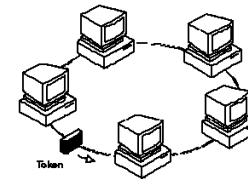


# Interconnecting Networks

COMP476  
Networked Computer Systems

## LAN – Local Area Networks

- There **is** a Limit to the Maximum Length of a LAN
  - Ethernet cables (segments) can be up to 500m.
  - The restrictions are due to power and propagation delay.
  - The speed of light or electricity is not infinite.



Example: Ethernet and Token Ring

## Bits on the Wire

- A 100 Mbit/sec Ethernet sends a bit every 10 nsec.
- Traveling at  $2.0 \times 10^8$  m/s, a bit occupies 2.0m of the wire.
- If two computers were located 16m apart, there would be 8 bits traveling between them.
- The first bit would arrive at the receiver just as the sender sent the 8<sup>th</sup> bit.

## CSMA/CD restriction

- The time to transmit a frame must be greater than twice the time for the frame to travel to the end of the cable.
- If the cable is too long, collisions might go undetected.

$$\frac{\min PacketSize}{transRate} > \frac{2 * length}{2.0 * 10^8}$$

## Max Ethernet Cable Length

- Consider a 100 Mbps Ethernet with 72 byte frame.

$$\text{min length} = \frac{\text{min PacketSize} * 10^8}{\text{transRate}}$$

$$\text{length} = \frac{72\text{bytes} * 8\text{bits} / \text{byte} * 10^8 \text{ m} / \text{sec}}{10^8 \text{ bits} / \text{sec}} = 576\text{m}$$

## Methods of Interconnecting Networks

Application	Router
Presentation	
Session	
Transport	
Network	Router
Data Link	Bridge
Physical	Repeater

## Repeaters

- Repeaters operate at the Physical Layer.
- Copies individual bits between cable segments.
- Every bit is copied to all segments, including collisions.
- Functions as an amplifier.
- Invisible to computers.
- Ethernet can be extended to 1500m with no more than 4 repeaters between hosts.

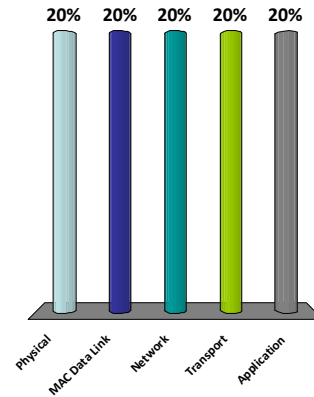
## Hubs



- Logically, a hub is a very short cable with long connecting wires
- Bits flow in one wire and out all others
- Hubs are usually less expensive than switches

## On what OSI layer does a hub operate?

1. Physical
2. MAC Data Link
3. Network
4. Transport
5. Application



## Bridges

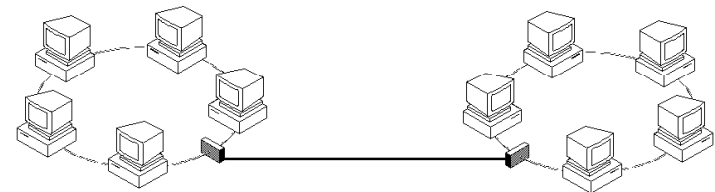
- Bridges operate at the Data Link Layer.
- Store and forward frames between LANs. Bridges receive a packet and then transmit it on the other side.
- Retransmitting the packet introduces a delay.
- Invisible to computers on the network.
- Each segment is shielded from local traffic on the other segments (reduces collisions).

## More on Bridges

- Bridges only forward frames that need to go to the other side (Frame Filtering)
- Broadcasts always go through a bridge
- Bridges *learn* the location of hosts

## Long Distance Bridging

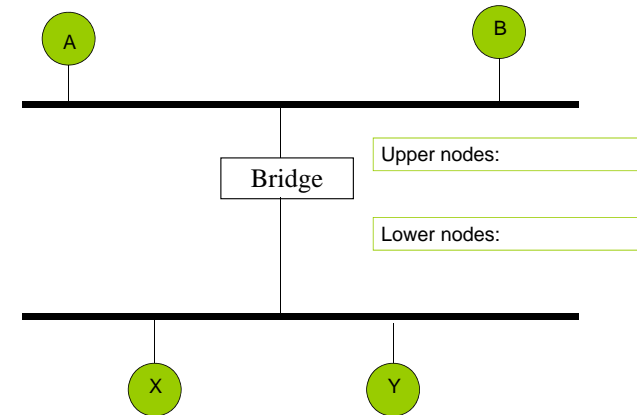
- Bridges (designed for this purpose) can be connected by a point to point connection (fiber optic line, leased phone line or satellite).



