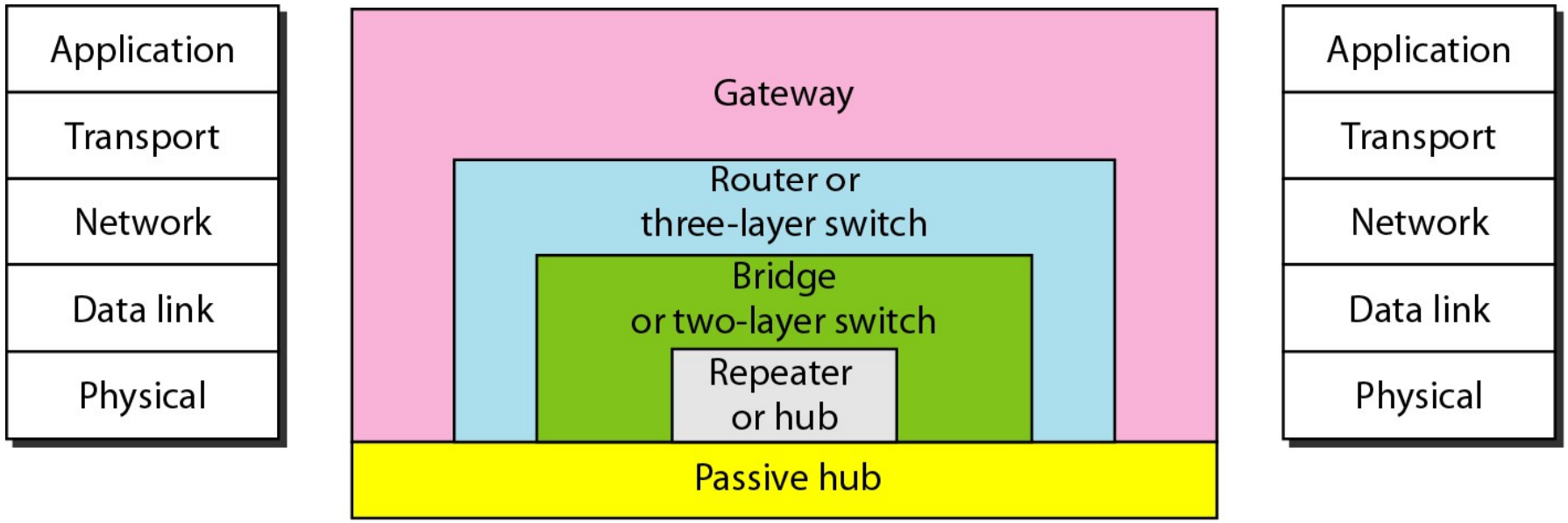
Data Link Layer:
Framing
and
Connecting Devices

AGENDA

- **Connecting Devices**
- LANs do not normally operate in isolation. They are connected to one another or to the Internet.
- To connect LANs, or segments of LANs, we use connecting devices.
- Connecting devices can operate in different layers of the Internet model. These connecting devices are used to create backbone networks.
- Passive Hubs, Repeaters, Active Hubs, Bridges, Two-Layer Switches, Routers, Three-Layer Switches, Gateway.
- We divide connecting devices into five different categories based on the layer in which they operate in a network, as shown in Figure 15.1.

Network Connecting Devices

Figure 15.1 ***Five categories of connecting devices***



The five categories contain devices which can be defined as in Table 1.

Connecting Devices

- The five categories contain devices which can be defined as
- 1. Those which operate below the physical layer such as a passive hub.
- 2. Those which operate at the physical layer (a repeater or an active hub).
- 3. Those which operate at the physical and data link layers (a bridge or a two-layer switch).
- 4. Those which operate at the physical, data link, and network layers (a router or a three-layer switch).
- 5. Those which can operate at all five layers (a gateway).

