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Introduction (Contd...)

Networking: A Top Down Approach Featuring the Internet, Jim Kurose, Keith Ross

Physical Media

Bit: propagates between transmitter/rcvr pairs

physical link: what lies between transmitter & receiver

guided media:

signals propagate in solid media: copper, fiber, coax

unguided media:

signals propagate freely, e.g., radio

Twisted Pair (TP)

two insulated copper wires

Category 3: traditional phone wires, 10 Mbps Ethernet

Category 5: 100Mbps Ethernet

1Gbps Ethernet

Physical Media: coax, fiber

Coaxial cable:

two concentric copper conductors

bidirectional

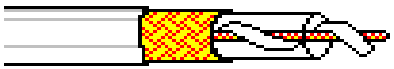
baseband:

-single channel on cable

-legacy Ethernet

broadband:

-multiple channels on cable



Fiber optic cable:

glass fiber carrying light pulses, each pulse a bit

high-speed operation:

high-speed point-to-point transmission (e.g., 10's-100's Gps)

low error rate: repeaters spaced far apart ; immune to electromagnetic noise

Physical media: radio

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- signal carried in electromagnetic spectrum
- no physical “wire”
- bidirectional
- propagation environment effects:
  - reflection
  - obstruction by objects
  - interference

Radio link types:

terrestrial microwave

e.g. 45 Mbps channels

LAN (e.g., Wifi)

11Mbps, 54 Mbps

wide-area (e.g., cellular)

e.g. 3G/4G: hundreds of kbps

satellite

Kbps to 45Mbps channel (or multiple smaller channels)

270 msec end-end delay

geosynchronous versus low altitude

Types of Computer Networks

Spread, size, inter-node-distance and purpose based classification:

- **Personal Area Networks (PANs)**: Often Wireless: WPANs
- **Local Area Networks (LANs)**:LANs & Wireless LANs: WLANs
- **Metropolitan Area Networks (MANs)**: Wireline and Wireless MANs
- **Wide Area Networks (WANs):** Wireless, Fixed / Mobile,

