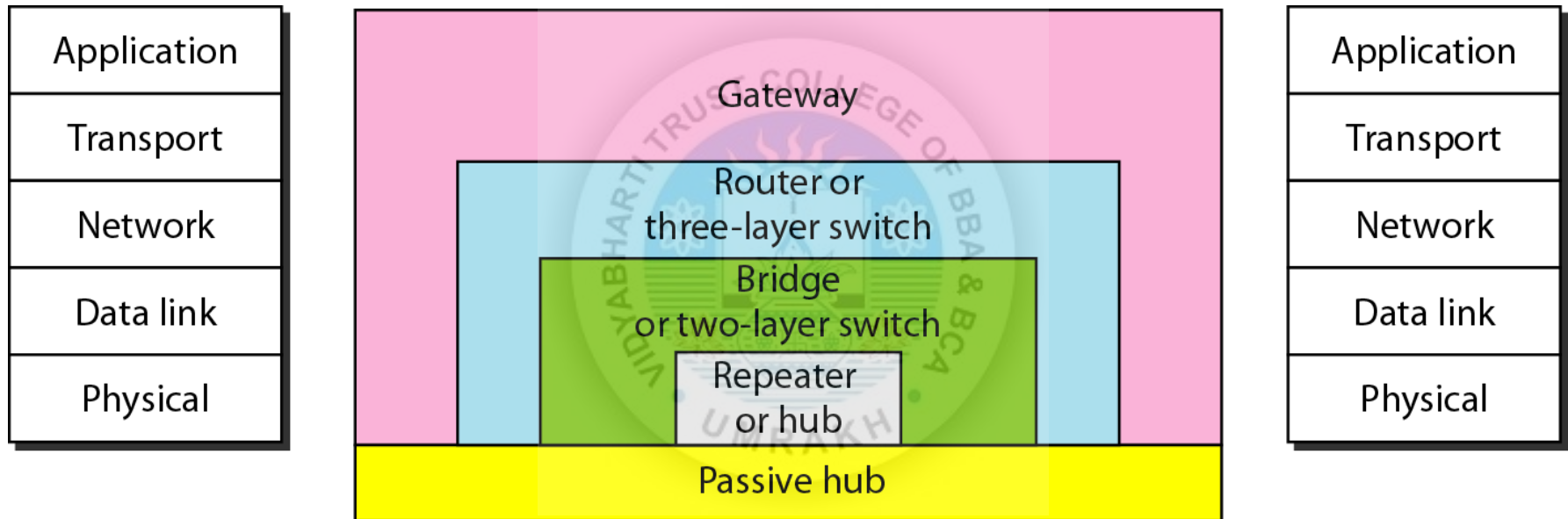
# Internetworking Devices



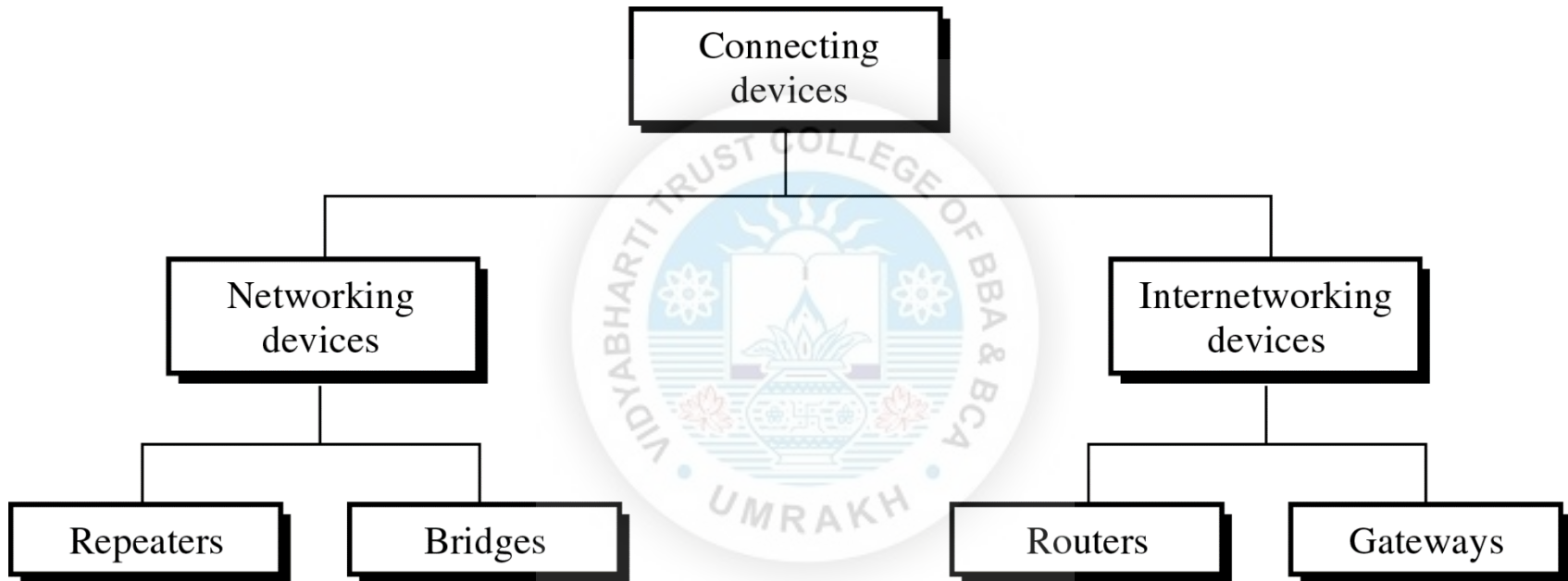
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By Amit Patel

# Connecting Devices and the OSI Model



# Connecting Devices



# Connecting Devices

- When two or more separate network are connected for exchanging data or resources , they become an internetwork.
- To linking a number of LAN require following internetworking devices.
  - Repeater
  - Hub
  - Switch
  - Bridge
  - Router
  - Gateway

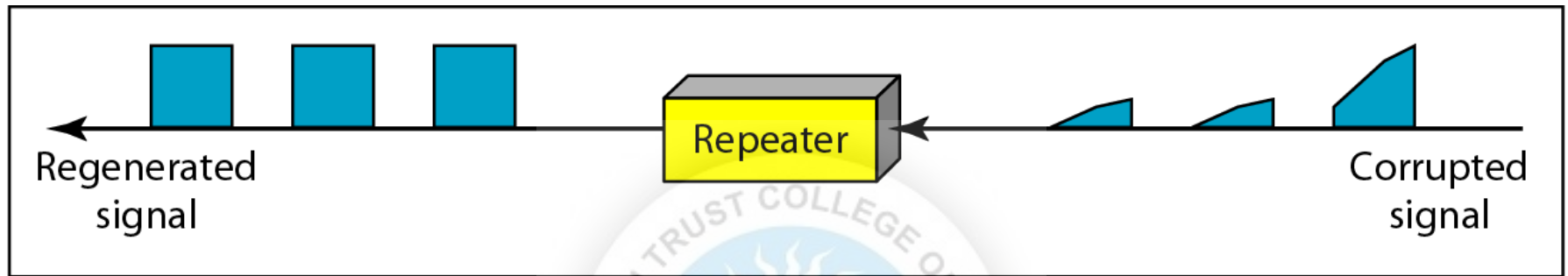


# Why Interconnect LAN?

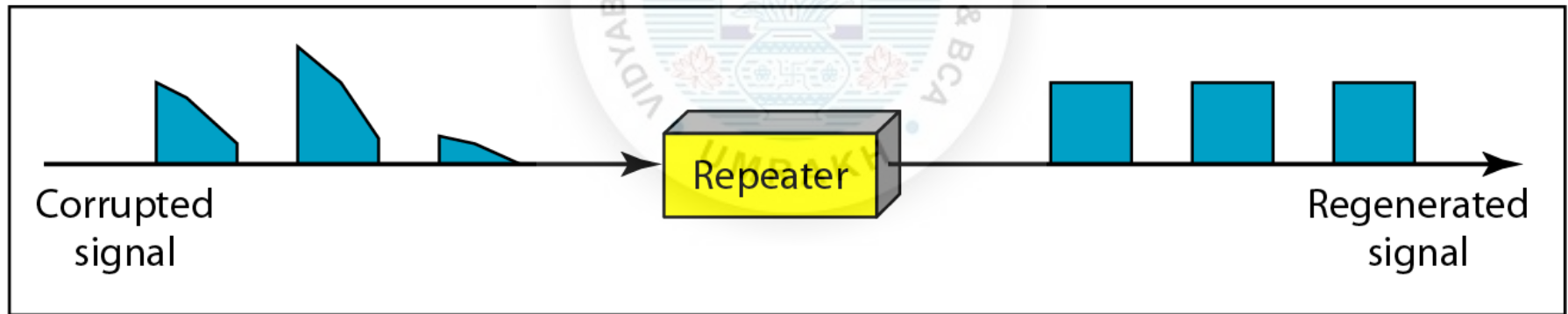
- To separate / connect one corporate division with another.
- To connect two LANs with different protocols.
- To connect a LAN to the Internet.
- To break a LAN into segments to relieve traffic congestion.
- To provide a security wall between two different types of users.
- To connect WLAN to LAN

# Repeater ( Regenerator )

- Repeater is an electronic device.
- Operate on **Physical layer** of OSI layer
- Signal that carry information within a network can travel fixed distance before signal weak.
- Repeater installed on link receive the signal before it becomes weak.
- Repeater **regenerate the original bit pattern and put refreshed copy on the link.**
- To extend only physical length of the network.



a. Right-to-left transmission.



b. Left-to-right transmission.

# Repeater

- Used in LAN to **connect cable segments** and **extend the maximum cable length** to extending the **geographical LAN range**
  - ❑ Ethernet 10base5 – Max. segment length 500m – 4 repeaters (5 segments) are used to extend the cable to **2500m**)
  - ❑ Ethernet 10Base2- Max. segment length 185m - 4 repeaters (5 segments) are used to extend the cable to **925m**





Figure 3-2: Back Panel



# Continue...

- Repeater must be placed so that signal reaches it before any noise may change the meaning of bits.
- No filtering capability.
- Repeater is not a amplifier because
  - ❑ Amplifier can't differentiate between signal and noise, it amplifies equally everything equally.
  - ❑ A repeater regenerate signal only. When it receive a weekend or corrupted signal , it create a new copy bit for bit