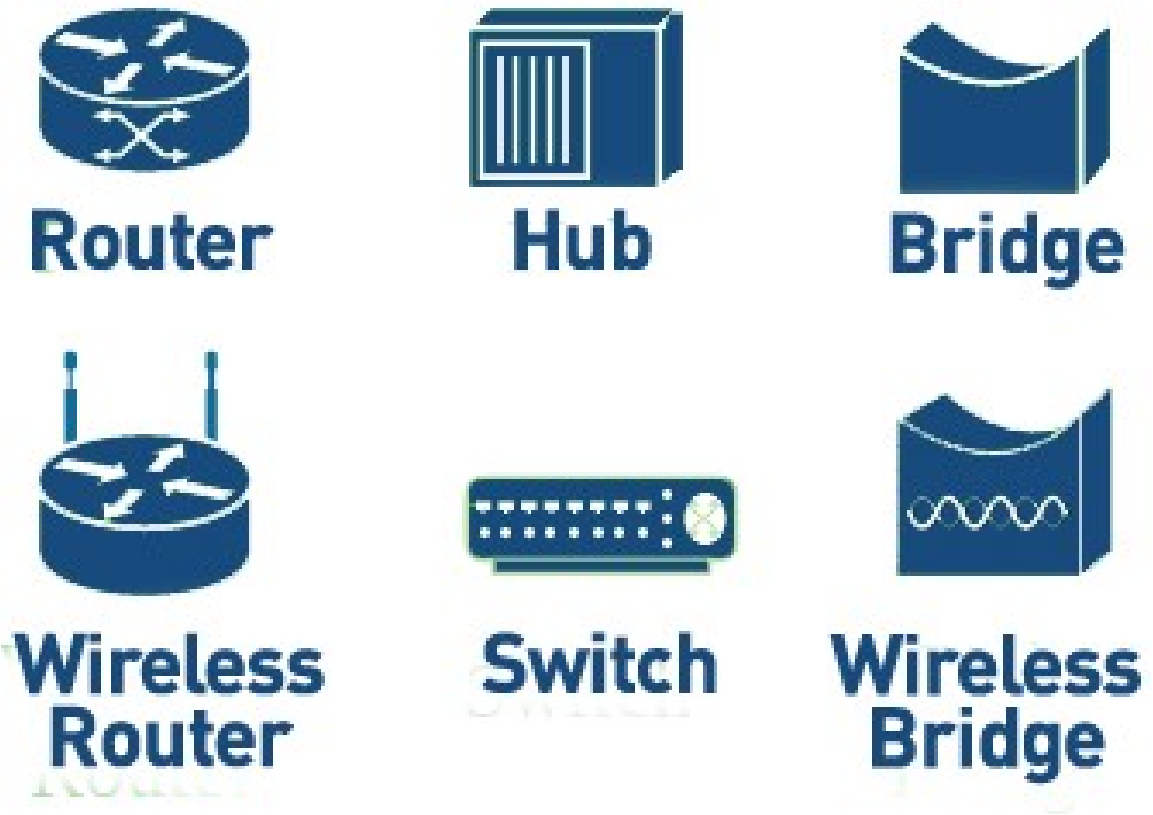
Connecting Devices

- The five categories contain devices which can be defined as in Table 1.

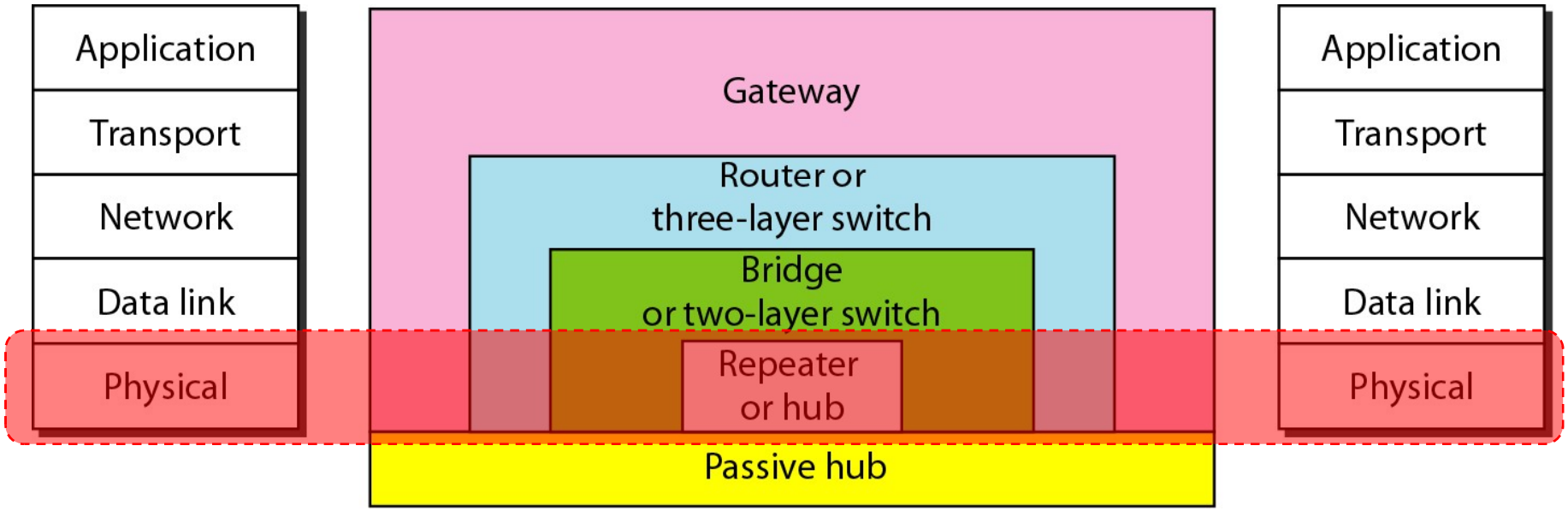
Table 1: Connecting Devices

S. No.	Device	Layer(s)
1.	Passive hub	*below the physical layer*
2.	Repeater/Active hub	*at the physical layer*
3.	Bridge/Two-layer switch	*at the physical and data link layers*
4.	Router/Three-layer switch	*at the physical, data link, and network layers*
5.	Gateway	*at all five layers*