Types of Computer Networks

Intranet: Completely private network of networks

Wireline

Wireless

-Fixed

-Mobile

The Internet: Global public network of networks

Wireline

Wireless

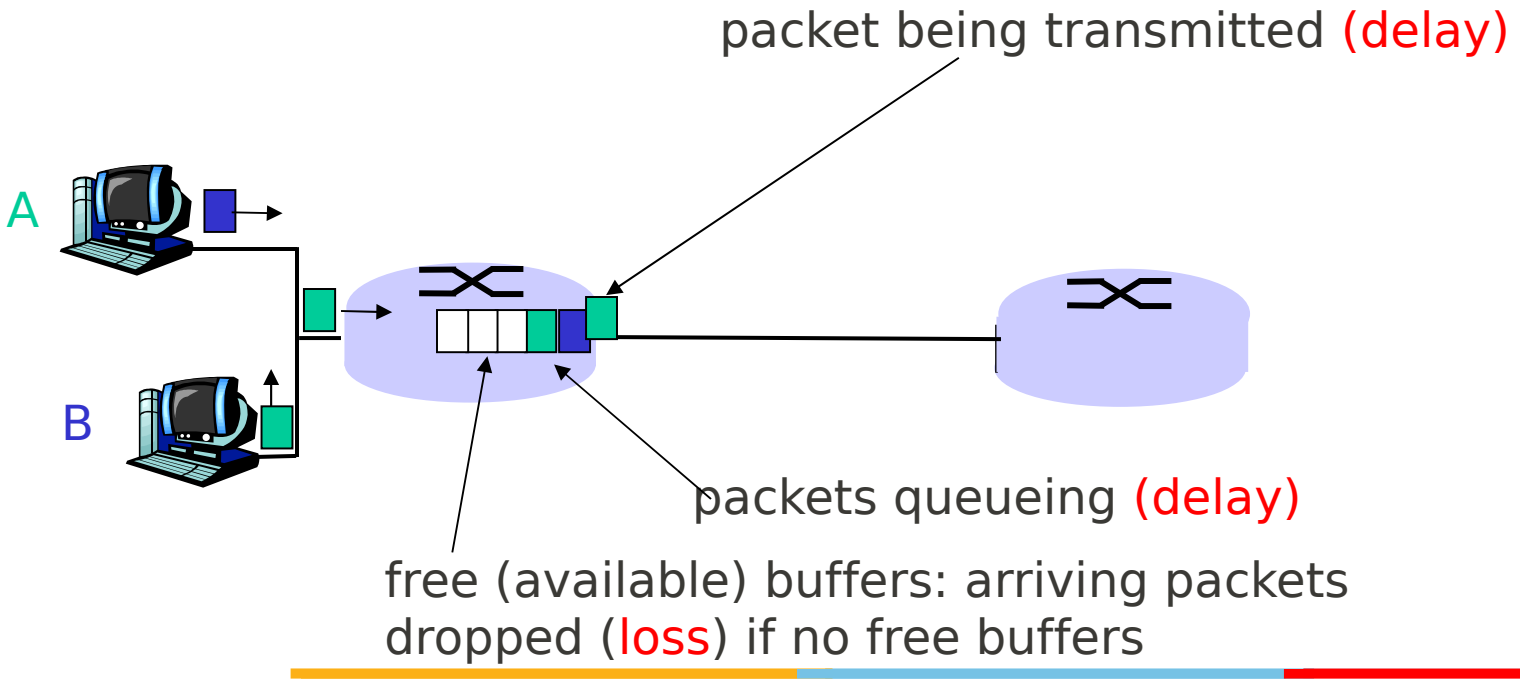
-Fixed

-Mobile

How do loss and delay occur?

packets *queue* in router buffers

- packet arrival rate to link exceeds output link capacity
- packets queue, wait for turn



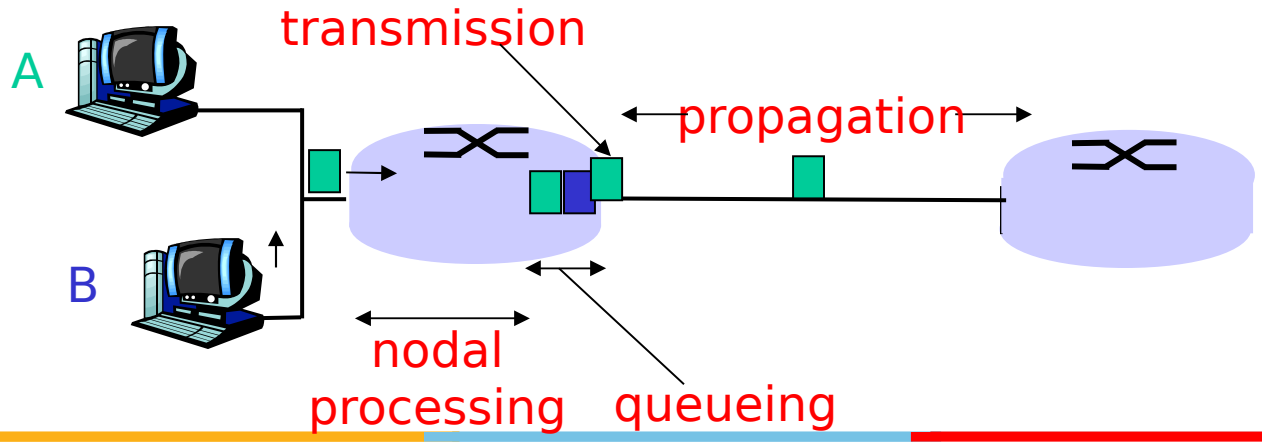
Four sources of packet delay

nodal processing:

- check bit errors
- determine output link

queueing

- time waiting at output link for transmission
- depends on congestion level of router