# ADVANTAGES

## ■ Advantages of a repeater

- ❑ Simple to connect
- ❑ Cost effective
- ❑ Ability to strengthen signal

## ■ Disadvantages of a repeater

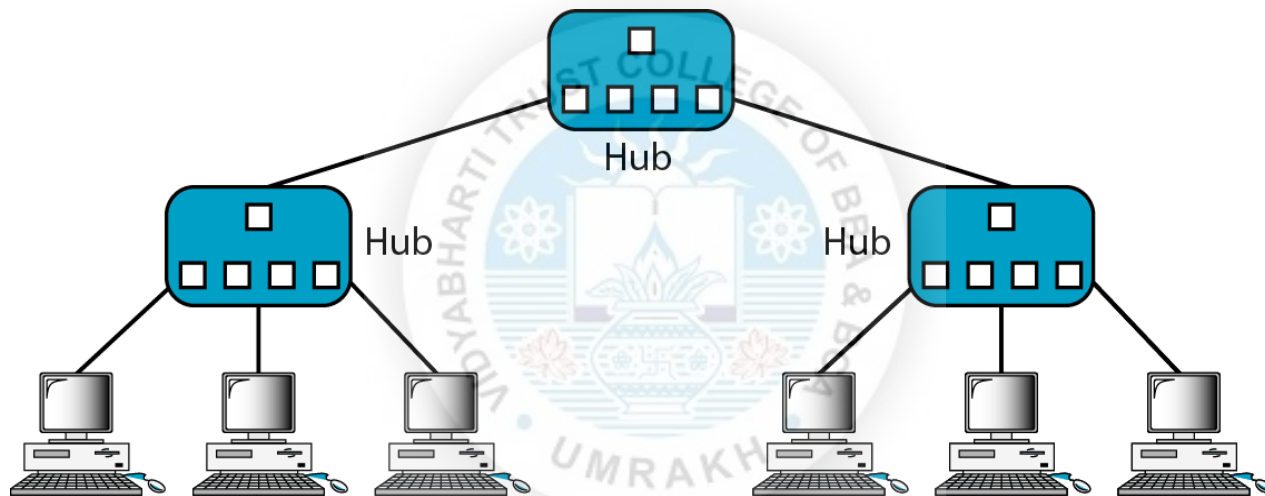
- ❑ Repeaters provide no method for isolating traffic generated on one cable segment from traffic generated by the other cable segment.
- ❑ When network uses a repeater to connect cable segment A to segment B whether or not there is a station in segment B that is the destination of the signal

# HUB

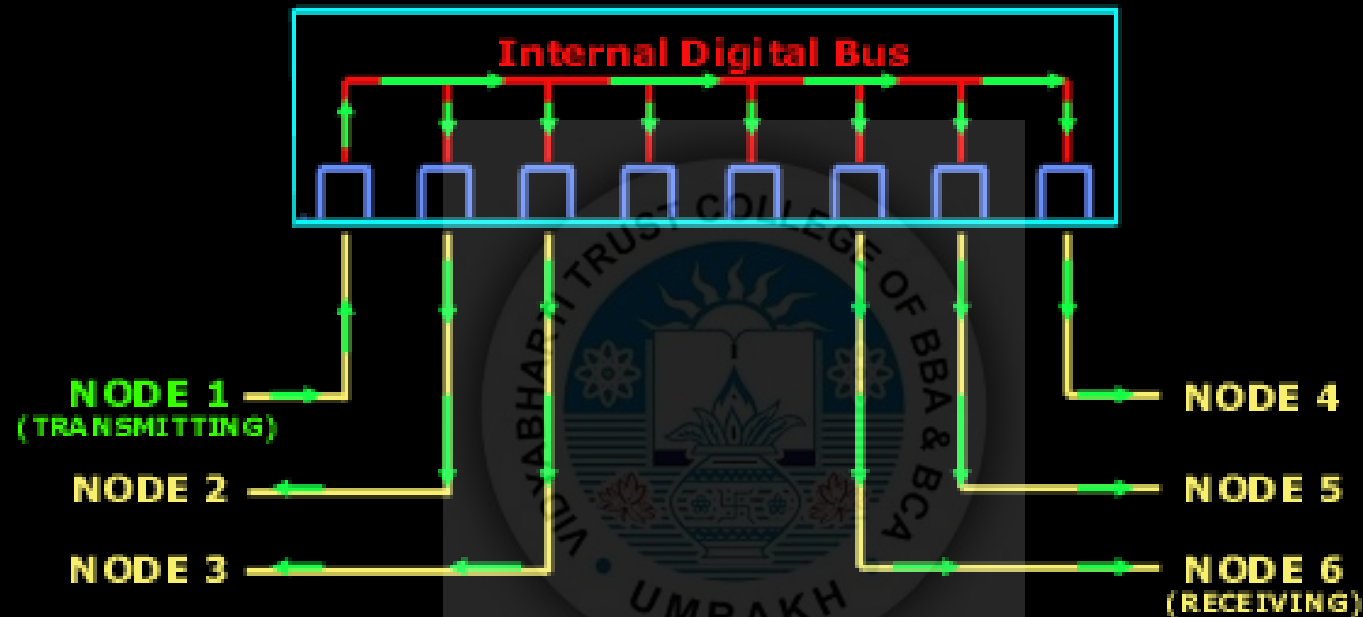
- Acts on the physical layer
- Operate on bits rather than frames
- Also called **Multiport Repeater**
- Used to connect stations adapters in a physical star topology but logically bus
- Hub receives a bit from an adapter and sends it to all the other adapters without implementing any access method.
- Does not do filtering (forward a frame into a specific destination or drop it) just it copy the received frame onto all other links

# HUB

- Multiple Hubs can be used **to extend** the network length

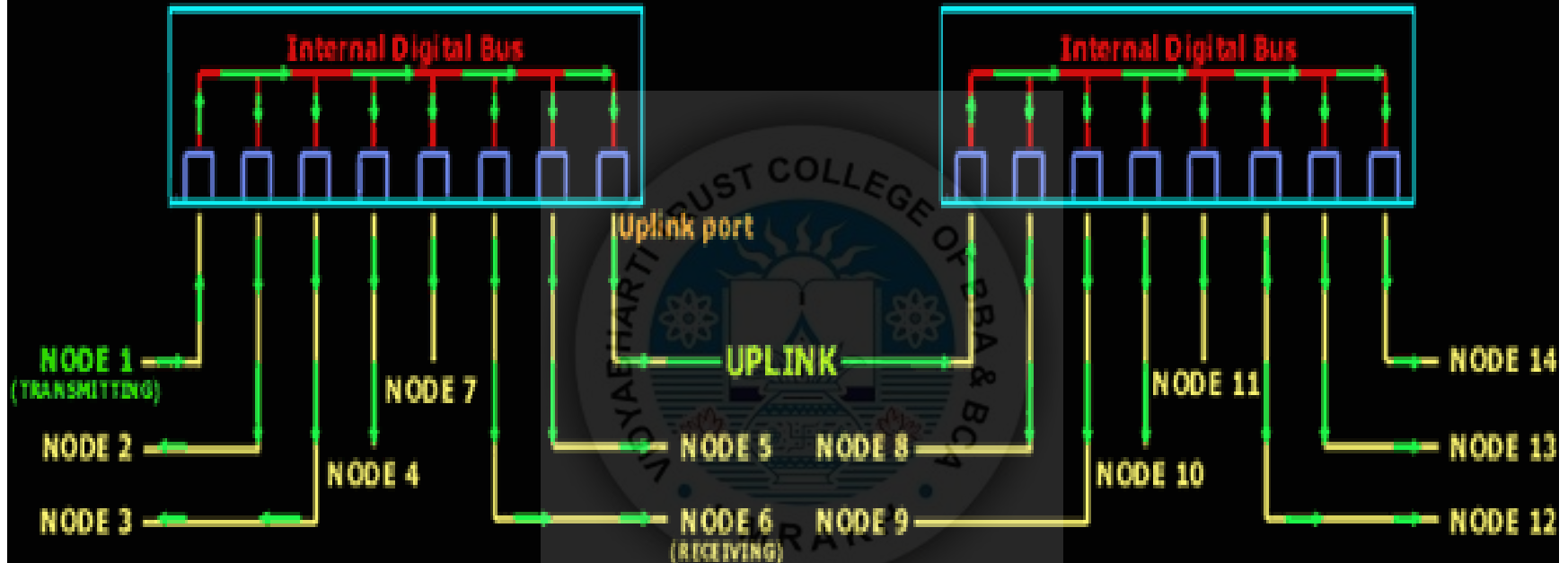


## How Hubs work



Every node here is part of the same collision and broadcast domain

## Daisy chaining Hubs together



Every node here is part of the same collision and broadcast domain

# Types of HUB

- There are two types of HUB
  - Active Hub
  - Passive Hub





# Difference

ACTIVE HUB	PASSIVE HUB
The Hub which has a Repeater in it is known as an Active Hub.	the Hub which is without Repeater is called as Passive Hub.
It is known as “Multiport Repeater”	It is known as “Concentrator”
Amplify the electrical signal of incoming packets before broadcasting them out to the network.	do not amplify the electrical signal of incoming packets before broadcasting them out to the network.
It is expensive	It is cheaper then Active Hub.
Active hubs also help in troubleshooting at a certain level	It is very hard to get any help from the passive hubs while troubleshooting in case there is any fault in the hardware or the network.

# Bridges

- Operate on both **Physical and Data link layer** of OSI model.
- Work with MAC Address.
- **Filters data traffic at a network boundary.**
- **Bridges reduce the amount of traffic on a LAN by dividing it into two segments.**
- Intelligent than repeater
- Contain logic that allow them to keep traffic of each segment separate.
- Provide – security, filter traffic , controlling congestion, isolation problem link.

# Bridge

- When a frame enters a bridge, the bridge not only **regenerate** the signal but check the address of the destination and **forward** the new copy to the segment to which address belongs.
- Bridge does not send the received frame to all other interfaces like hubs and repeaters, but it performs **filtering** which means:
  - Whether a frame should be **forwarded** to another interface that leads to the destination or **dropped**
- This is done by a bridge table (**forwarding table**) that contains entries for the nodes on the LAN
  - The bridge table is **initially empty** and **filled automatically** by **learning from frames movements** in the network

# Bridge

- An entry in the bridge table consists of : **MAC Address, Bridge Interface to which the node is connected to, the record creation time**

Address	Interface	Time
62-FE-F7-11-89-A3	1	9:32
7C-BA-E2-B491-10	3	9:36
...	...	...

- A bridge runs **CSMA/CD** before sending a frame onto the link not like the hub or repeater
- Bridge frame handling is done in **software**