Connecting Devices



Layer-1 Connecting Devices



Repeaters

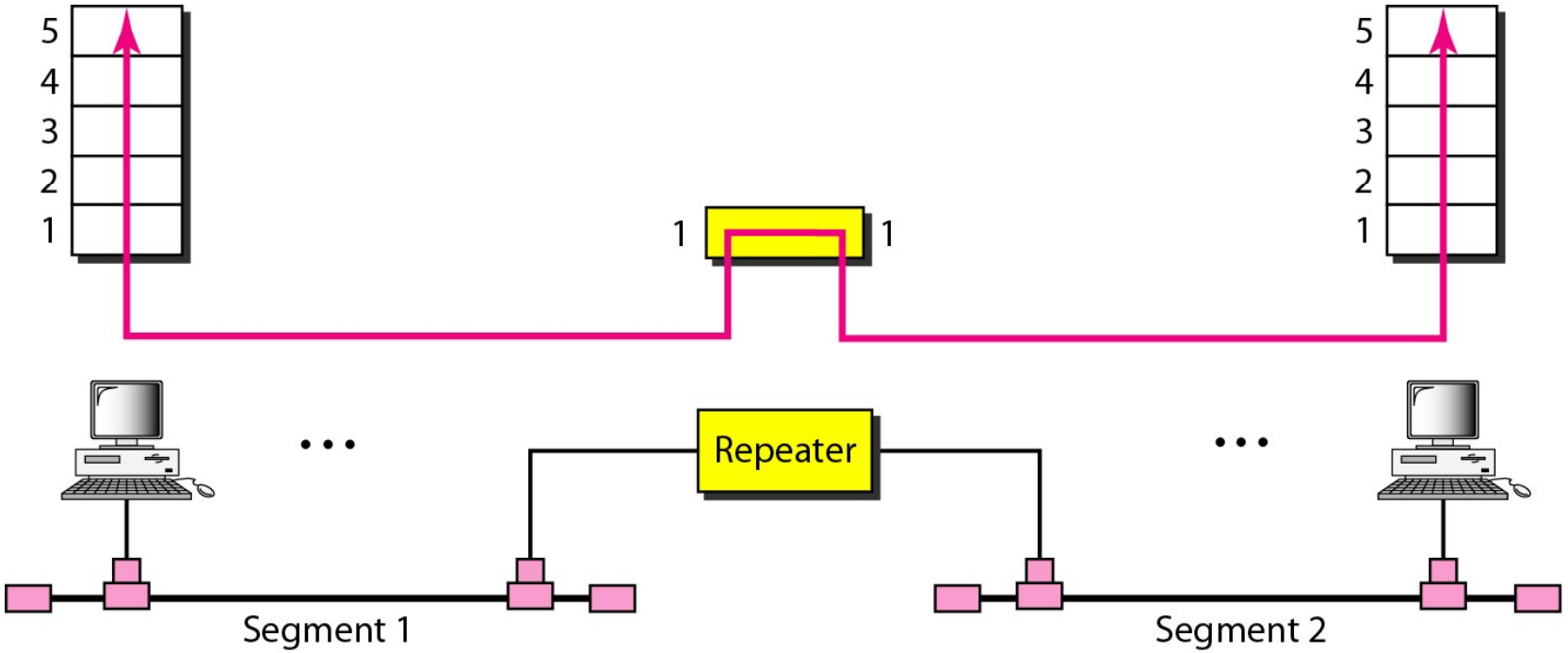
- A repeater operates at the physical layer. Its job is to regenerate the signal over the same network before the signal becomes too weak or corrupted so as to extend the length to which the signal can be transmitted over the same network.
- An important point to be noted about repeaters is that they do not amplify the signal.
- When the signal becomes weak, they copy the signal bit by bit and regenerate it at the original strength.
- It is a 2 port device.

Repeaters

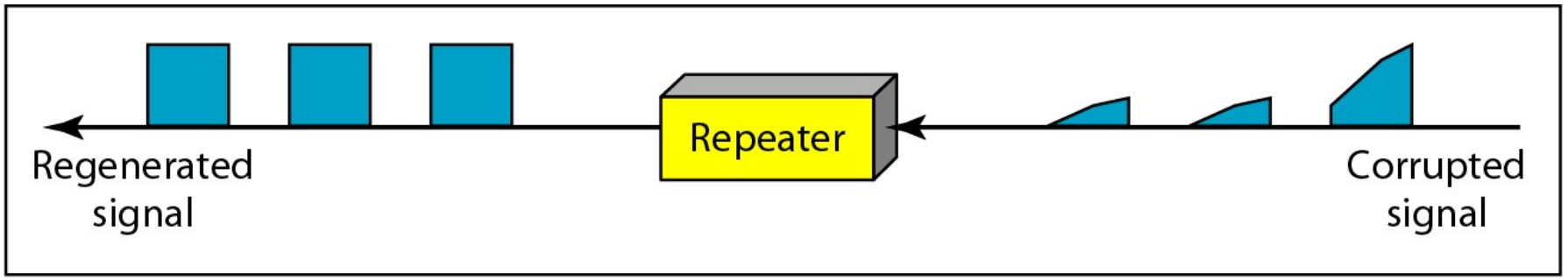
- A repeater can overcome the 10Base5 Ethernet length restriction. In this standard, the length of the cable is limited to 500 m.
- To extend this length, we divide the cable into segments and install repeaters between segments.
- Note that the whole network is still considered one LAN, but the portions of the network separated by repeaters are called segments.
- A repeater forwards every frame; it has no filtering capability.
- A repeater is a regenerator, not an amplifier.

Repeaters

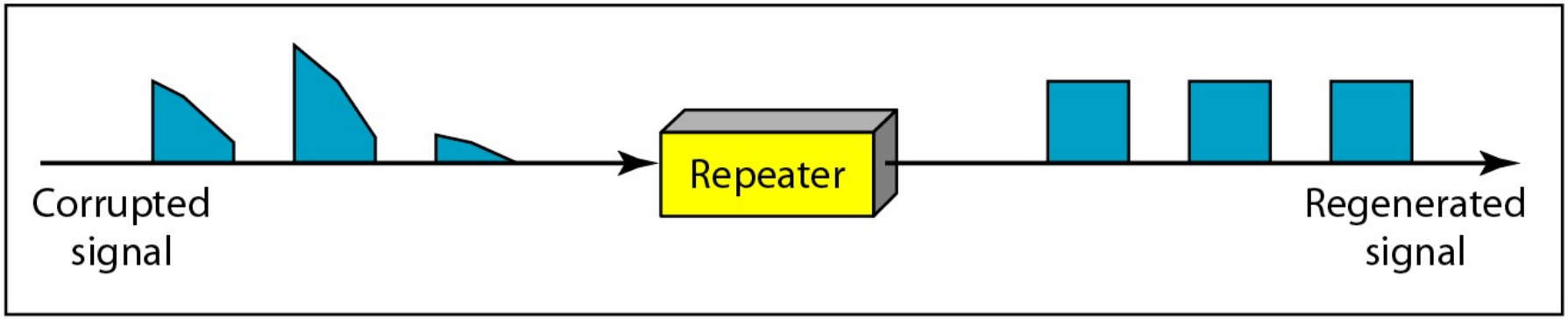
- Connected segments become single collision domain



Repeater Function



a. Right-to-left transmission.



b. Left-to-right transmission.