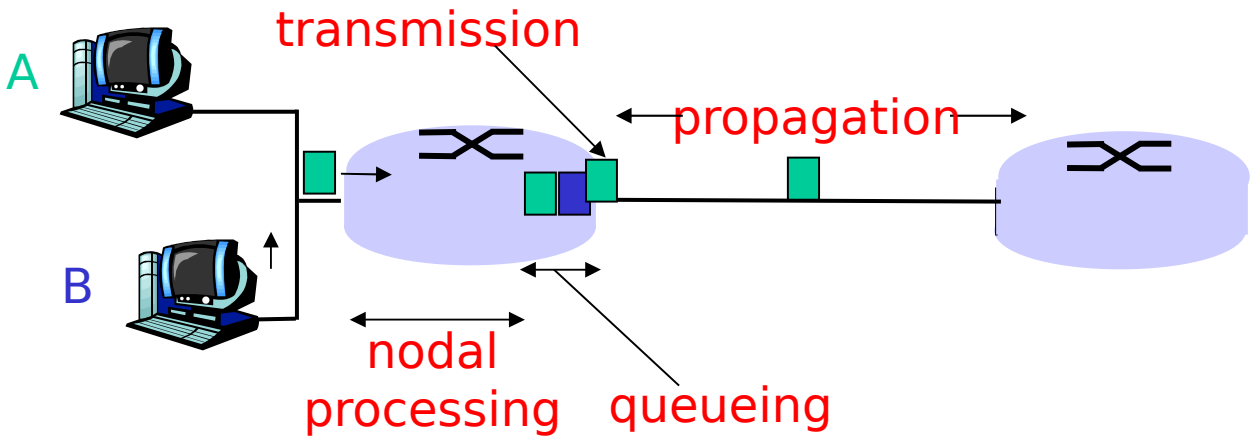
packet delay (contd..)

Transmission delay:

- R=link bandwidth (bps)
- L=packet length (bits)
- time to send bits into link = L/R

Propagation delay:

- d = length of physical link
- s = propagation speed in medium (~2x10^8 m/sec)
- propagation delay = d/s



Topologies & Network Devices (contd...)

Types of Topologies

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Bus

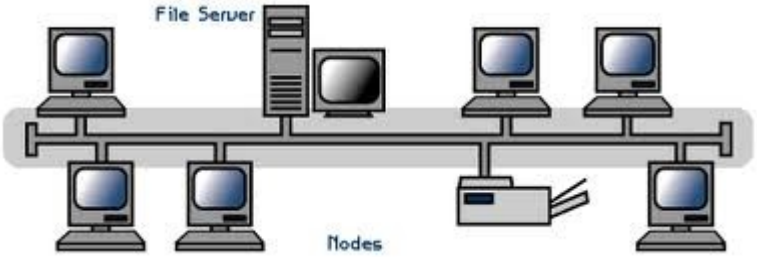
Ring

Star

Mesh

Tree

- Nodes are connected via a shared communications line, called a bus.
- Commonly referred to as a linear bus, all the devices on a bus topology are connected by one single cable.
- simplest way to connect multiple clients, but may have problems when two clients want to transmit at the same time on the same bus.



Types of Topologies

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Bus

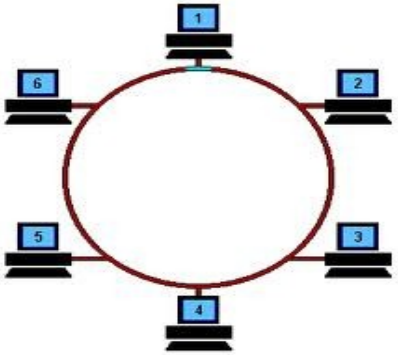
Ring

Star

Mesh

Tree

- Each node connects to exactly two other nodes
- A frame travels around the ring, stopping at each node. If a node wants to transmit data, it adds the data as well as the destination address to the frame.
- The frame then continues around the ring until it finds the destination node, which takes the data out of the frame.
- **Single ring** – All the devices on the network share a single cable
- **Dual ring** – The dual ring topology allows data to be sent in both directions.