# Bridge

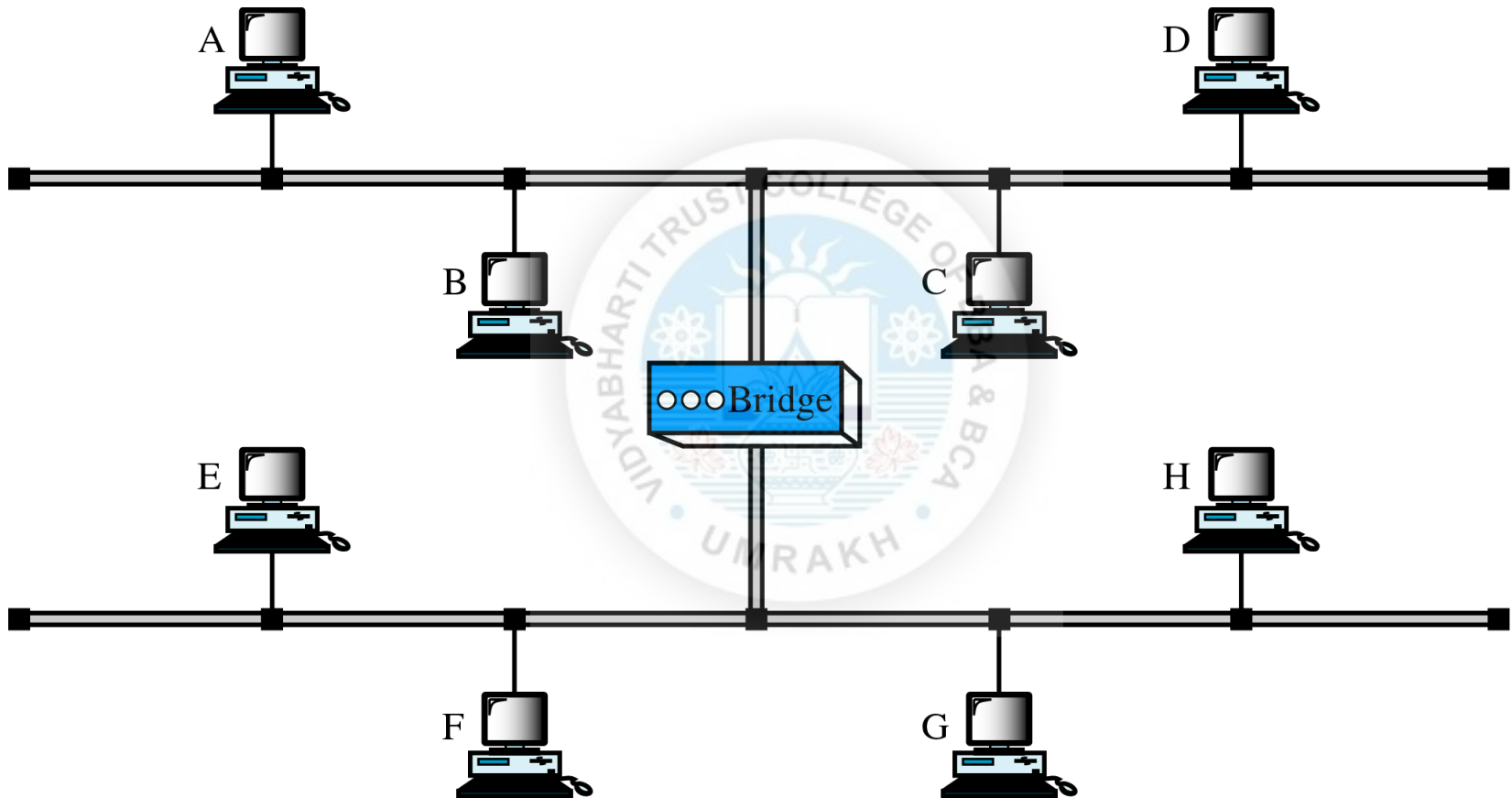


Figure 15.6 A learning switch and the process of learning

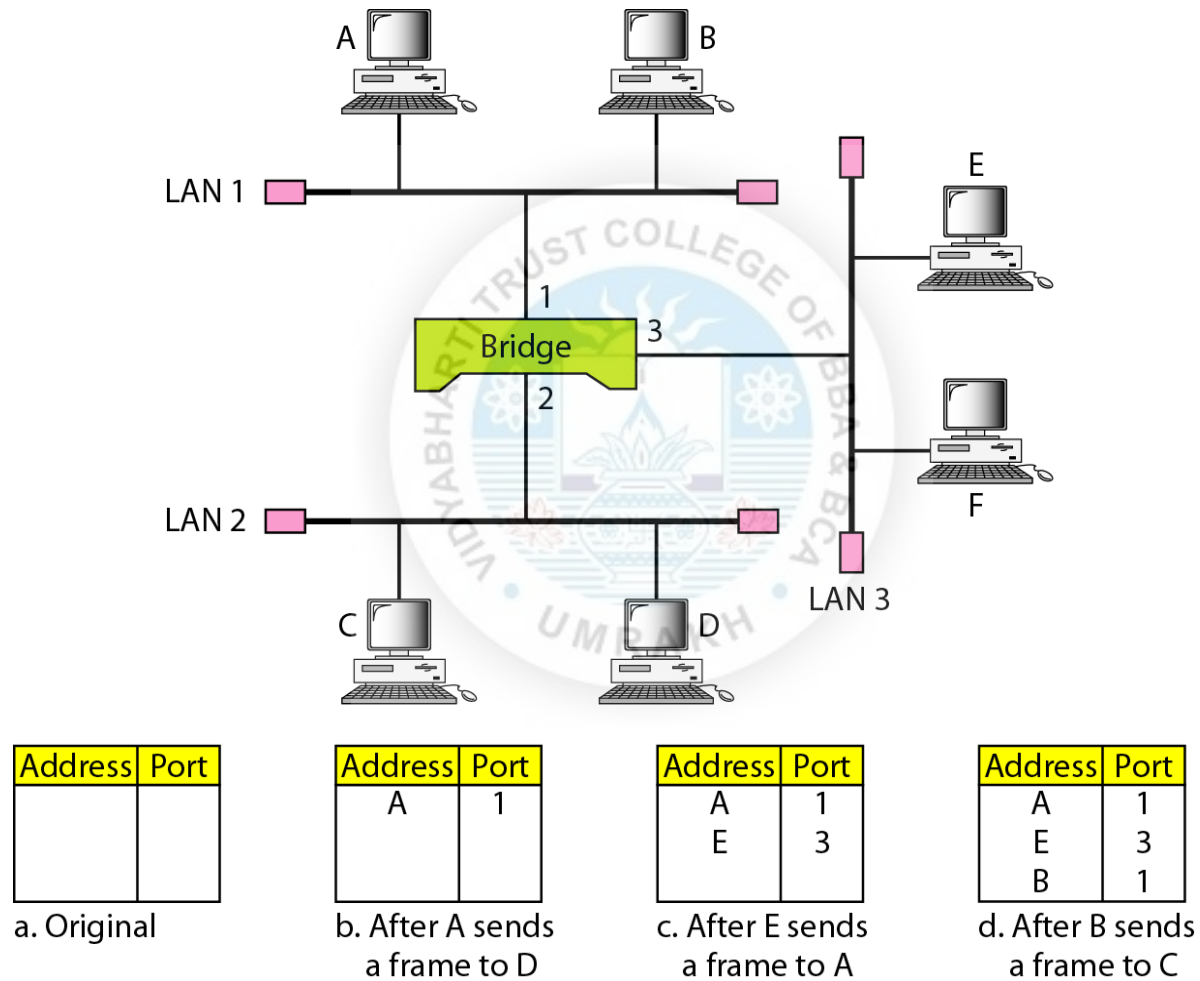
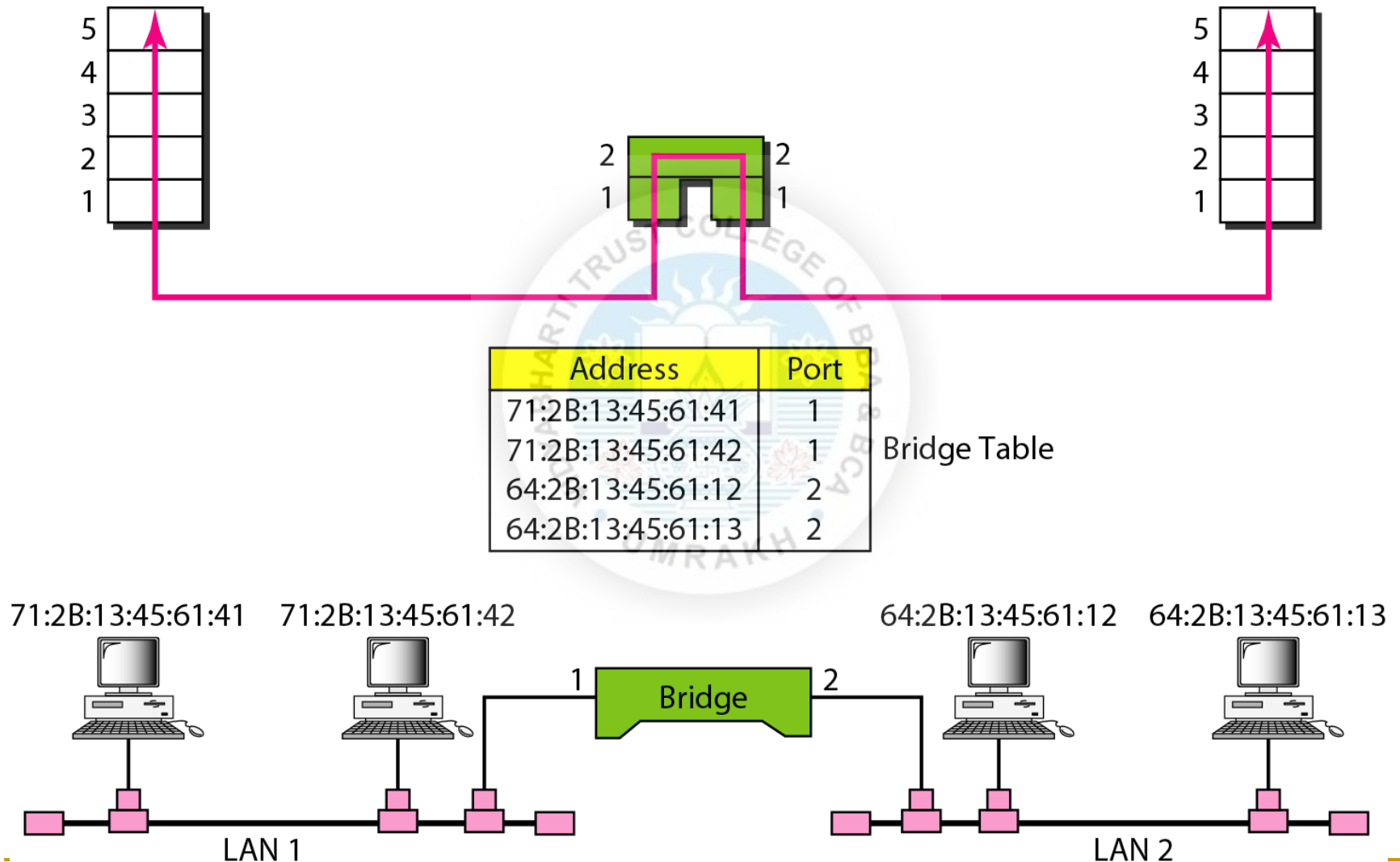
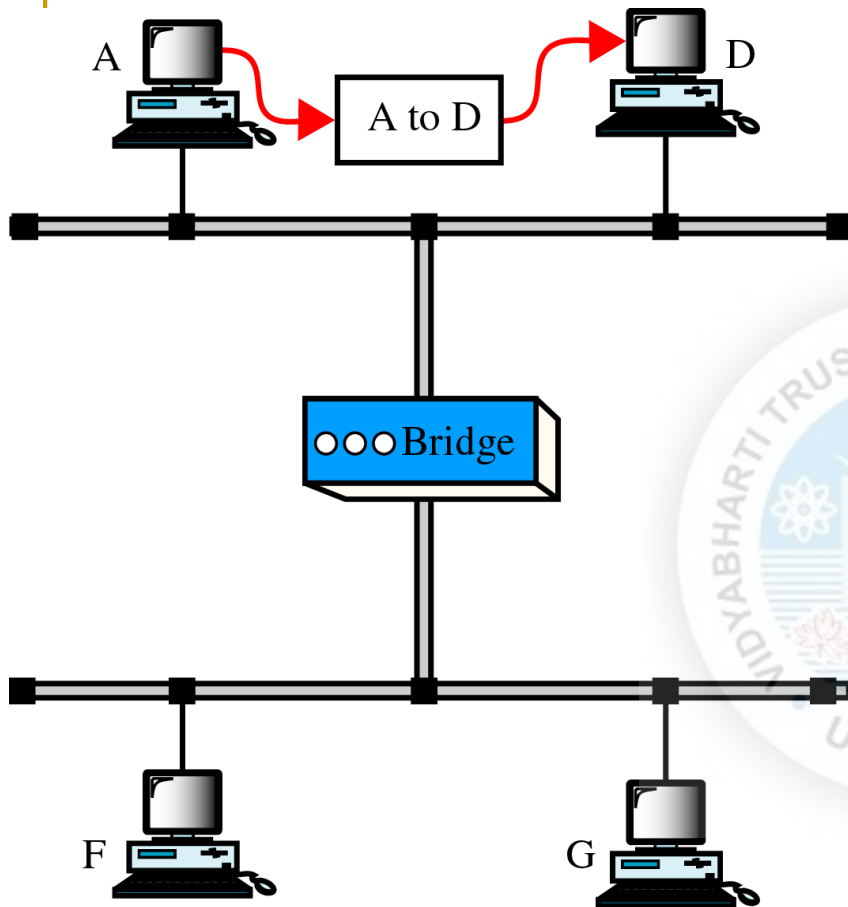
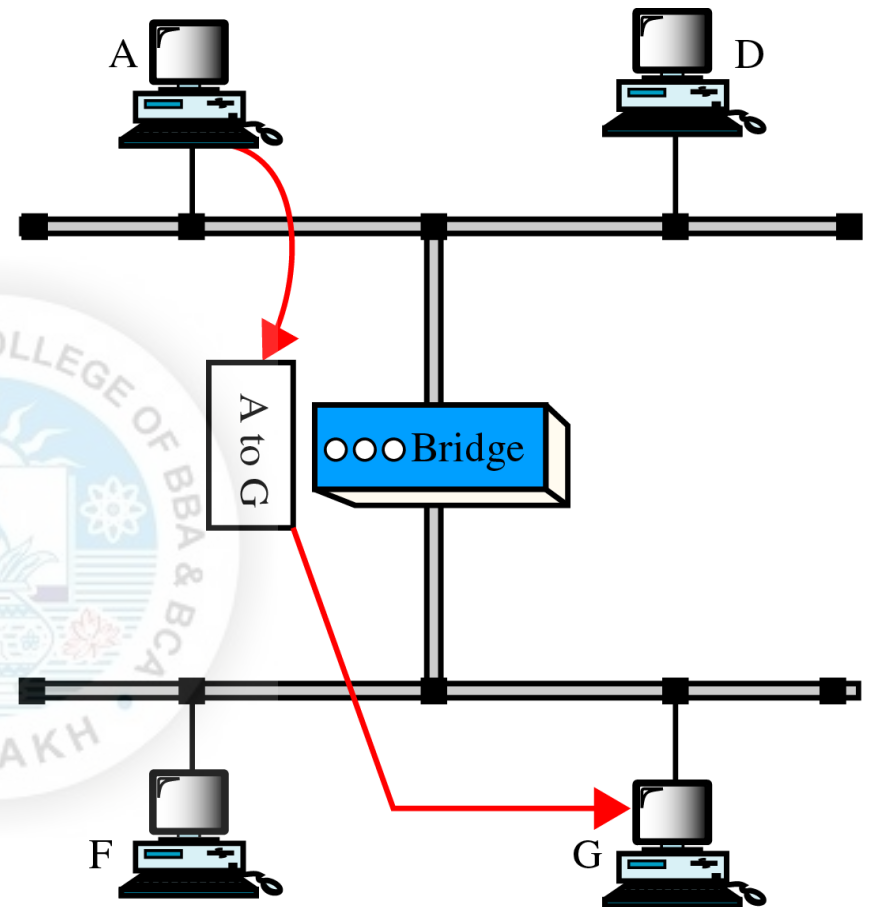