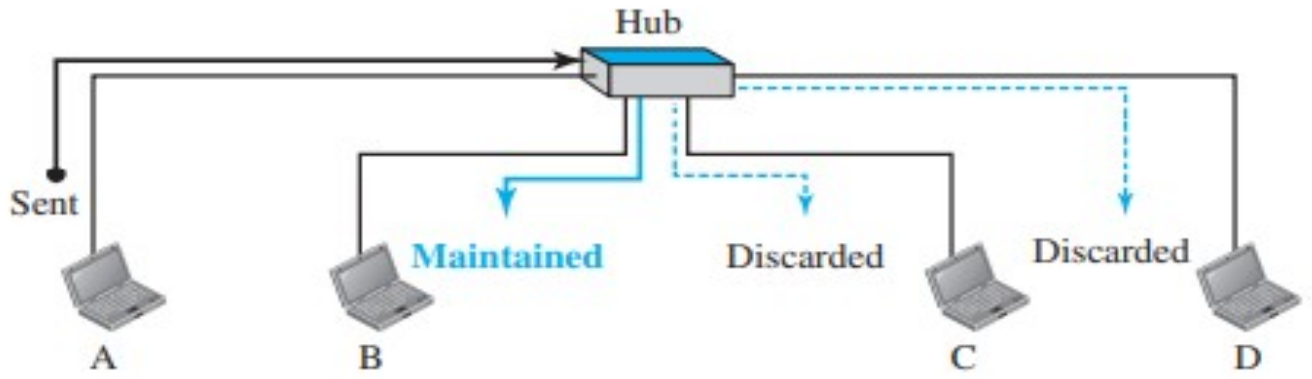
Repeater function

- Physical layer
- Can extend the physical length of the LAN
- Connects two LAN segments
- Can not connect LAN of different protocol segment
- No filtering capability

Hubs

- A hub is basically a multiport repeater, connects multiple wires coming from different branches, e.g, the connector in star topology which connects different stations.
- Hubs cannot filter data, so data packets are sent to all connected devices. In other words, the collision domain of all hosts connected through Hub remains one.
- Also, they do not have the intelligence to find out the best path for data packets which leads to inefficiencies and wastage.

Figure 17.2 *A hub*

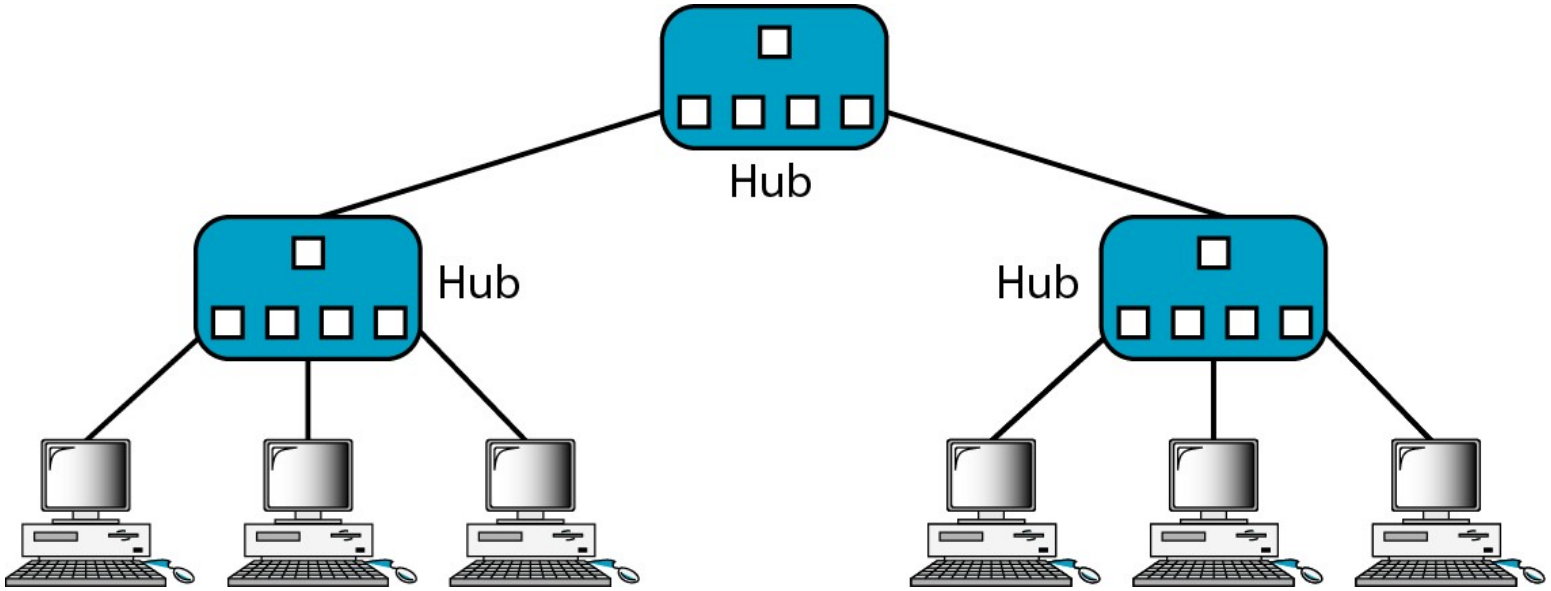


Hubs

- Passive Hub
  - These are the hubs that collect wiring from nodes and power supply from the active hub.
  - These hubs transmit the signals over the network without improving & cleaning them.
  - They are not suitable for extending the distance between nodes like an active hub.

Hubs

- Active Hub
  - These hubs have their own power supply and can clean, boost, and relay the signal along with the network. It serves both as a repeater as well as a wiring centre.
  - These are used to extend the maximum distance between nodes.