Types of Topologies

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Bus

Ring

Star

Mesh

Tree

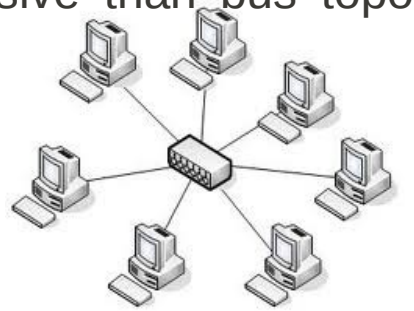
Star network consists of one central switch, hub or computer, which acts as a central point to transmit messages

Merits of a Star Topology

- Easy to install and wire
- No disruptions to the network while connecting or removing devices
- Easy to detect faults and to remove nodes (except the central one)

Demerits of a Star Topology

- Requires more cable length than a bus topology
- If the hub or concentrator fails, nodes attached are disabled
- More expensive than bus topologies because of the cost of the concentrators



Types of Topologies

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Bus

Ring

Star

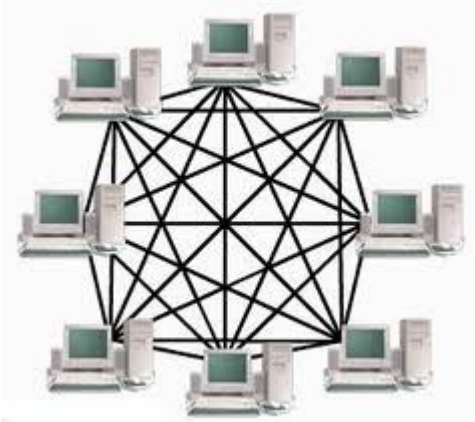
Mesh

Tree

The mesh topology connects all devices (nodes) to each other for redundancy and fault tolerance.

It is used in WANs to interconnect LANs and for mission critical networks like those used by banks and financial institutions.

Implementing the mesh topology is expensive and difficult.



Types of Topologies

Bus

Ring

Star

Mesh

Tree

Hierarchical network

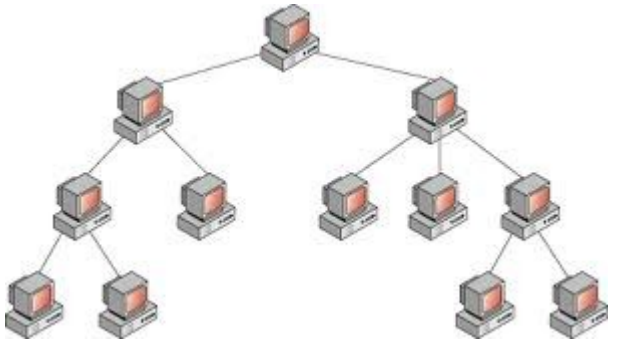
Merits of a Tree Topology

Individual segments can be linked to increase the overall length of the network

Easy to segregate each zone from the other

Demerits of a Tree Topology

Difficult to provide different services to each node in the same sub-tree



Networking Devices.

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Repeaters

Hubs

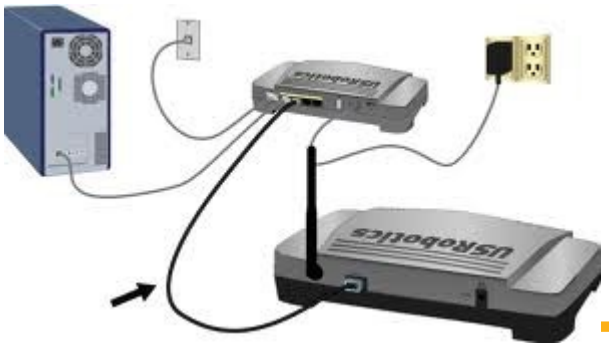
Bridges

Routers

Inter-networking devices are devices used to connect networks. As computer networks grow in size and complexity, so do the inter-networking devices used to connect them.