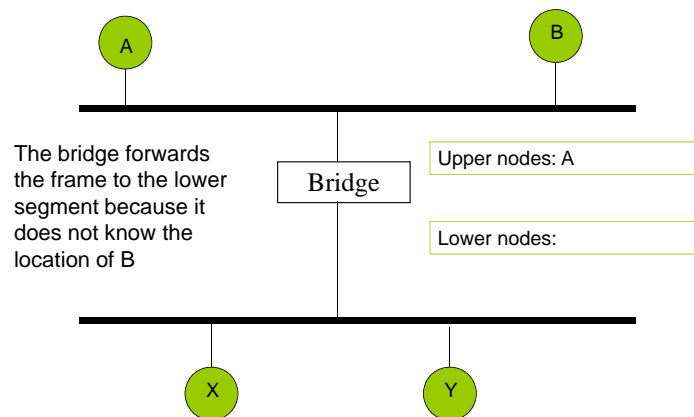
## Learning Bridges

- Bridges do not need to be configured. They can be used straight from the box.
- Bridges automatically learn which side of the bridge a computer is located.
- Bridges look at all source addresses to determine where a computer is located.
- If the bridge does know that the destination is on the same side as the source, it will forward the frame.

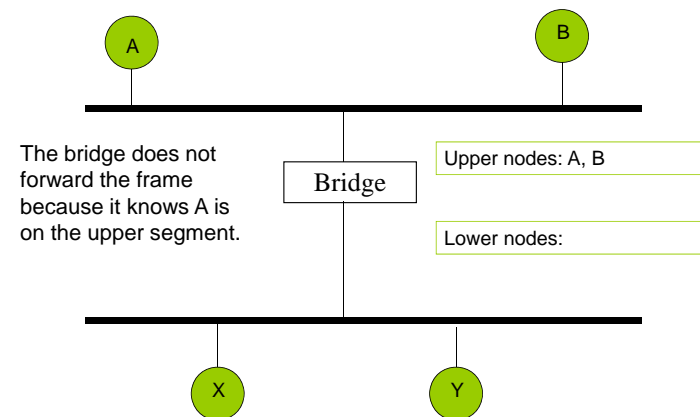
## Bridge Learning



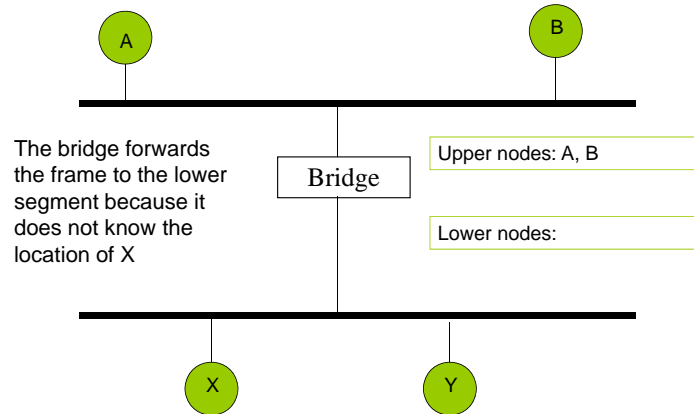
## A sends a frame to B



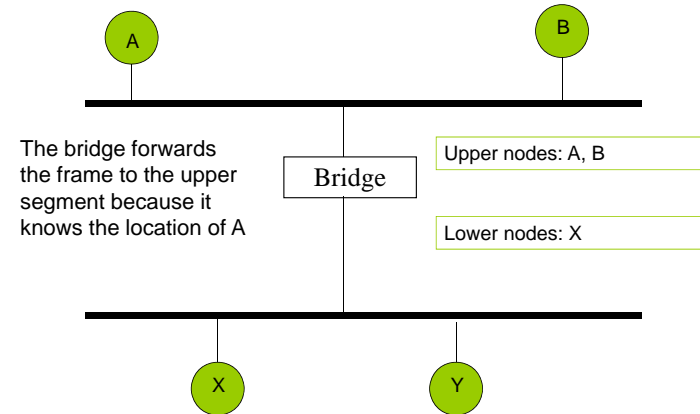
## B sends a frame to A



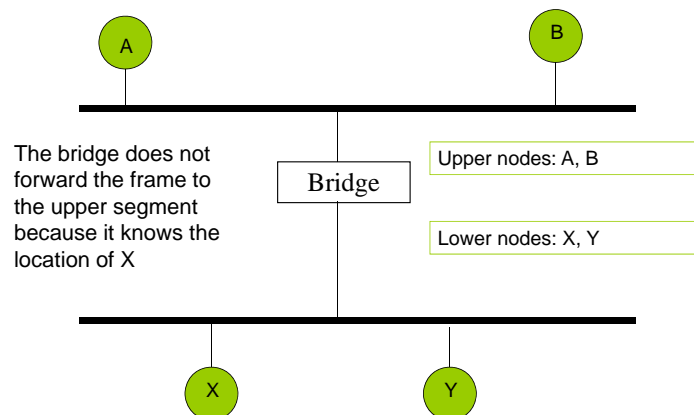
## A sends a frame to X



## X sends a frame to A



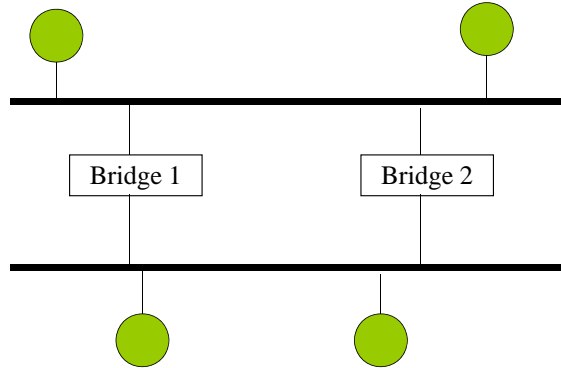
## Y sends a frame to X



## Cycles of Bridges

- **Cycles** of bridges have to be avoided.
- A packet could circulate forever.
- Sometimes it is advantageous to have extra bridges for robustness and performance.
- When a Bridge starts, it communicates with other bridges to learn the configuration.
- Bridges form a *Distributed Spanning Tree* to determine how frames will be forwarded.

## Bridge Cycle



## Switches



- An Ethernet switch is very similar to a bridge
- A switch usually has several ports

## Layer 2 Switches

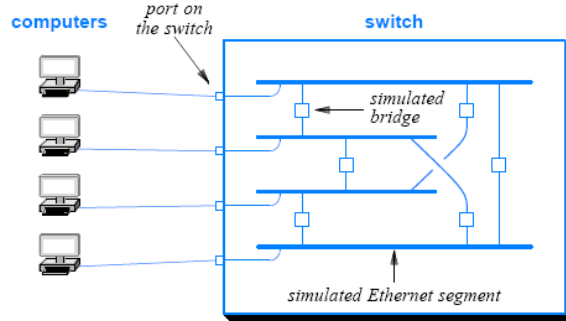
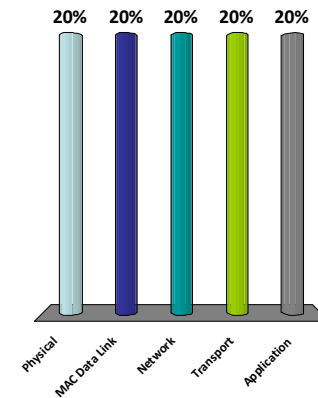


Figure 17.6 Conceptual organization of a switched LAN.

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## On what OSI layer does a switch operate?

1. Physical
2. MAC Data Link
3. Network
4. Transport