Figure 15.5 A bridge connecting two LANs





a. A packet from A to D



b. A packet from A to G



# Bridge

- In figure, bridge join two segment.
- A packet from station A addressed to station D arrive at bridge. Station A is on the same segment as station D, so packet is blocked from crossing into the lower segment. Instead the packet is relayed to entire upper segment.
- In next figure, a packet generated by station A is intended for station G. The bridge allow the packet to cross and relay it to the entire lower sement. Where it is received by station G.

# Bridge

- A bridge may implement an **interface table** using a software data structure or use a **Contents Addressable Memory (CAM) chip**.
- In either case, the size of the table is finite, and usually constrained to 1000's - 10 000's of entries.
- In a large LAN this may be a limit. To help keep the table small, most bridges maintain a check of how recently each address was used. Addresses which have not been used for a long period of time (e.g. minutes) are deleted.

# Switch

- Also work at Physical and Data link layer of OSI Model.
- It is also known as multiport bridge.
- N-Port bridge where N is equal to number of stations.
- **Function:** Usually used to connect individual computers not LANs like bridge
- Use **Filter Table** to forward traffic in LAN.
- Use **ASIC** ( Application Specific Integrated Circuits ) to build and maintain filter table.

# Switch

- Using **Hardware address** of device on a LAN to forward the frame.
- Provide **independent bandwidth** to each port.
- Allows more than one device connected to the switch directly to transmit **simultaneously**
- Can operates in **Full-duplex** mode (can send and receive frames at the same time over the same interface)
- Performs MAC address recognition and frame forwarding in **hardware** (bridge in software)

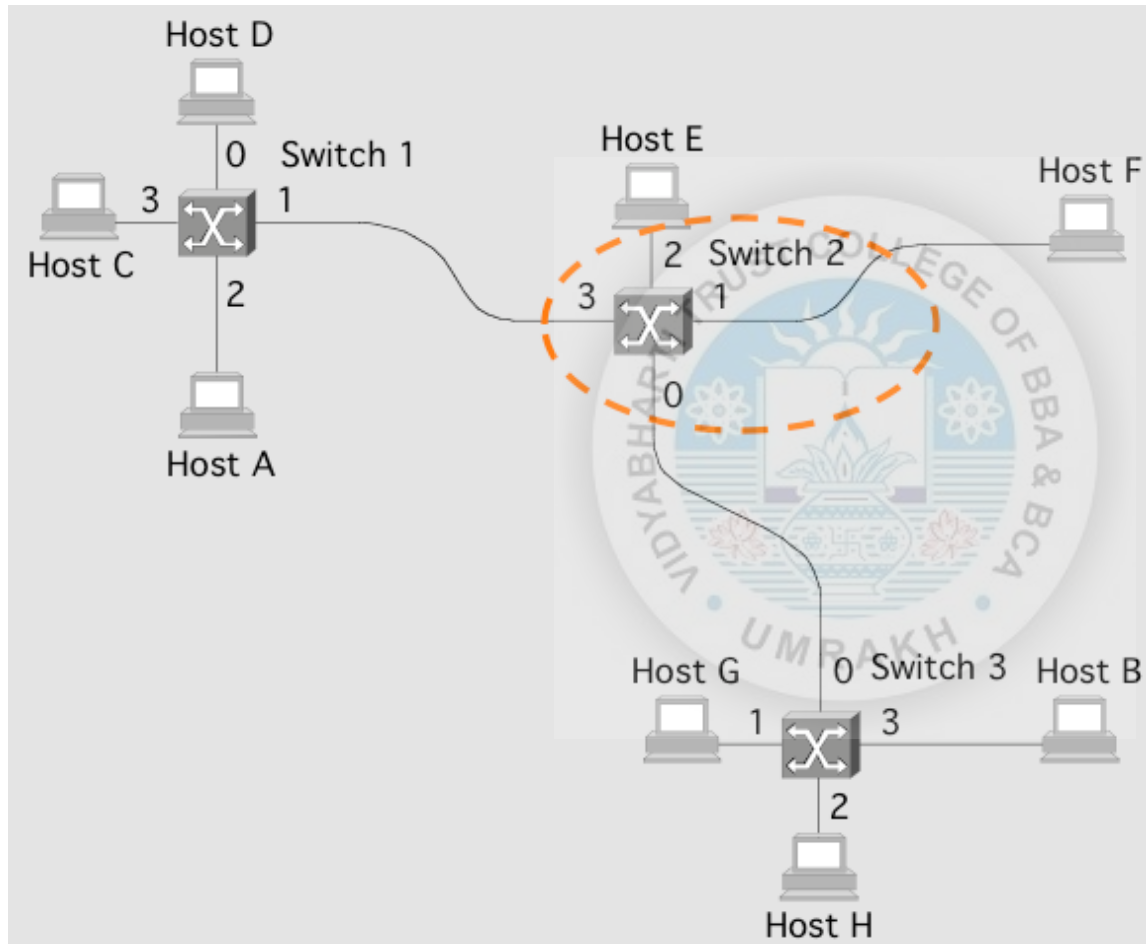
# Switch

- When the switch receives a frame, it compares the **source address** of the frame with each entry in the forwarding table
  - If **No match is found**, the switch will **add** to the table the frame **source address** and the **Interface** on which the frame **was received**.
  - If a **match is found**, the switch **updates** the **Interface number** on which the frame was received if **it is different** from the one in the table . Also it **updates** the **record time**

# Switch

- Then, the switch compares the **destination address** of the frame with each entry in the **forwarding table (MAC table)**
  - If a match is found then
    - The bridge compares the **interface number** on which the frame was received and the interface number in the table, if they are **different** the bridge **forwards** the frame through the interface number stored in the table. Otherwise, if they are the **same** the switch **discards (drops)** the frame.
  - If no match is found, the switch **floods the frame** on **all interfaces** except the one on which the frame was received.

# Switch



Destination	Port
A	3
B	0
C	3
D	3
E	2
F	1
G	0
H	0

# Switch

- *Two types :*

- ❑ **Store-and-forward:** switch receives the whole a frame on the input line, buffers it briefly , performs error checking, then routes it to the appropriate output line (similar to bridge). **Buffering** will cause some **delay**.
- ❑ **Cut-through:** based on the fact that the destination address appears at the beginning of the MAC frame, so once the address is recognized the frame is directly sent to the appropriate output line if the output buffer is empty (no need to buffer it). ➔ no buffering delay ➔ NO ERROR CHECKING



# Switch Advantages – Disadvantages.

- Increases reliability, performance, and security.
- Increases geographical coverage
  - No limit on the size of the LANs connected through switches
- **Transparent:** installing or removing a switch does not require the stations networking software to be reconfigured.
- **(“plug-and-play”):** *no configuration necessary* at installation of switch /switch or when a host is removed from one of the LAN segments
- **Disadvantage:** switch does not allow multiple paths between LAN segments or between any two devices.

# Difference

SWITCH	BRIDGE
Switch has higher port than Bridge.	Bridge has less port than Bridge.
Switch are hardware based because they use ASIC chip to help make filtering decisions.	Bridge are software based.
Switch operate with higher speed than Bridge.	Bridge has lower speed than Switch.
Switch operate on half duplex or full duplex mode.	Bridge operate on half duplex mode.
Switch have many Spanning Tree instance.	Bridge can have only one Spanning Tree instance.

