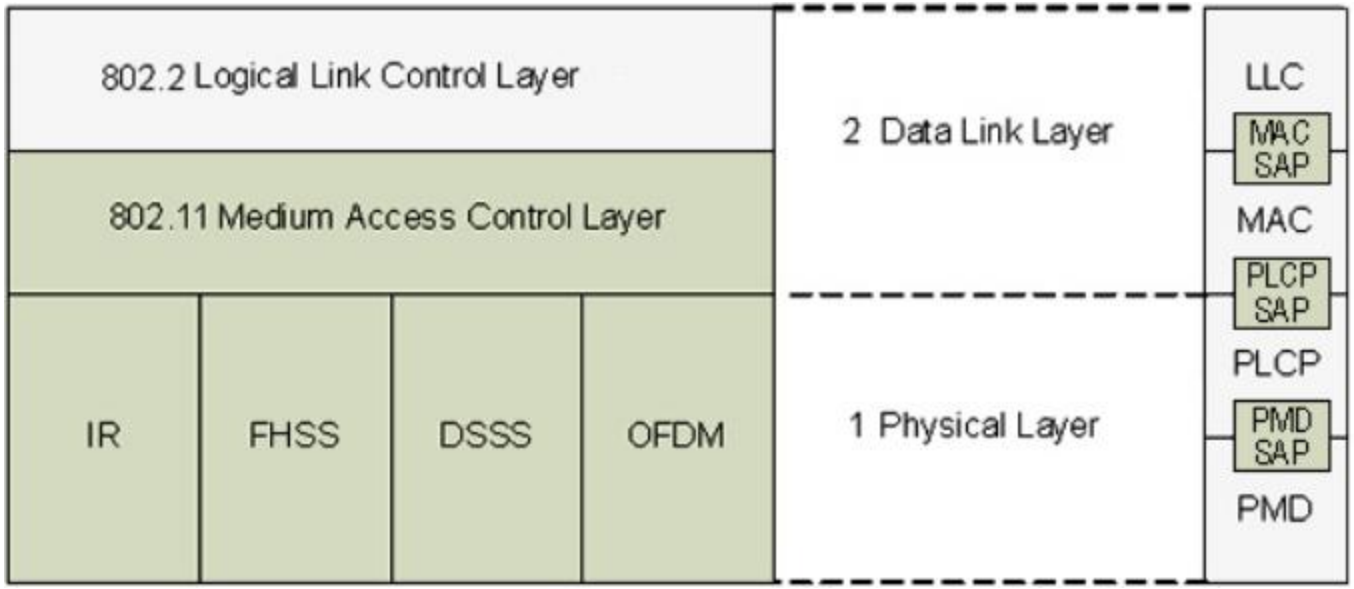
Data Link Layer

Chapter 4

Summary



Data link layer composed of two sublayers

1. Logical link Control
2. Media Access Control

Media Access Control

- Refers to controlling when computers can use the media i.e. when can they transmit and receive.

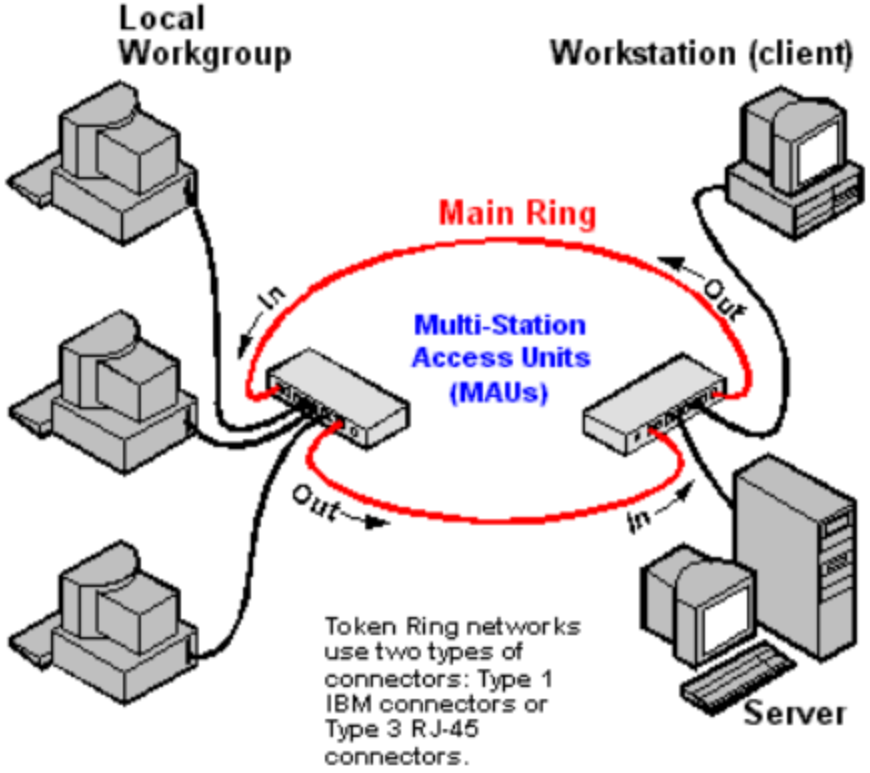
Three approaches.