5. Application



## Routers



- Routers operate at the Network Layer.
- Can store and forward frames between dissimilar networks
- May perform protocol conversion.
- A router is located at any gateway (where one network meets another).
- The name Router and Gateway are sometimes used synonymously.

## PCs as Routers

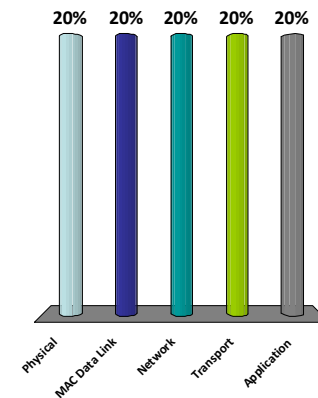
- A computer with two or more network interfaces can function as a router
- Microsoft Windows Server and Linux Server have options to function as a router
- Hardware routers can be used for high performance
- Routers are used throughout the Internet

## Visibility

- A router is visible to the network
- All nodes in a network need to know the IP address of their local router
- Packets must be sent to the router
- Repeaters and bridges are invisible
  - Nodes do not know they are on the network
  - Packets are never addresses to a bridge

## On what OSI layer does a router operate?

1. Physical
2. MAC Data Link
3. Network
4. Transport
5. Application

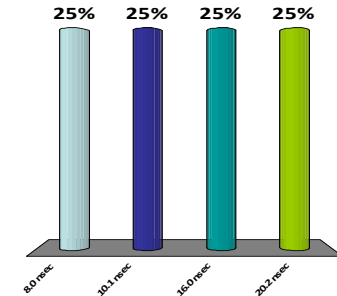


### Methods of Interconnecting Networks

Application	Router
Presentation	
Session	
Transport	
Network	Router
Data Link	Bridge
Physical	Repeater

How long does it take to send 100 bytes over a 100 Mb/s Ethernet to another node when there is a **repeater** between the nodes?

1. 8.0 nsec
2. 10.1 nsec
3. 16.0 nsec
4. 20.2 nsec



How long does it take to send 100 bytes over a 100 Mb/s Ethernet to another node when there is a **bridge** between the nodes?

1. 8.0 nsec
2. 10.1 nsec
3. 16.0 nsec
4. 20.2 nsec