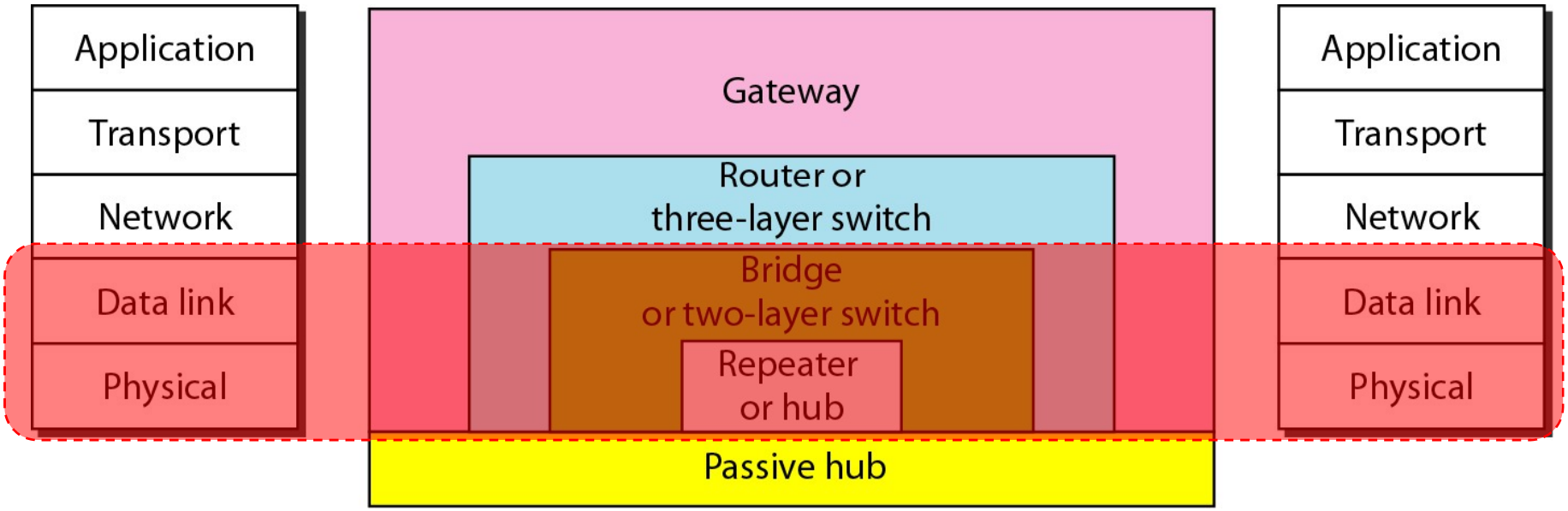


Hubs

- A repeater receives a signal and, before it becomes too weak or corrupted, regenerates and retimes the original bit pattern.
- The repeater then sends the refreshed signal.
- In the past, when Ethernet LANs were using bus topology, a repeater was used to connect two segments of a LAN to overcome the length restriction of the coaxial cable.
- Today, however, Ethernet LANs use star topology. **In a star topology, a repeater is a multiport device, often called a hub**, that can be used to serve as the connecting point and at the same time function as a repeater.

- A hub is neither a collision domain separator nor a broadcast domain separator because hubs do not segment a network, they just connect network segments..

Layer-2 Connecting Devices

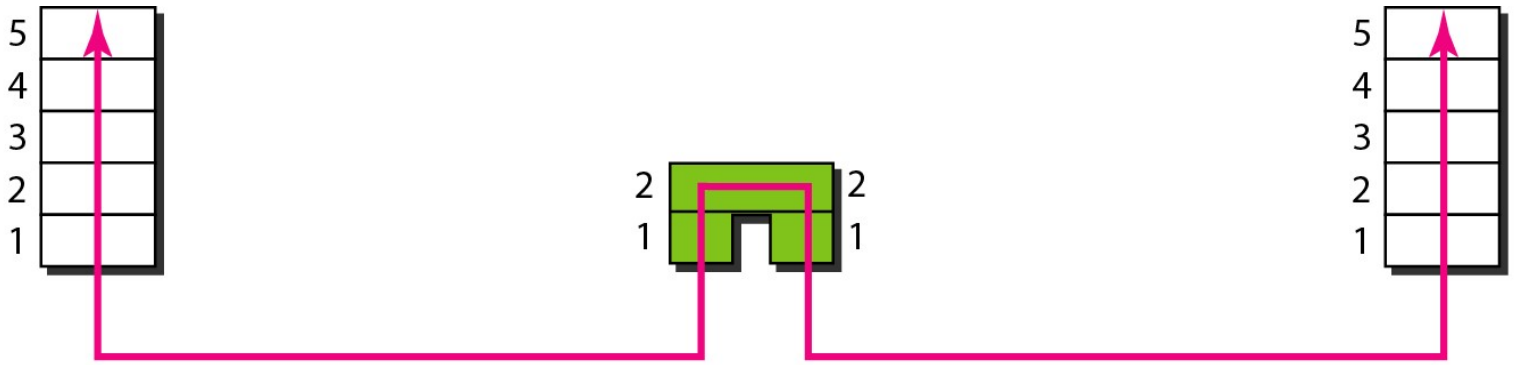


Bridges

- A bridge operates in both the physical and the data link layer. As a physical layer device, it regenerates the signal it receives.
- As a data link layer device, the bridge can check the physical (MAC) addresses (source and destination) contained in the frame.
- A bridge as a repeater, has add on functionality of filtering content by reading the MAC addresses of source and destination.
- A bridge does not change the physical (MAC) addresses in a frame.
- It is also used for interconnecting two LANs working on the same protocol. It has a single input and single output port, thus making it a 2 port device.