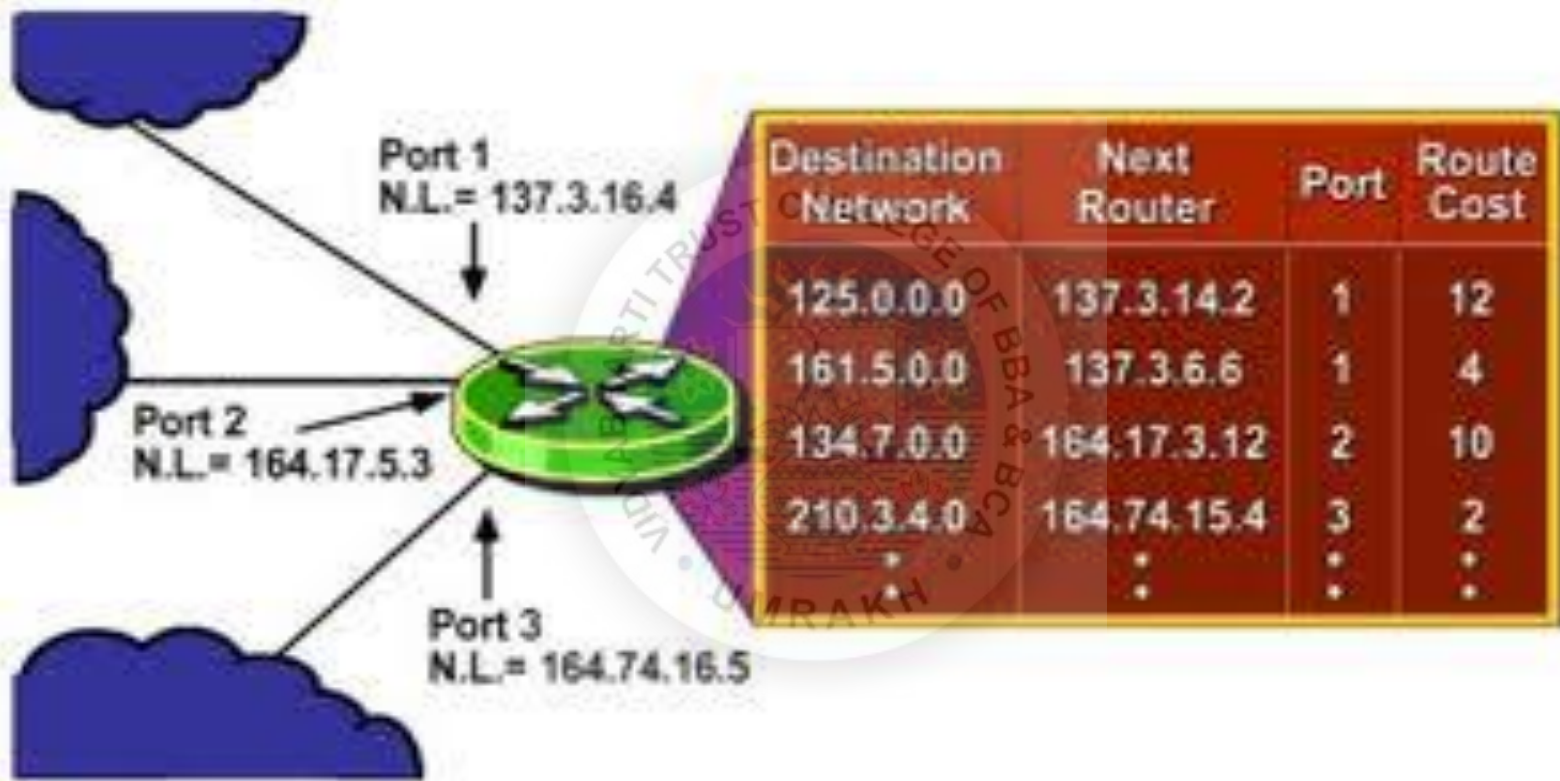
# Hub Vs Switch

- Hubs were the standard for connecting devices on a local area network (LAN).
- The problem with hubs was that everything that went through them had to share the bandwidth of the link.
- Bandwidth was wasted because all traffic was sent to all devices, and there were a lot of collisions because the hub didn't do anything to prevent them.
- A switch fixes these problems.

# Routers

- Operates at network layer = deals with **packets** not **frames**
- **Function:** Connect LANs and WANs with similar or different protocols together
- Responsible for Source to Destination delivery of packet.
- Routing traffic to all the network in your internetwork.
- Deals with global address – **IP Address**.
- Can't forward but route the packet.
- **Routing:** Process of finding a suitable path to moving packets from one network to another network
- Use **Routing table** to send packet to other network.

# Router



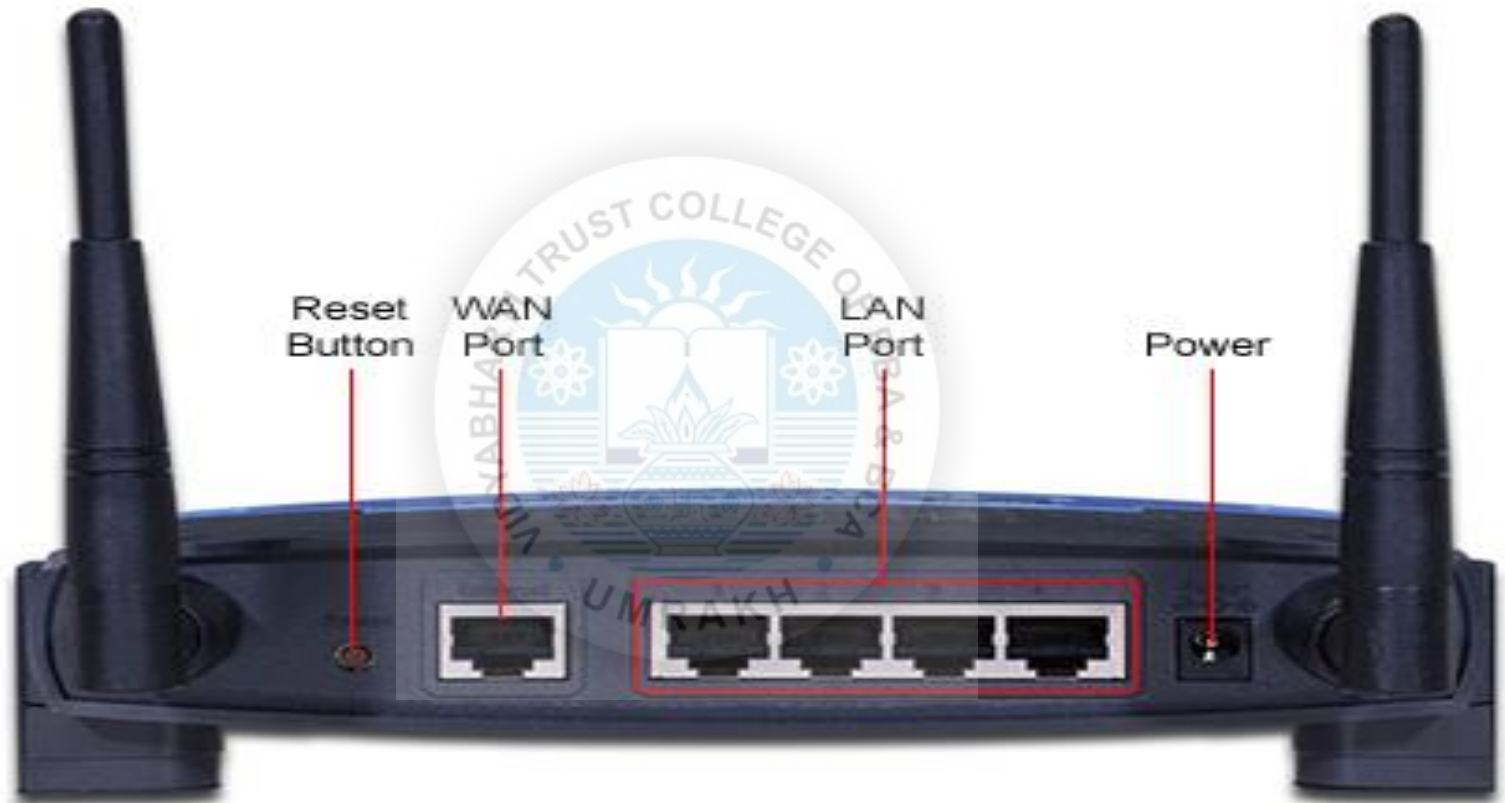
# Routing Table

- It is the heart of the router operation.
- The routing table contain following information
  - Address of all known network ( Destination Network ID )
  - Next router in the path to the network. ( IP Address of next router )
  - Interface of the router used to forward packet to network ( Port )
  - Cost of using this path ( Router Cost )

# Router

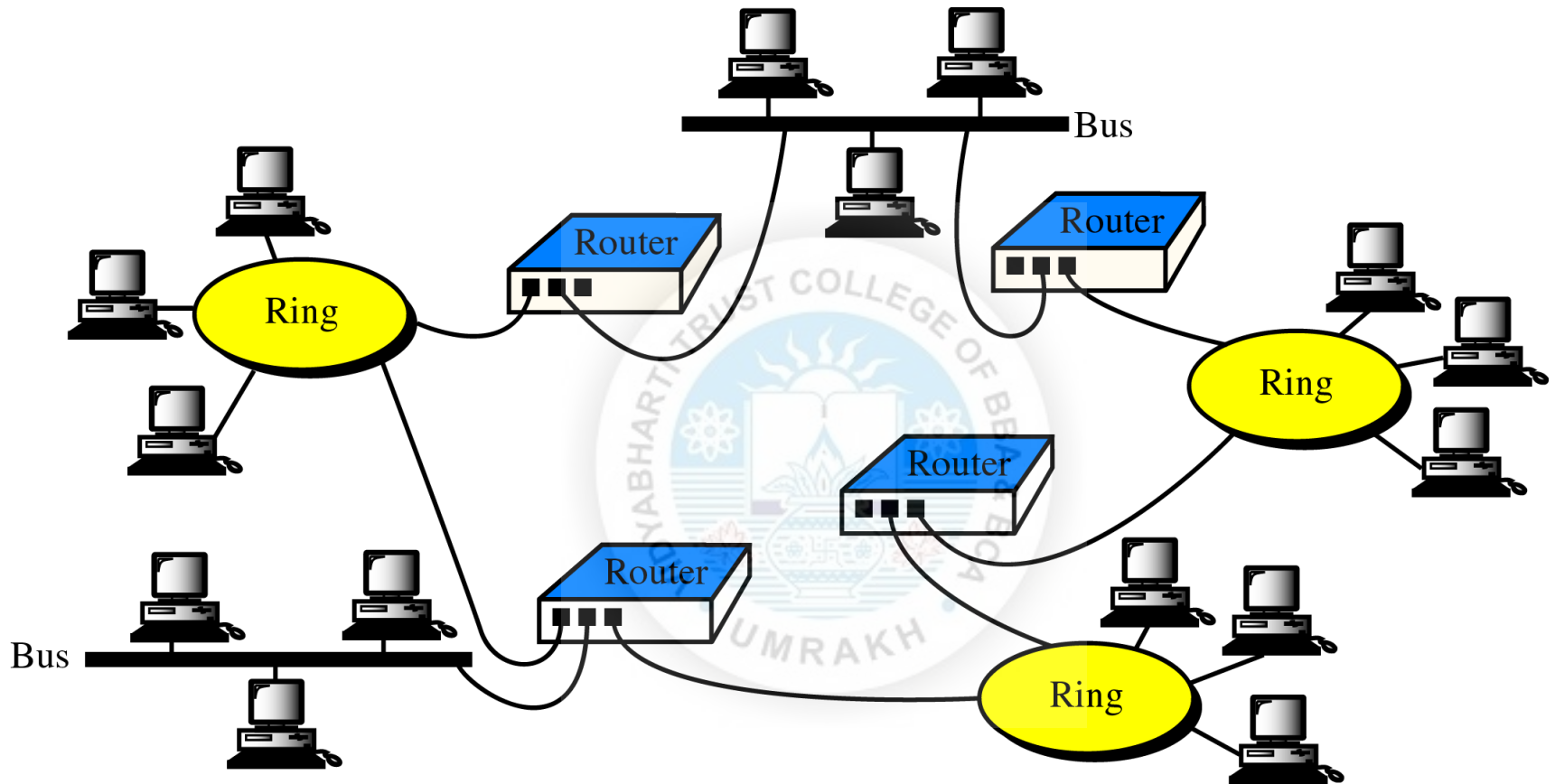
- Routers **Communicate with each other** and exchange routing information.
- Determine best route using **routing algorithm** by special software installed on them.
- **Forward traffic if information of destination** is available otherwise **discard** it (not like a switch or bridge).