- Contention
- Token passing
- Polling

Media Access Control: Contention

- Contention
  - Computers listen and transmit only when no others are transmitting.
  - Works better for small networks that have low levels of usage.
  - Listen before talk
    - AKA the cocktail party model

Media Access Control: Token Passing



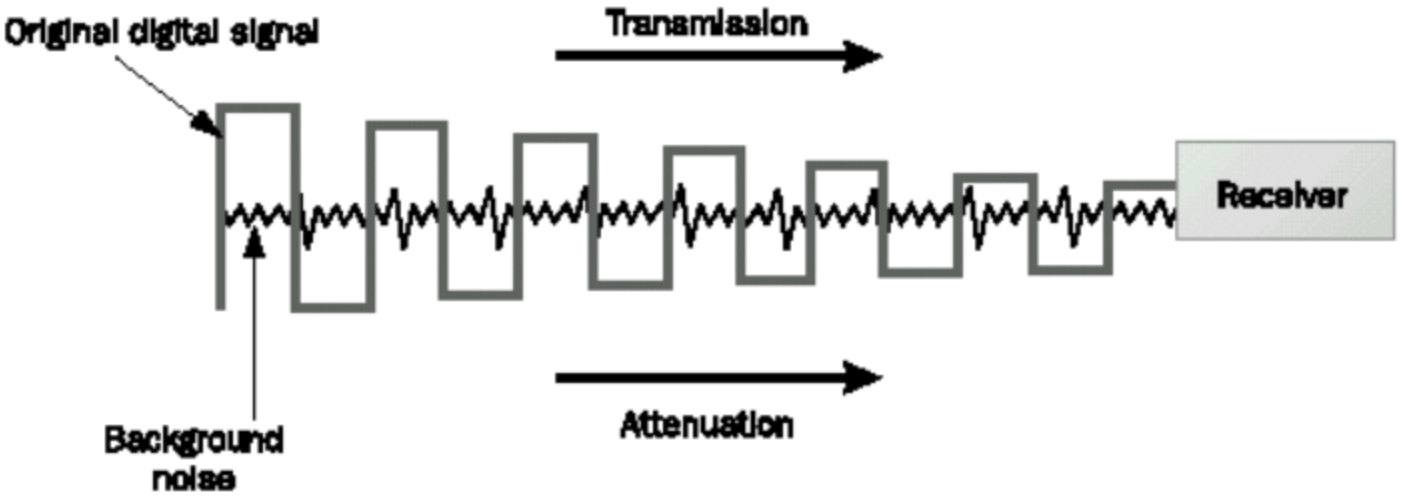
- Token passing
  - Computers themselves manage when they can transmit by passing a special packet called a token.
  - Only the computer that has the token can transmit.
  - Ring is logical topology
    - Physical topology is normally star

Logical Link Control

- LLC sublayer acts as an interface between the media access control (MAC) sublayer and the network layer.
- LLC sublayer provides multiplexing mechanisms that make it possible for several network protocols (IP, IPX, Decnet and Appletalk) to coexist within a multipoint network and to be transported over the same network medium.
- Can also provide flow control and automatic repeat request (ARQ) error management mechanisms.