Purposes

- Allow a greater number of nodes to be connected to the network.
- Extend the distance over which a network can extend.
- Localize traffic on the network.
- Merge existing networks.
- Isolate network problems so that they can be diagnosed easily.



Networking Devices.

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Repeaters

Hubs

Bridges

Routers

When signals first leave a transmitting station, they are clean and easily recognizable. However, the longer the cable length, the weaker and more deteriorated the signals become as they pass along the networking media.

Network repeaters regenerate incoming electrical, wireless or optical signals.

Physical media like Ethernet or Wi-Fi, data transmissions can only span a limited distance before the quality of the signal degrades.

All repeaters are technically OSI **physical layer** devices.

Networking Devices.

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Repeaters

Hubs

Bridges

Routers

Disadvantage

It can't filter network traffic. Data, sometimes referred to as bits, arriving at one port of a repeater gets sent out to other port

Data gets passed along by a repeater to all other LAN segments of a network regardless of whether it needs to go there or no

Networking Devices.

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Repeaters

Hubs

Bridges

Routers

Multi-port repeaters are often called hubs.

Hubs are very common inter-networking devices.

Hubs uses star topology.

Passive hubs(Concentrators) just repeat any incoming signals to every port available, therefore does not act as a line repeater.

Passive hubs just split signals to multiple ports but do not regenerate the signals, which means that they do not extend a cable's length. They only allow two or more hosts to connect to the same cable segment.

Active hubs regenerate signals.

Intelligent hubs have console ports, to allow monitoring of the hubs status and port activity.

Networking Devices.

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Repeaters

Hubs

Bridges

Routers

Advantages

- As an active hubs regenerate signals, it increases the distance that can be spanned by the LAN.
- Hubs can also be connected locally to a maximum of two other hubs, thereby increasing the number of devices that can be attached to the LAN.
- Active hubs are usually used against attenuation, which is a decrease in the strength of the signal over distance.

Disadvantages

- Bandwidth is shared by all hosts i.e. 10Mbs shared by 25 ports/users.
- Can create bottlenecks when used with switches.
- Have no switching capability.
- Most Hubs are unable to utilize VLANS.

Networking Devices.

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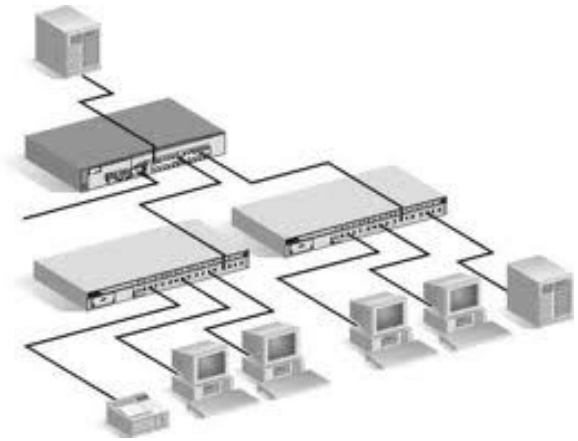
Repeaters Devices that connect and pass packets between two network segments

Hubs

Bridges More intelligent than Hub

Routers Analyze the incoming packet and forward it based on destination address

It operates at OSI **data link layer**



Networking Devices.