Bridges

- Works on both physical and data link layer
- Bridges process information up to the frame-level (layer 2)
- Regenerates the signals and check physical address

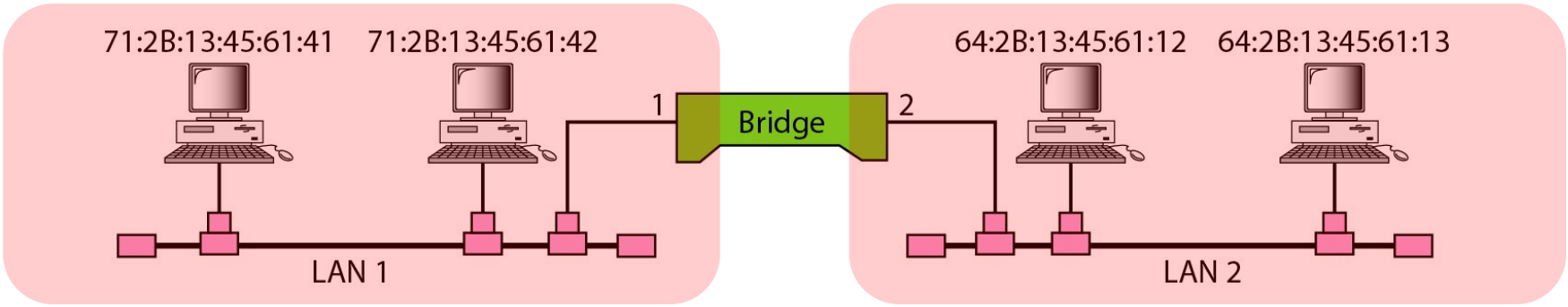


Bridges

- Connecting LANs while separating collision domains
  - MAC addresses are used for filtering
  - Connected segments form a single network (same broadcast domain)
  - Filtering capability

Address	Port
71:2B:13:45:61:41	1
71:2B:13:45:61:42	1
64:2B:13:45:61:12	2
64:2B:13:45:61:13	2

Bridge Table



Switches

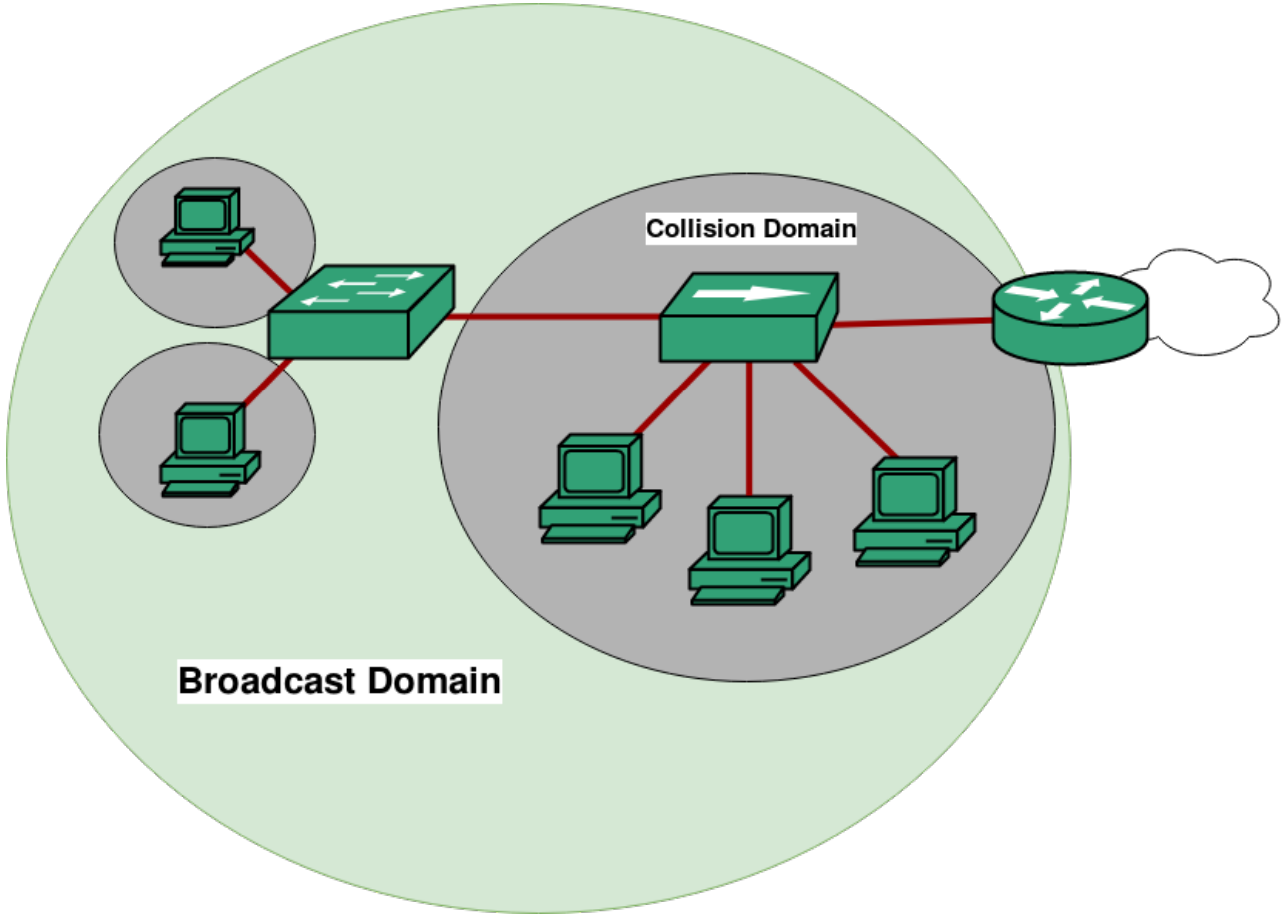
- We can have a two-layer switch or a three-layer switch. A three-layer switch is used at the network layer; it is a kind of router. The two-layer switch performs at the physical and data link layers.
- A two-layer switch is a bridge, a bridge with many ports and a design that allows better (faster) performance. A bridge with a few ports can connect a few LANs together.
- A three-layer switch is a router, but a faster and more sophisticated. The switching fabric in a three-layer switch allows faster table lookup and forwarding.