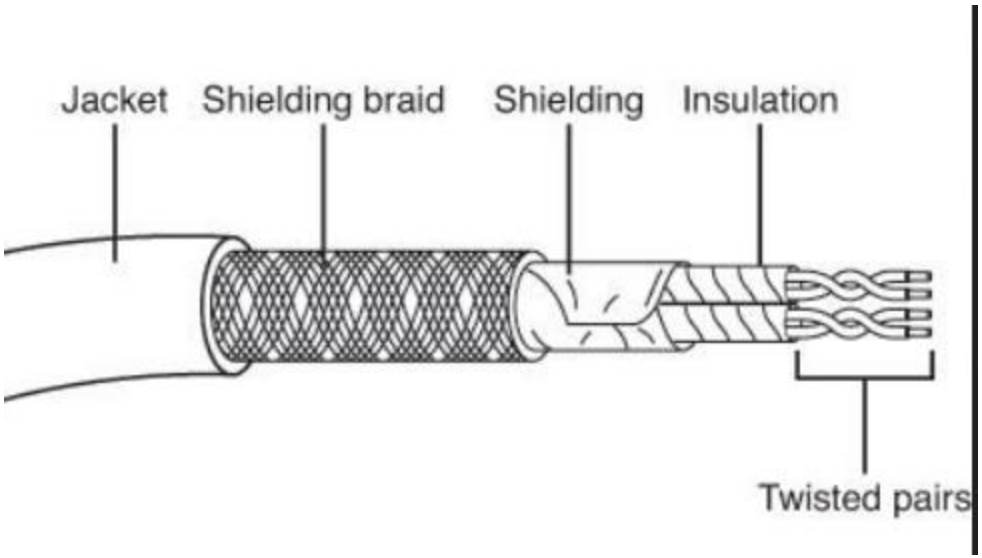
Error Sources

- Errors occur in all networks.
  - Tend to occur in groups (bursts).
- Primary sources of errors include:
  - Impulse noises (e.g. lightning)
  - Cross-talk
  - Echo



Error Prevention

- Errors can be prevented or reduced by:
  - Shielding cables
  - Moving cables away from sources of noise and power sources;
  - Using repeaters
  - Improving the quality of the equipment, media, and their connections.



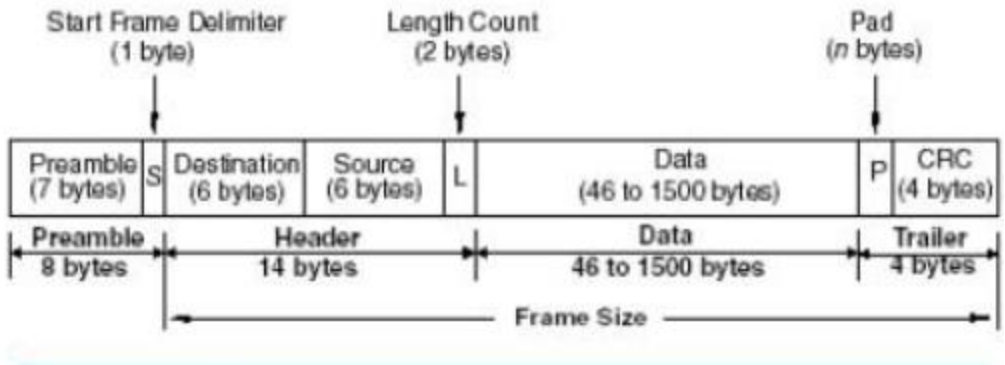
Error Detection

- Error-detection schemes attach additional error-detection data, based on a mathematical calculation, to the user's message.
- Receiver performs the same calculation on incoming messages.
  - If the results of this calculation do not match the error-detection data on the incoming message, an error has occurred.
- Parity, checksum, and CRC most common error-detection schemes.

Original Data	Even Parity	Odd Parity
0 0 0 0 0 0 0 0	0	1
0 1 0 1 1 0 1 1	1	0
0 1 0 1 0 1 0 1	0	1
1 1 1 1 1 1 1 1	0	1
1 0 0 0 0 0 0 0	1	0
0 1 0 0 1 0 0 1	1	0

Error Correction

- Most common error-correction technique is simply to ask the sender to retransmit the message until it is received without error.
- A different approach, forward error correction, includes sufficient information to allow the receiver to correct the error in most cases without asking for a retransmission.



