CS 154 – Networks I

Set 5a
Connectivity Devices
Growing Networks

- As organizations grow, so do their networks. LANs outgrow their original design and needs to be expanded.

- Topology Limitations

  Each topology and architecture has its limits. Networks cannot always be expanded by simply adding more servers and/or extra cabling.
Expanded LANs

- Segment existing LANs so that each segment becomes its own LAN.

- Join two separate LANs.

- Connect to other LANs and join them into a larger network.
Internetworking

- When diverse networks are interconnected, the collection is an internetwork (or internet), and the individual networks are subnetworks (subnets)
- Networks are interconnected using internetworking devices
- Note: The Internet ("uppercase I") is the largest and best known example of an internet ("lowercase I")
Internetworking Devices

- Repeaters
- Bridges
- Routers
- Brouters
- Gateways
- Switches
Repeaters

- Accepts a signal, regenerates or amplifies it, and passes it along at full strength
- Permits the originally-transmitted signal to go further than the attenuation limits
- Works at the OSI Physical layer
Repeater Characteristics

- Connects two segments of similar or dissimilar media
- Passes traffic in both directions, no isolation or filtering
When to use Repeaters

- Use a repeater when you need to connect two segments at low cost.

- Do not use repeaters when:
  - there is heavy network traffic
  - segments use different access methods
  - data filtering is needed
Bridges

- Operates at Layer 2 (Data Link Layer) of OSI
- Used between networks using identical physical and link layer protocols
- Provide a number of advantages
  - Reliability: Creates self-contained units
  - Performance: Less contention
  - Security: Not all data broadcast to all users
  - Geography: Allows long-distance links
Bridge Functions

- Read all frames from each network
- Accept frames from sender on one network that are addressed to a receiver on the other network
- Retransmit frames from sender using MAC protocol for receiver
- Must have some routing information stored in order to know which frames to pass
Bridges

Bridges can be used to:

- expand the distance of a segment
- reduce traffic bottlenecks due to excessive number of connected computers
- link unlike physical media
- link unlike network segments and forward packets between them
How Bridges Work

- listens to all traffic
- checks source and destination of each packet
- builds a routing table (or "forwarding" table)
- forwards packets as follows:
  - if the destination is not listed in the routing table then it is sent to all segments; or
  - if the destination is listed in the routing table then the bridge forwards it to the particular segment
Creating the Routing Table

- Bridges build their routing tables based on the addresses that have transmitted data on the network.
  - When the bridge receives a packet, the source address is compared to the routing table.
  - If the source address is not there, it is added to the table.
  - The bridge then compares the destination address with the routing table database.
Segmenting Network Traffic

- Bridges can use routing tables to reduce the traffic on the network by controlling which packets get forwarded to other segments.
Remote Bridges

- Capable of passing a data frame from one local area network to another when the two LANs are separated by a long distance and there is a wide area network (WAN) connecting the two LANs.
- A remote bridge takes the frame before it leaves the first LAN and encapsulates the WAN headers and trailers.
- When the packet arrives at the destination remote bridge, that bridge removes the WAN headers and trailers leaving the original frame.
Bridges and Repeaters

- Bridges work at a higher OSI layer than repeaters. This means that bridges have more intelligence and can take more data features into account.

- Bridges regenerate data at the packet level. Bridges can send packets over long distances using a variety of long distance media.
Bridge Considerations

- Bridges cannot take advantage of multiple paths simultaneously.
- Bridges pass all broadcasts, possible creating broadcast storms.
- Bridges pass packets with unknown destinations.
When to use Bridges

Use bridges to:

- connect two segments to expand the length or number of nodes on the network
- reduce traffic by segmenting the network
- connect dissimilar networks
Transparent Bridges

- Also called spanning tree bridge
- Source stations don’t need to know receiver’s locations
- No changes are required to install the bridge
- Intelligence necessary to make the relaying decision exists in the bridge itself
Transparent Bridge Operation

- Operates in promiscuous mode: accepts every frame transmitted on all LANs
- Decision to forward or to discard is made based on a destination table
  - lists each possible destination
  - determines LAN for source address
- Table created by listening to all transmissions (learning)
- Learns destinations from source addresses
Source Routing Bridges

- Assumes that the sender of each frame knows whether or not the destination is on its own LAN
  - When a workstation wants to send a frame, it must know the exact path of network / bridge / network / bridge / network …
  - If a workstation does not know the exact path, it sends out a discovery frame.
  - The discovery frame makes its way to the final destination, then as it returns, it records the path.
- Bridge itself requires less processing power
- Developed by IBM, used in token ring networks
Source Routing Transparent Bridges

- Used to connect a transparent bridge based network (CDMA/CD or Token bus) to a source routing based network (Token ring)
- Combines both methods
- Source routing is performed only when the frame received has the routing information
Routers

For more complex networks, a device is required that not only segments the LAN but also determines the best path for sending the data across segments. Such a device is called a router.
Routers

- Used to connect two networks that may or may not be similar
- Three primary functions
  - Provide a link between networks
  - Provide for routing and delivery of data between nodes on different networks
  - Provide services in a way that does not require modification of the subnets
- Operate at Layer 3 (Network Layer) of OSI model
Router Characteristics

- Protocol-based device; Protocol-specific information is exchanged between networks enabling packets to route packets across multiple networks.
- Most routers support TCP/IP; TCP provides end-to-end reliability at higher layers, so routers need not be concerned with error recovery or flow control.
- Network security and management is much more robust than with bridges.
Routing Table

- Each router maintains a routing table to determine the addresses of incoming data.

- The routing tables maintained by routers contain network addresses, information on how to connect to other networks, possible paths and the cost of sending data over those paths.

- Routers can also share status information with one another and use this information to bypass slow or malfunctioning connections.
Choosing Paths

- Based on all the information available, a router selects the best route for a data packet.
Multiple Paths

A bridge can only recognize one path between networks. A router can search among multiple active paths.
Routing Protocols

- To determine the **best path**, routers communicate with each other through **routing protocols**.

- In addition to its ability to find the best path, a routing protocol can be characterized according to its convergence time and bandwidth overhead:
  - **Convergence time**
    - The time it takes for a router to recognize a best path in the event of a change or outage.
  - **Bandwidth overhead**
    - Burden placed on an underlying network to support the routing protocol.
Routable Protocols

- Not all protocols support routing. Routable protocols include DECnet, IP, IPX, XNS and AppleTalk.

- Protocols which are not routable include Local Area Transport or LAT (from DEC) and NetBEUI.
Types of Routers

The two major types of routers are:

- **Static** - require an administrator to manually setup and configure the routing table and to specify each route.

- **Dynamic** - do an automatic discovery of routes; can examine information from other routers and make packet-by-packet decisions about how to send data across the network.
Bridges vs. Routers

- Bridges recognizes MAC sublayer addresses only (addresses of network cards in its own segment). Routers recognize network addresses.

- Bridges broadcasts everything it does not recognize and forwards all addresses it knows, but only out the appropriate port.

- The router only works with routable protocols.

- The router filters addresses. It forwards particular protocols to particular addresses.
Brouters

A brouter combines the best qualities of both a bridge and a router. It can:

- route selected routable protocols
- bridge nonroutable protocols
- deliver more cost-effective and more manageable internetworking than separate bridges and routers
When to Use Routers/Brouters

Use routers to:

- connect two networks and limit unnecessary traffic.
- separate administrative networks.