# Router





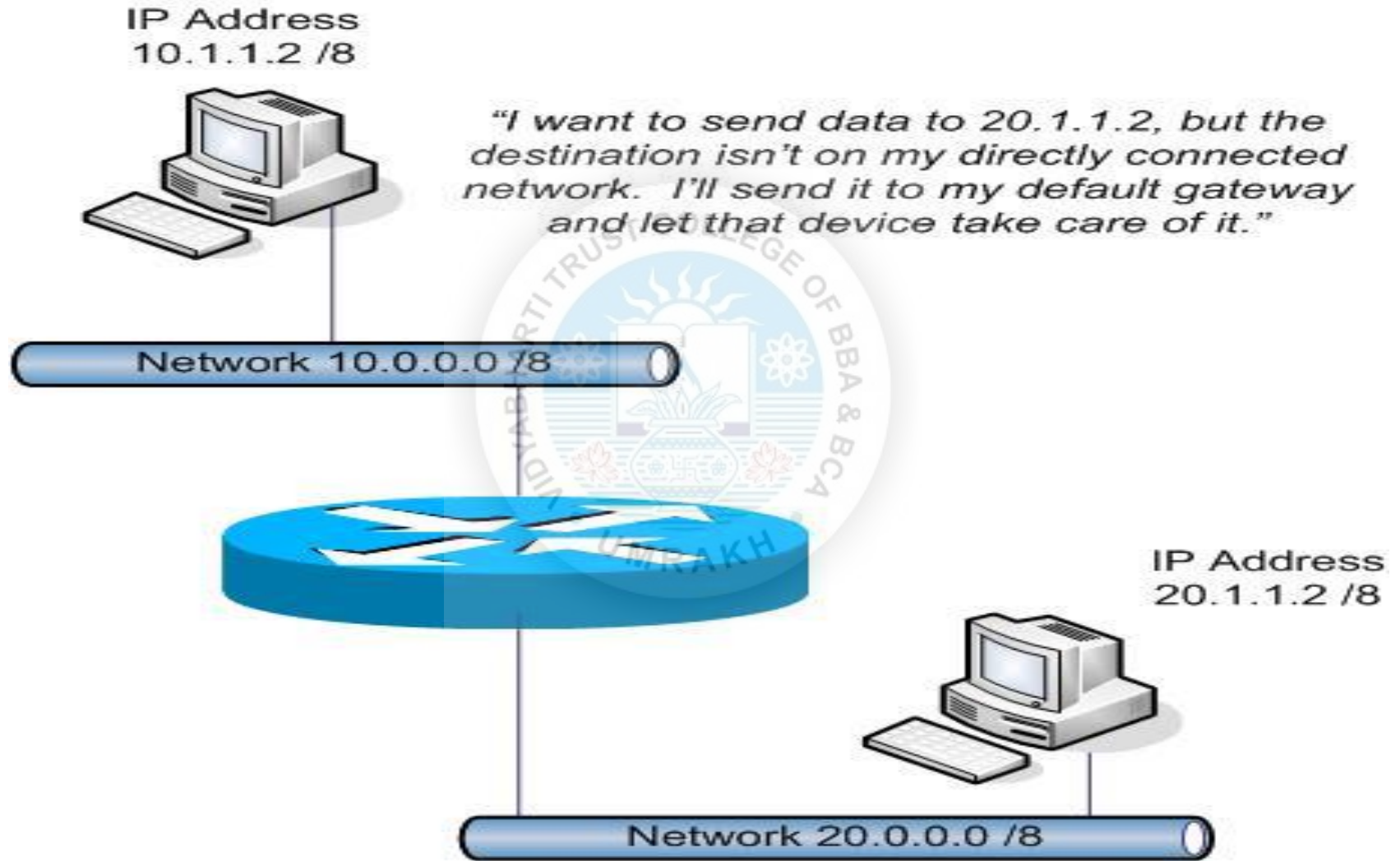
# Router



# Router

- Fig. show the internetwork of 5 networks.
- A packet sent from a station on one network to a station on a neighbor network goes first to the jointly held router, which switches it over to the destination network.
- If there is no router, the sending router transfer the packet across one of its connected network to the next router in the direction of the destination.

# Routing Process



# Routing Process

*"The data I received is destined for IP address 20.1.1.2 /8. According to my routing table, I'm directly connected to network 20.0.0.0 /8. That's a match. I will check my ARP table and send this data to the correct destination."*



IP Address  
20.1.1.2 /8



Network 20.0.0.0 /8

# Routers

- **Router types:**

- **Static router** – Routing tables are manually configured
- **Dynamic router** – Routing tables are automatically configured using routing protocol like
  - RIP ( Routing Information Protocol )
  - IGRP ( Interior Gateway Routing Protocol )
  - EIGRP ( Enhanced IGRP)
  - OSPF ( Open shortest Path First )

# Function Of Router

- Router has four function in network can be listed as
  - Packet Switching
  - Packet Filtering
  - Internetwork communication
  - Path Selection



# Router

- Router used logical addressing to forward the packet to destination is called **Packet switching**.
- Router can provide **Packet filtering** by using access control list.
- When router connect two or more network using IP address is called **internetworking**.
- Router use routing table to make a path selection and forward packet to remote network.

# Features of Router

## ■ Traffic Management

- ❑ Provide excellent traffic management using intelligent path selection.
- ❑ Select best route based on traffic loads, line speeds, number of hops.

## ■ Identify Address

- ❑ Work at network address and can access more information than bridge.

## ■ Multiple Active Path

- ❑ Router are able to keep track of multiple active path.



# Features of Router

## ■ Performance

- ❑ Perform complex task.
- ❑ Slower than bridge because they keep processing data intensively.

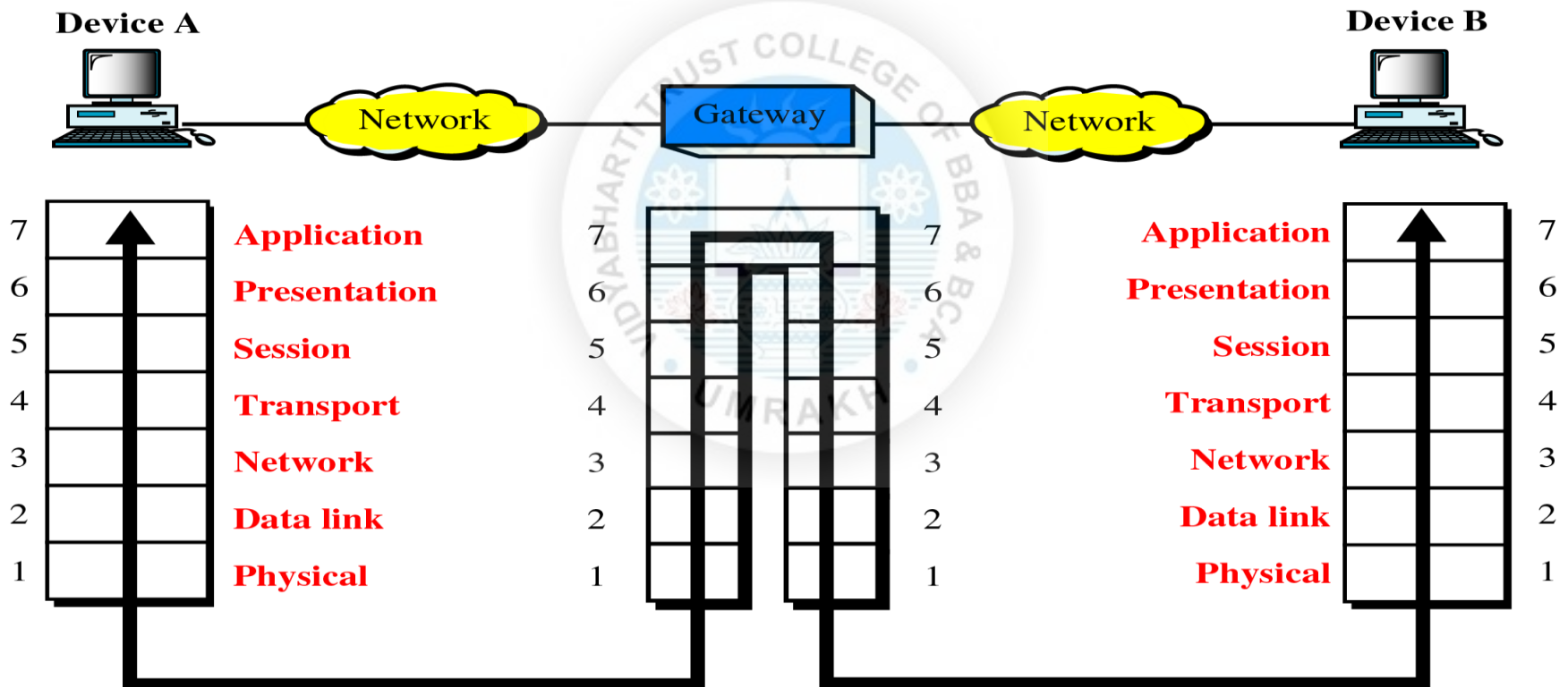
## ■ Sharing Information

- ❑ Share status and routing information with other router.
- ❑ By doing this they can listen to the network and identify which connection are busy and which are not.

SWITCH	ROUTER
It is work on Data link layer.	It is work on Network Layer.
It uses Hardware address to forward the frame.	It uses IP address to forward the packet.
Small hardware device that joins multiple computers together within one LAN	Routers are designed to join together multiple LAN with a WAN
Switch don't have its IP Address.	Router has its own IP Address.
Switch doesn't have OS.	Router has its own OS.
Router has 2/4/8 ports.	Switch has 24/48 ports.
Use Forwarding Table to forward frame.	Use Routing Table to route the packet to network.
Router transfer data in form of Packet	Switch Transfer data in form of Frame.