Message Delineation

- Message delineation means to indicate the start and end of a message.
- Done differently depending on whether transmission is Asynchronous or Sychronous
  - Asynchronous transmission uses start and stop bits on each letter to mark where they begin and end.
  - Synchronous techniques (e.g., SDLC, HDLC, Ethernet, PPP) group blocks of data together into frames that use special characters or bit patterns to mark the start and end of entire messages.

Transmission Efficiency and Throughput

- Every protocol adds additional bits to the user's message before sending it (e.g., for error detection).
  - These are called overhead bits because they add no value to the user.
- Efficiency of a transmission protocol is the number of information bits sent by the user divided by the total number of bits transferred (information bits plus overhead bits).
- Synchronous transmission provides greater efficiency than does asynchronous transmission.

Transmission Efficiency and Throughput

- In general, protocols with larger frame sizes provide greater efficiency than those with smaller frame sizes.
  - One drawback is that they are more likely to be affected by errors and thus require more retransmission.
- Small frame sizes better suited to error-prone circuits
- Large frames better suited to error-free circuits.

Questions?

Transport and Network Layer Protocols

Chapter 5

Summary

TCP/IP Transport And Network Protocols.

Perform

- Logical addressing (finding destination addresses)
- Routing (finding "best" route through the network)
- Segmenting (breaking large messages into smaller packets for transmission and reassembling them at the destination).

Transport Layer

- **Major functions**
  - Tracking Individual Conversations
  - Segmenting Data
  - Reassembling Segments
  - Identifying the Applications
- **Control conversation**
  - Establishing a Session
  - Reliably delivery
  - Same order delivery
  - Flow Control

- Transport layer (TCP) uses source and destination port addresses to link the application layer software to the network.
- Responsible for segmenting
  - Breaks large messages into smaller segments for transmission and reassembling them at receiver.
- When connection-oriented routing is needed, TCP establishes connection or session.
- UDP connectionless.

QOS

- Quality of service provides the ability to prioritize packets.
- Consequently, real-time voice packets can be transmitted more quickly than email packets.

Address	Example Software	Example Address
Application layer	Web browser	www.kelley.indiana.edu
Network layer	Internet Protocol	129.79.127.4
Data link layer	Ethernet	00-0C-00-F5-03-5A

Addressing

Different layers different types of addresses:

- Application layer address
- Transport layer port address
- Network layer address
- Data link layer address
  - Usually done in hardware
  - In contrast, network layer, transport, and application layer addresses are done in software.