Switches

- A switch is a multiport bridge with a buffer and a design that can boost its efficiency(a large number of ports imply less traffic) and performance.
- A switch is a data link layer device. The switch can perform error checking before forwarding data, which makes it very efficient as it does not forward packets that have errors and forward good packets selectively to the correct port only.
- In other words, the switch divides the collision domain of hosts, but broadcast domain remains the same.

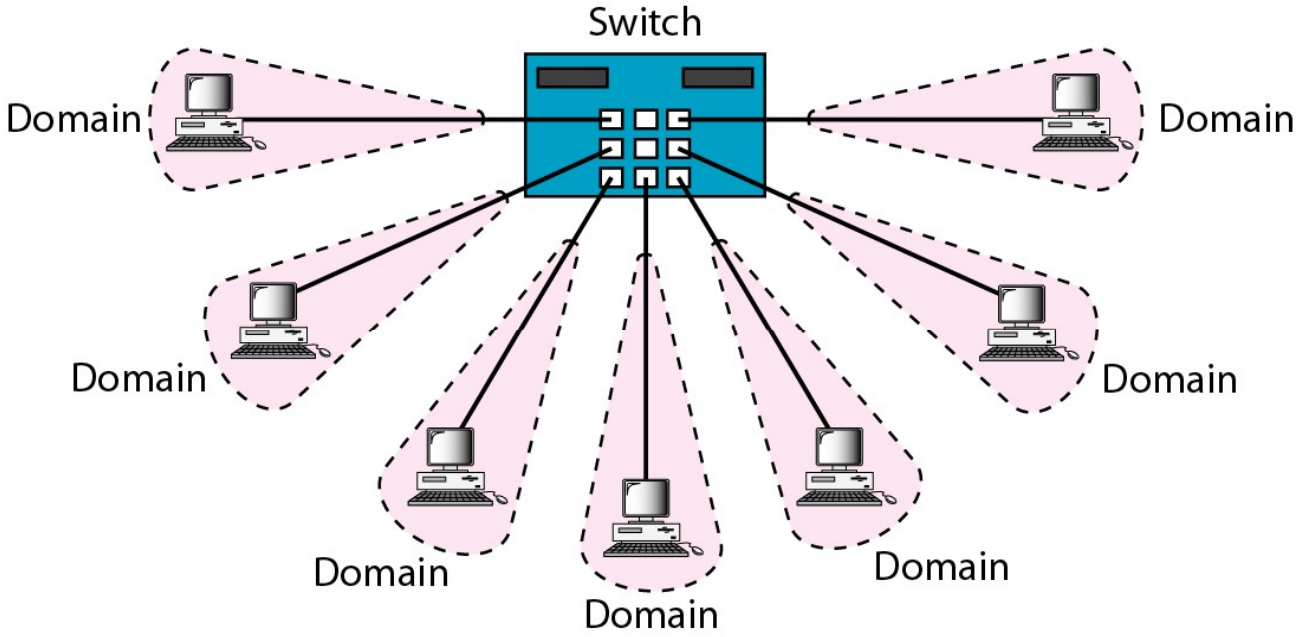
- **Note:** A **Collision Domain** is a scenario in which when a device sends out a message to the network, all other devices which are included in its collision domain have to pay attention to it, no matter if it was destined for them or not.
- A **Broadcast Domain** is a scenario in which when a device sends out a broadcast message, all the devices present in its broadcast domain have to pay attention to it.

Switches



Switches

Similar to multiport bridges



A switch is a collision domain separator. So messages that come from devices connected to different ports never experience a collision.