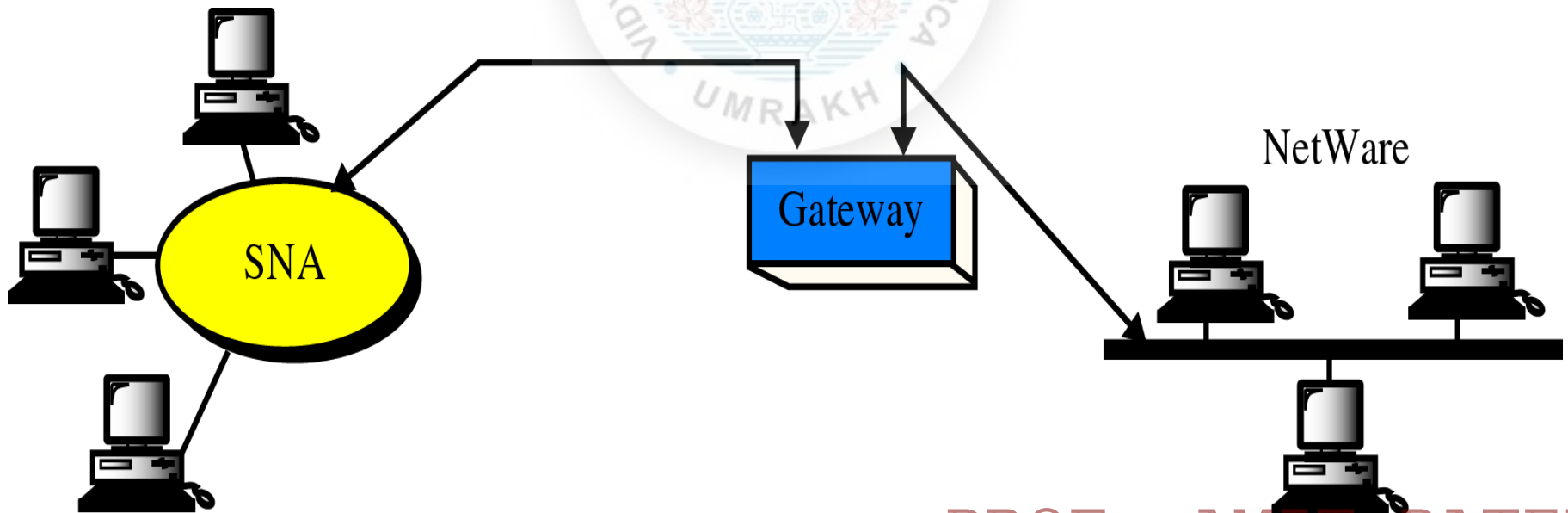
# Gateways

- Gateways potentially operate in all seven layers of the OSI model.



# Gateways

- A gateway is a protocol converter.
- A router by itself transfers, accepts, and relays packets only across networks using similar protocols.
- A gateway can accept a packet formatted for one protocol (e.g. AppleTalk) and convert it to a packet for another protocol (e.g. TCP/IP).



# Gateways

- A gateway is **generally software installed within a router.**
- The gateway understands the protocols used by each network linked into the router and is therefore able to translate from one to another.



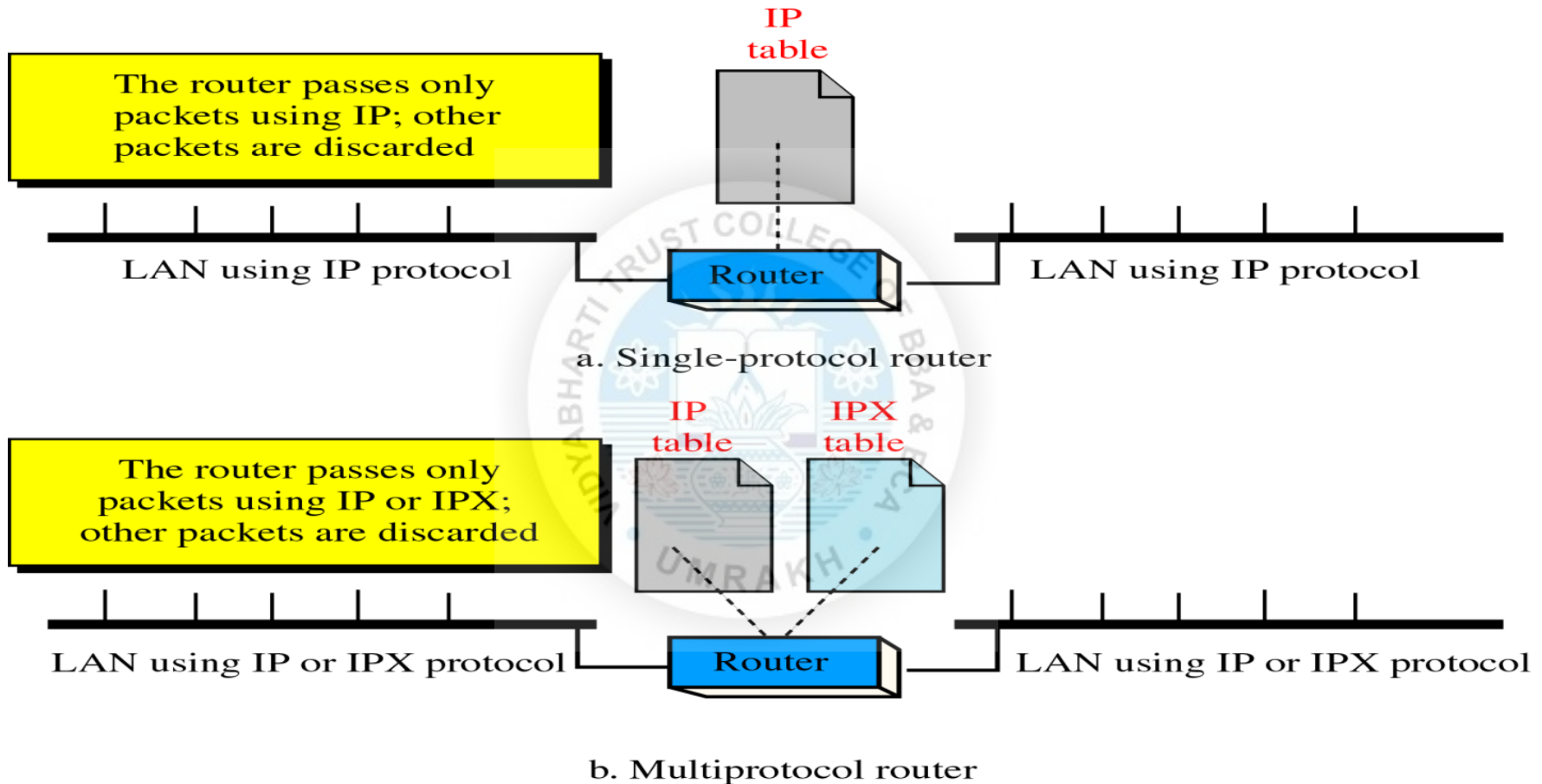
# Difference

GATEWAY	ROUTER
Gateway works on all layer of OSI model	Works on First Three layer of OSI model
Gateway is protocol converter.	It is not a converter.
Gateway accept packet formatted for one protocol and convert it to a packet formatted for another protocol.	Router accept and relays packets only across network of similar protocols.
Gateway understand protocol used by each network linked into the router.	Cant understand protocol used by network.

# BRouter

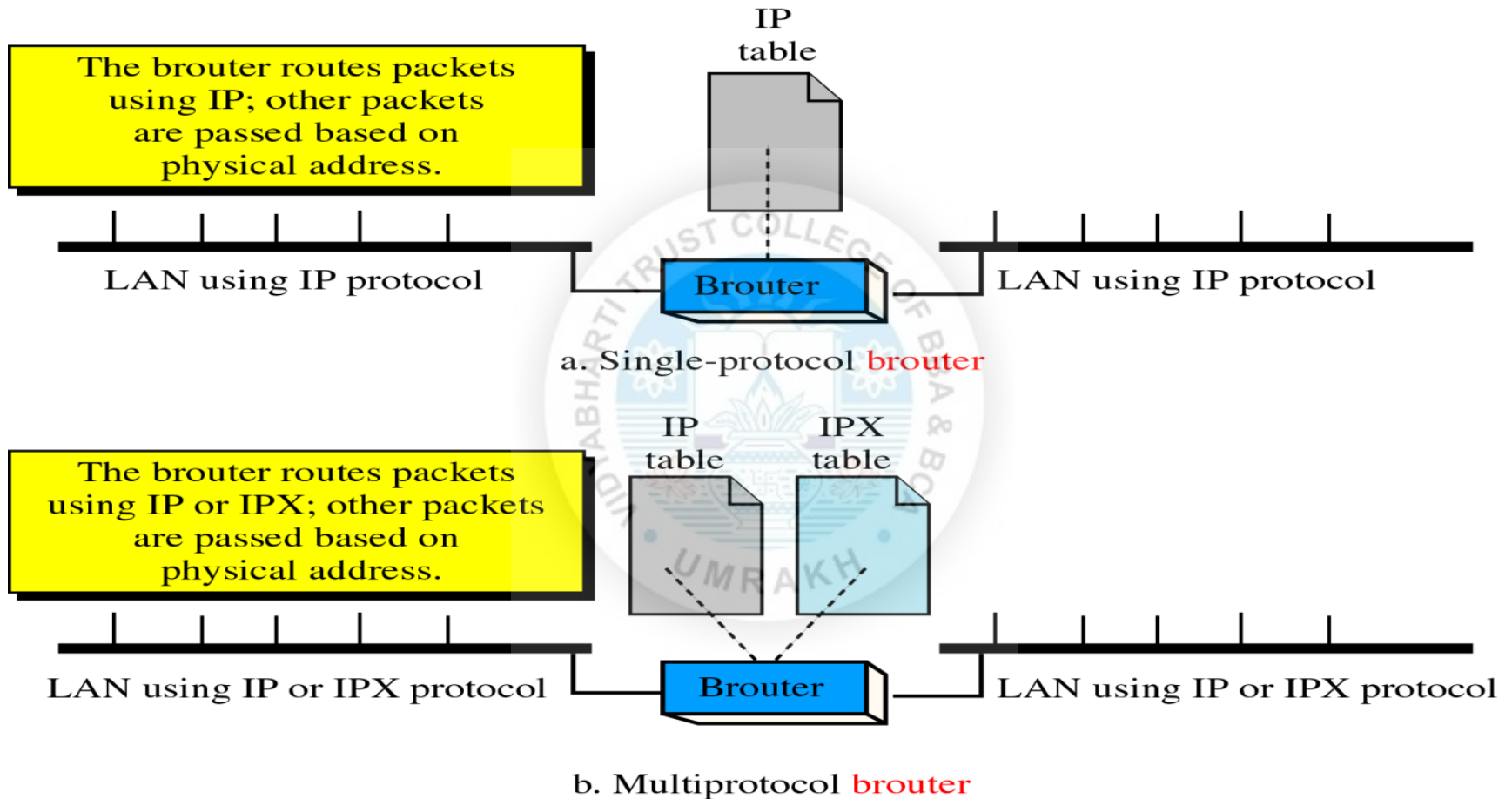
- A Brouter ( Bridge/Router) is a single-protocol or multiprotocol router that sometimes act as router and sometime act as bridge.
- Brouters operate at both the **Network** layer for routable protocols and at the **data link** layer for non-routable protocols.
- Brouters are used as connecting devices in the networking system, so it acts as a bridge in a network and as a router in an internetwork.