Network and Application Layer Addresses

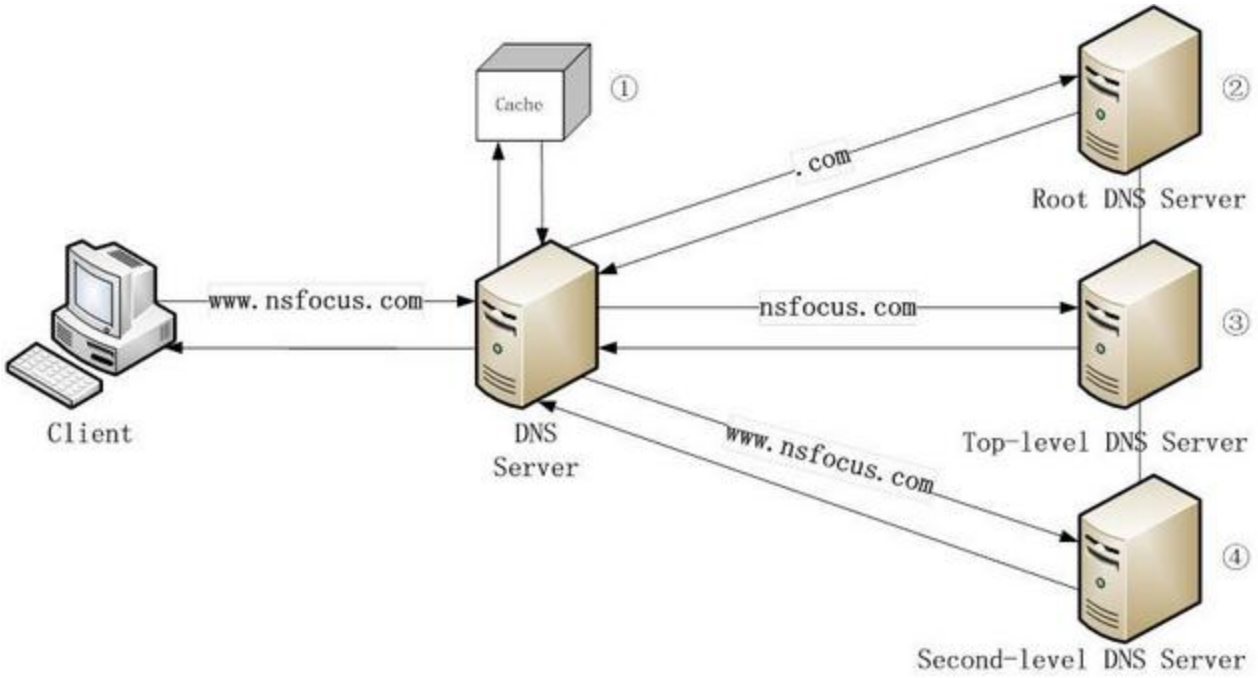
- Assigned by Internet registrars.
- A domain name registrar is an organization or commercial entity that manages the reservation of Internet domain names.
- Since 1999, supervised by the Internet Corporation for Assigned Names and Numbers (ICANN)
- ICANN accredits domain-name registrars for top level domains…

Network and Application Layer Addresses

- Addresses within one organization are usually assigned so that computers in the same LAN, or subnet, have similar addresses.
- Subnet masks indicate whether the first 2 or 3 bytes (or partial bytes) indicate the same subnet.
- While an administrator can manually assign static network layer addresses on the client computer, most will use dynamic addressing
  - DHCP server assigns addresses when a computer first joins the network.