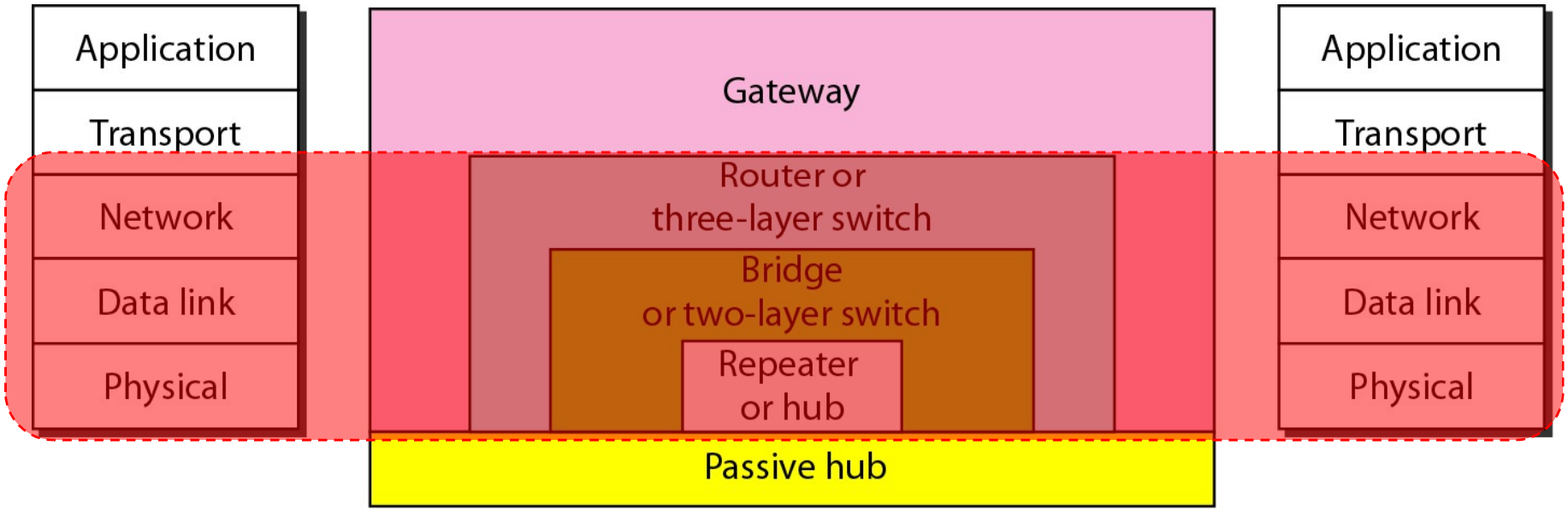
Switches

- 2-Layer and 3-Layer Switches
- Layers 2 and layer 3 switches are adopted in the Open System Interconnect (OSI) model, which is a reference model for describing and explaining network communications.
- The layer 2 and Layer 3 differs mainly in the routing function.
- A Layer 2 switch works with MAC addresses only and does not care about IP address or any items of higher layers.
- Layer 3 switch, or multilayer switch, can do all the job of a layer 2 switch and additional static routing and dynamic routing as well.
- A Layer 3 switch has both MAC address table and IP routing table, and handles intra-VLAN communication and packets routing between different VLANs

Switches

Layer 2 Switch	Layer 3 Switch
Operate on layer 2 (Data link) of OSI model.	Operate on layer 3 (Network Layer) of OSI model.
Send "frames" to destination on the basis of MAC address.	Route Packet with help of IP address
Work with MAC address only	Can perform functioning of both 2 layer and 3 layer switch
Used to reduce traffic on local network.	Mostly Used to implement VLAN (Virtual Local area network)
Quite fast as they do not look at the Layer 3 portion of the data packets.	Takes time to examine data packets before sending them to their destination
It has single broadcast domain	It has multiple broadcast domain.
Can communicate within a network only.	Can communicate within or outside network.

Layer-3 Connecting Devices

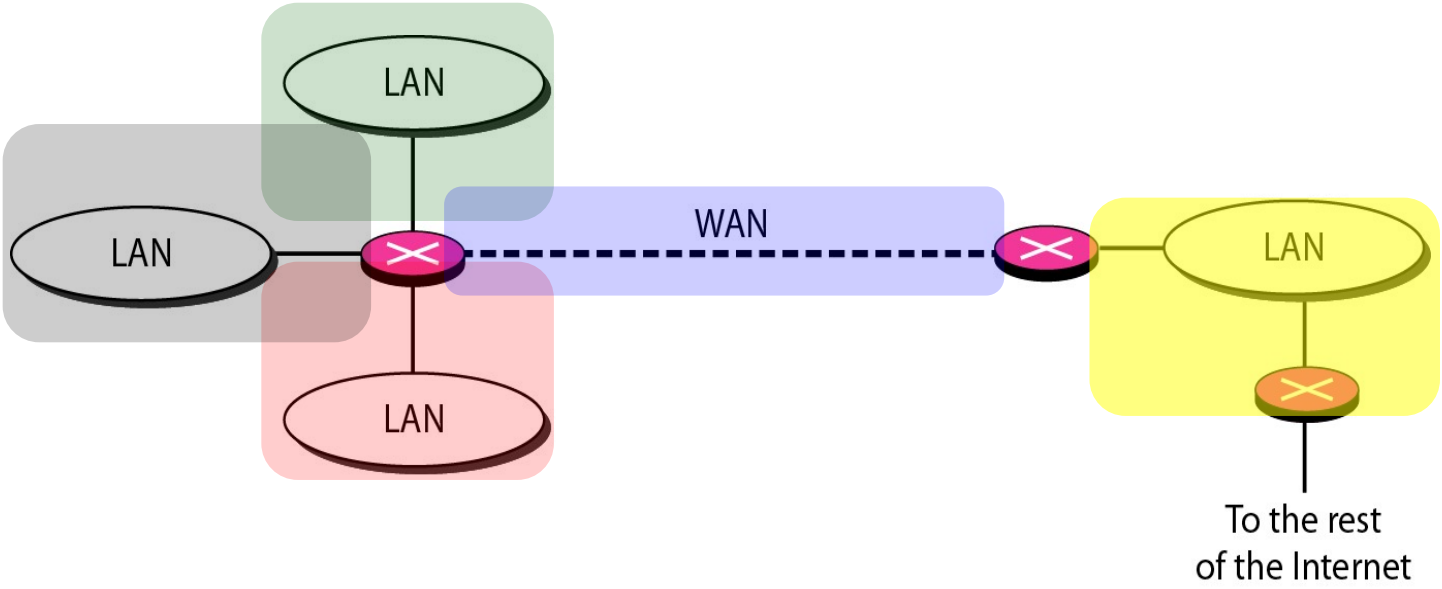


Routers

- A router is a three-layer device that routes packets based on their logical addresses (host-to-host addressing).
- A router normally connects LANs and WANs in the Internet and has a routing table that is used for making decisions about the route.
- The routing tables are normally dynamic and are updated using routing protocols

Routers

- Capable of connecting networks of different types
- Routers separate networks into different broadcast domains
- It is both collisions as well as broadcast domain separator



Gateway

- A gateway, as the name suggests, is a passage to connect two networks together that may work upon different networking models.
- A network gateway is a device or node that connects disparate networks by translating communications from one protocol to another.
- They basically work as the messenger agents that take data from one system, interpret it, and transfer it to another system.
- Gateways are also called protocol converters and can operate at any network layer and are generally more complex than switches or routers.
- A physical network gateway includes network interface cards (NICs) and inputs and outputs—usually Ethernet—and software for translating network protocols.

Gateway

- A gateway

Gateway

- A gateway is typically used on the network layer of the Open Systems Interconnection (OSI) model, but it could theoretically be deployed on any of the OSI layers.
- Standalone or virtual gateways may be placed anywhere in a network where translation is needed.
- They can be unidirectional (allowing data to flow in only one direction) or bidirectional (allowing data to flow both in and out of a network).
- As an entry or exit point for data, a gateway can be used in a variety of security processes, such as a firewall to scan and filter data or a proxy server to maintain restricted access to certain applications or assets.