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Repeaters

Hubs

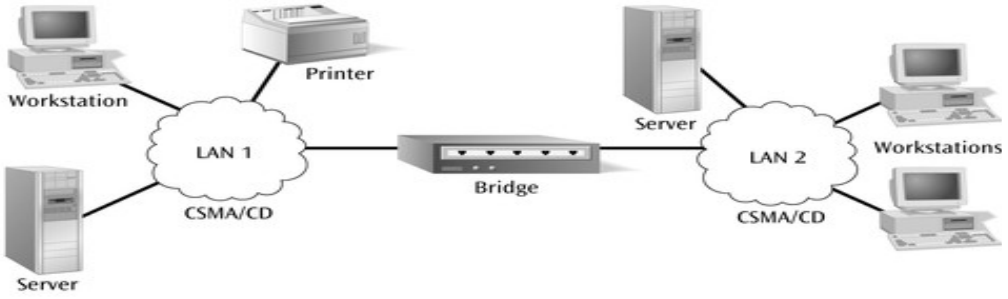
Bridges

Routers

Bridge installation breaks huge LAN's into LAN segments

Bridges filter frames,

- Frames destined for nodes in the same LAN segment are not forwarded onto other LAN segments
- Different LAN segments become separate collision domains



Networking Devices.

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Repeaters

Hubs

Bridges

Routers

A router is used to connect at least two networks

Most common connections are two LAN's or two WAN's or a LAN and its ISP's network

Routers may be used to connect two or more IP networks, or an IP network to an Internet connection

Networking Devices.

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Repeaters

Hubs

Bridges

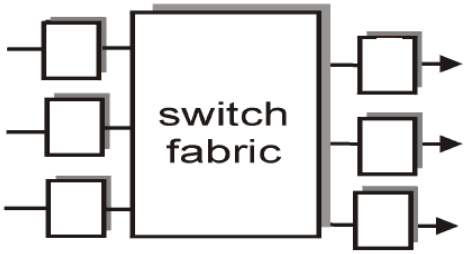
Routers

Routers use packet headers and forwarding tables to determine the best path for forwarding the packets .

They use protocols such as ICMP (Internet Control Message Protocol) to communicate with each other and configure the best route between any two hosts .

It uses Routing Tables, to make decisions about the route .
The routing tables are dynamic and are updated by Routing Protocols .

A router consists of a processor with at least two network interface cards supporting the IP protocol



Networking Devices.

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Repeaters

Hubs

Bridges

Routers

Received packets have all link layer protocol headers removed and transmitted packets have new link protocol header added prior to transmission

The router uses the information held in the network layer header (i.e. IP header) to decide whether to forward each received packet and which network interface to use to send the packet

A filter table may also be used to ensure that unwanted packets are discarded

The filter may be used to deny access to particular protocols or to prevent unauthorized access from remote computers by discarding packets to specified destination addresses

Networking Devices.

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Other Network Devices (Application Layer *)

-Gateway

-Firewall

Gateways

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- A network gateway is an internetworking system, a system that joins two networks together
- A node on a network that serves as an entrance to another network
- In enterprises, the gateway is the computer that routes the traffic from any workstation to the outside network
- In enterprises, the gateway node often acts as a proxy server and a firewall
- At home, the ISP works as the gateway that connects the user to the Internet

Firewalls

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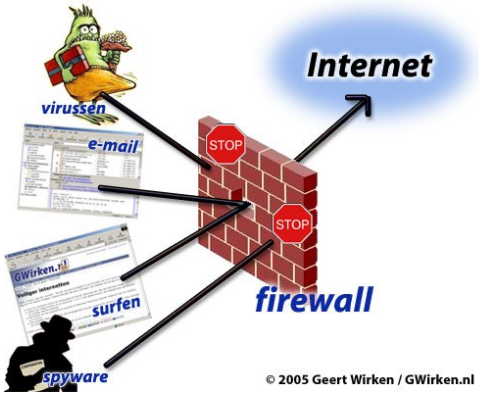
- A system designed to prevent unauthorized access to or from a private network

- A firewall is a hardware or a software device which is configured to permit, deny or proxy data, through a computer network which has different levels of trust

- All messages entering or leaving the Intranet pass through the firewall, which examines each message and blocks those that do not meet the specified security criteria



Firewalls

First generation: packet filters
Second generation: "state-full" filters
Third generation: application layer

Type:

- Proxies
- Network address translation