# BRouter





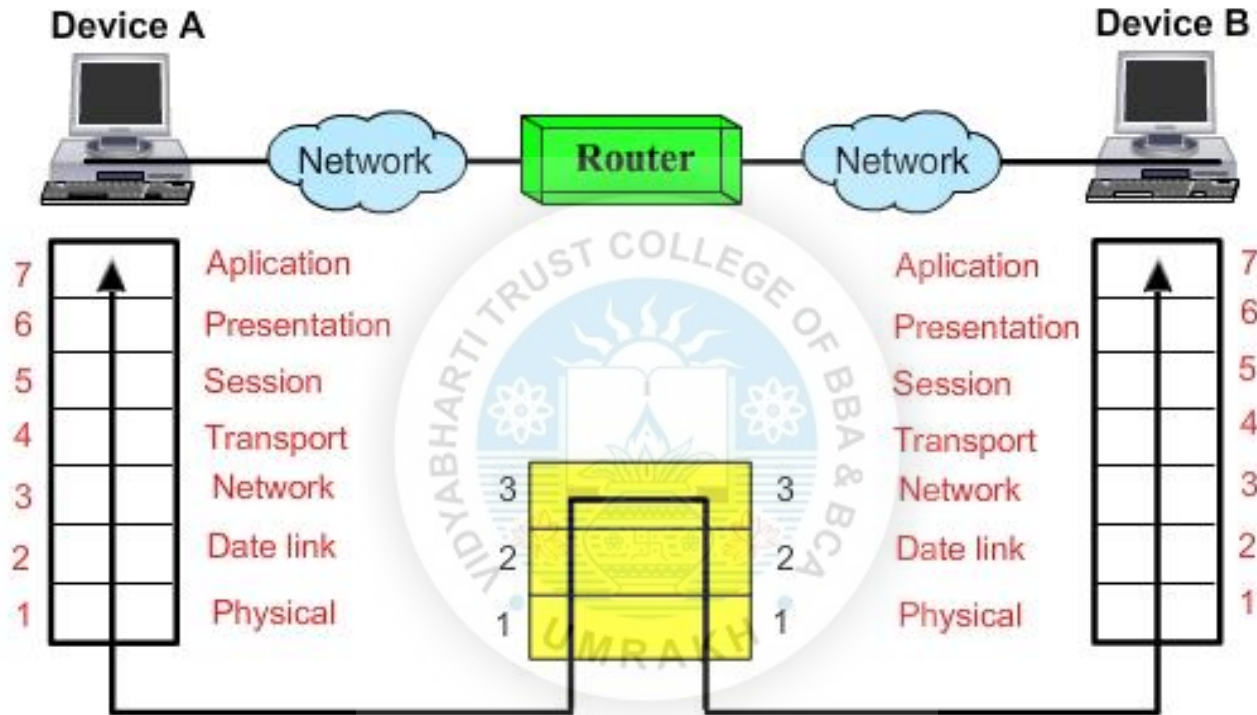
# BRouter



# BRouter

- When a single protocol Brouter receives a packet belonging to the internet for which it is designed, it routes the packet based on the network layer address otherwise it act as bridge and passes the packet using the data link layer address.
- When a multiprotocol Brouter receives a packet based on the network layer address, it routes the packet based on the network layer address. Otherwise it is act as bridge and passes the packet using the data link layer address.

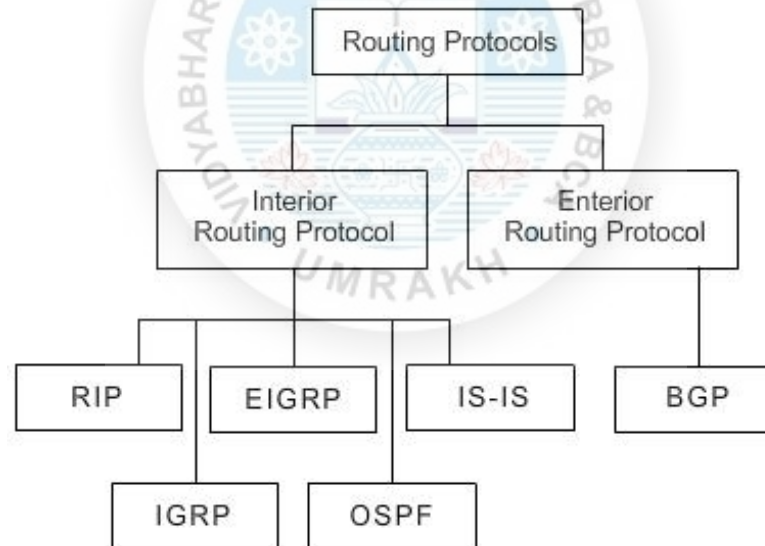
# Routers - I



- Operate at Network Layer of the OSI model
- Can connect nearer or far network segments

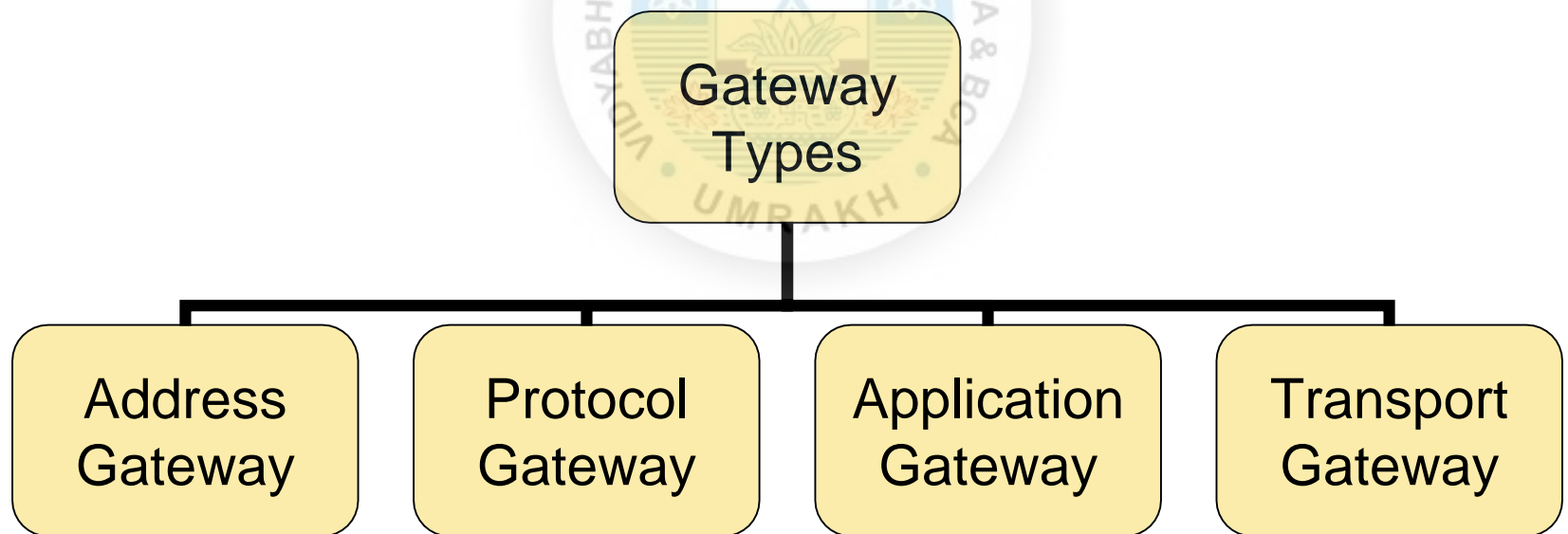
# Routing Protocols - I

- Helps routers to learn network topology and network changes
- Routing algorithms are used by routing protocols for deciding the path



# Gateways - I

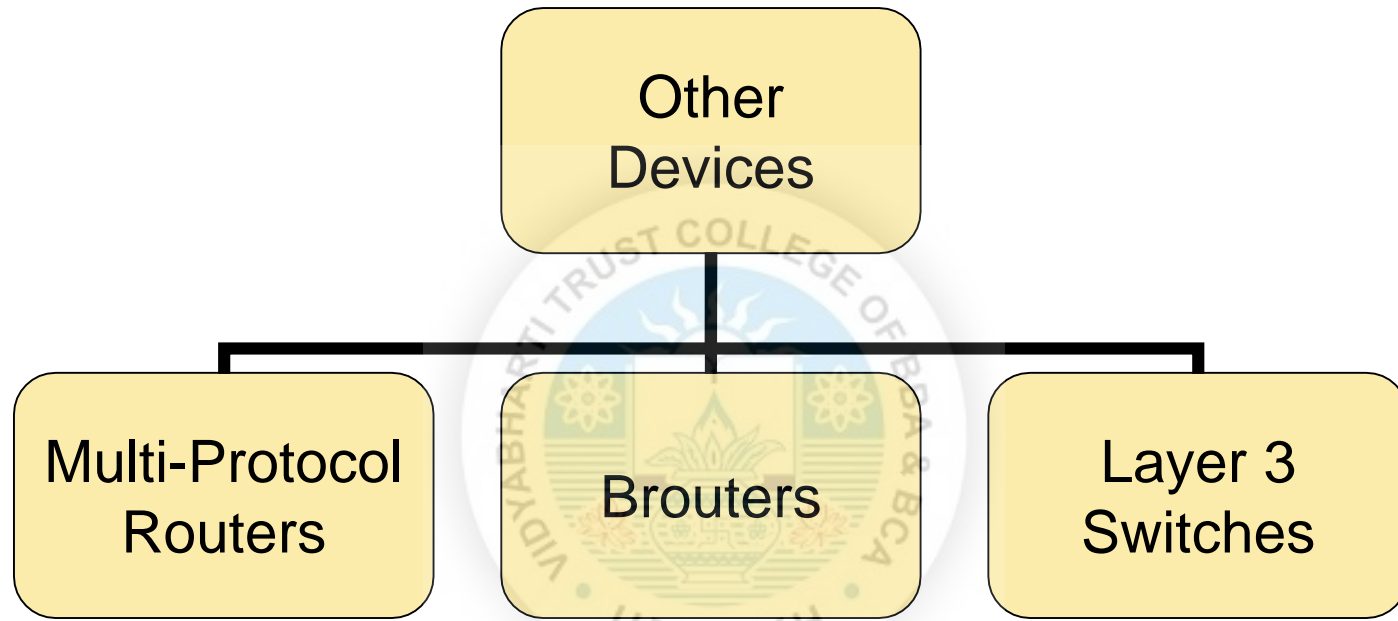
- Operate at all layers of the OSI model
- Act as gate to other networks
- A default gateway is on the same subnet as your computer



# Gateways - II

- Address Gateway – Interconnects same protocol networks
- Protocol Gateway – Interconnects different protocol networks
- Application Gateway – Connects two parts of applications
- Transport Gateway – Connects networks at transport layer

# Other Devices - I



- Multi-protocol router supports multiple communication protocols
- Like router, it operates at Network Layer

# Other Devices - II

- Brouter provides combined functions of Bridge and Router
- Works at two layers, Data Link and Network
- Can operate only as bridge or only as router
- High performance switch operating at network layer is Layer 3 Switch



# Summary - I



- Repeater is basically a regenerator as it regenerates the signal
- Repeater and Hub are layer 1 devices as they operate at the Physical layer of the OSI model
- A multi-port repeater is known as Hub
- Hubs are of three types, active hub, passive hub and intelligent hub
- Active hub regenerates the signal before passing and Passive hub does not regenerate signal
- Types of bridges are Transparent bridge, Translational bridge and Source-route bridge

# Summary - II



- Switch filters and forwards data to the destination
- Switch uses cut through, store and forward or fragment free method for switching
- A router is an intelligent device which functions at the Network layer
- Router is capable of connecting many network segments even though the segments are far
- Routers are of two types, Static router and Dynamic router
- The Netstats and Route Print commands are used to view the routing table

# Summary - III



- Routing algorithms are used by the routing protocols to determine the next port to which the packet is to be sent
- Routing protocols are of two types, interior and exterior
- RIP, IGRP, EIGRP, OSPF and IS-IS are interior routing protocols and BGP is an exterior routing protocol
- OSPF and IS-IS uses Link state algorithm
- BGP uses path vector routing

# Summary - IV



- Gateway is a networking device which converts data format and not actual data
- Backbone is a segment that connects other segments
- Multi-protocol routers support more than one communication protocols and works at network layer
- Brouter provides combinational functions of a bridge and a router
- As name suggests Layer 3 switch operates at layer 3 i.e. network layer of the OSI model