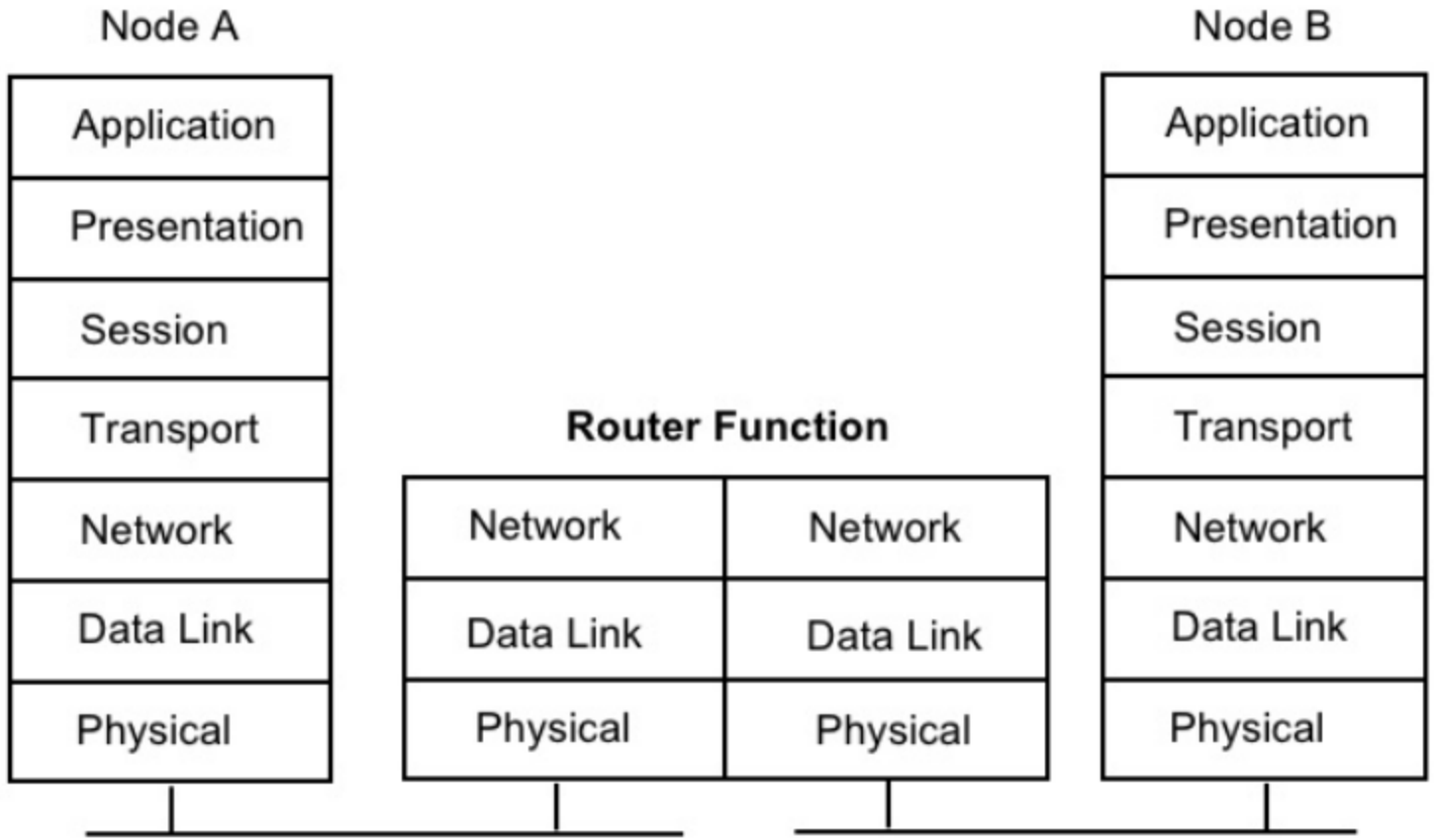
DNS: Address Resolution

- Process of translating:
  - An application layer address into a network layer address (DNS)
  - A network layer address into a data link layer address (ARP)



DNS: Address Resolution

- Network layer resolution is done by sending a query to a DNS server (also called a name server) that asks for the IP address (e.g., 129.29.98.5) for a given Internet address (e.g., www.uh.edu).
- If a DNS server does not have an entry for the requested Internet address, it will forward the request to another DNS server that is likely to have the address.
- That server will either respond or forward the request to another DNS server, and so on, until the address is found or it becomes clear that the address is unknown.



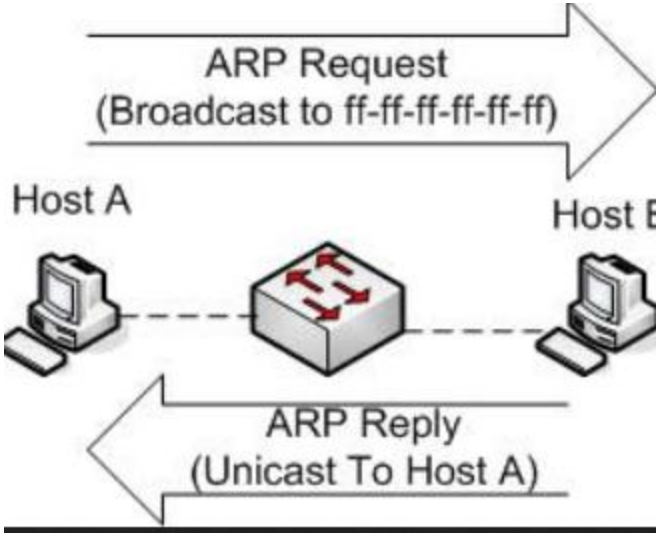
- You can only send packets to a physical address…
  - You can't send packets to a logical address…
- The above figure illustrates what happens as a packet goes across a router.
  - Physical source and destination address change while logical addresses remain same…

TCP/IP Example

- IP packet contains the original source and ultimate destination address for the packet.
- Sending computer also creates a data link layer frame (e.g., Ethernet) for each message.
- This frame contains the data link layer address of the current computer sending the packet and the data link layer address of the next computer in the route.
- The data link layer frame is removed and replaced with a new frame at each computer at which the message crosses.
- Thus, the source and destination data link layer addresses change at each step along the route whereas the IP source and destination addresses never change.

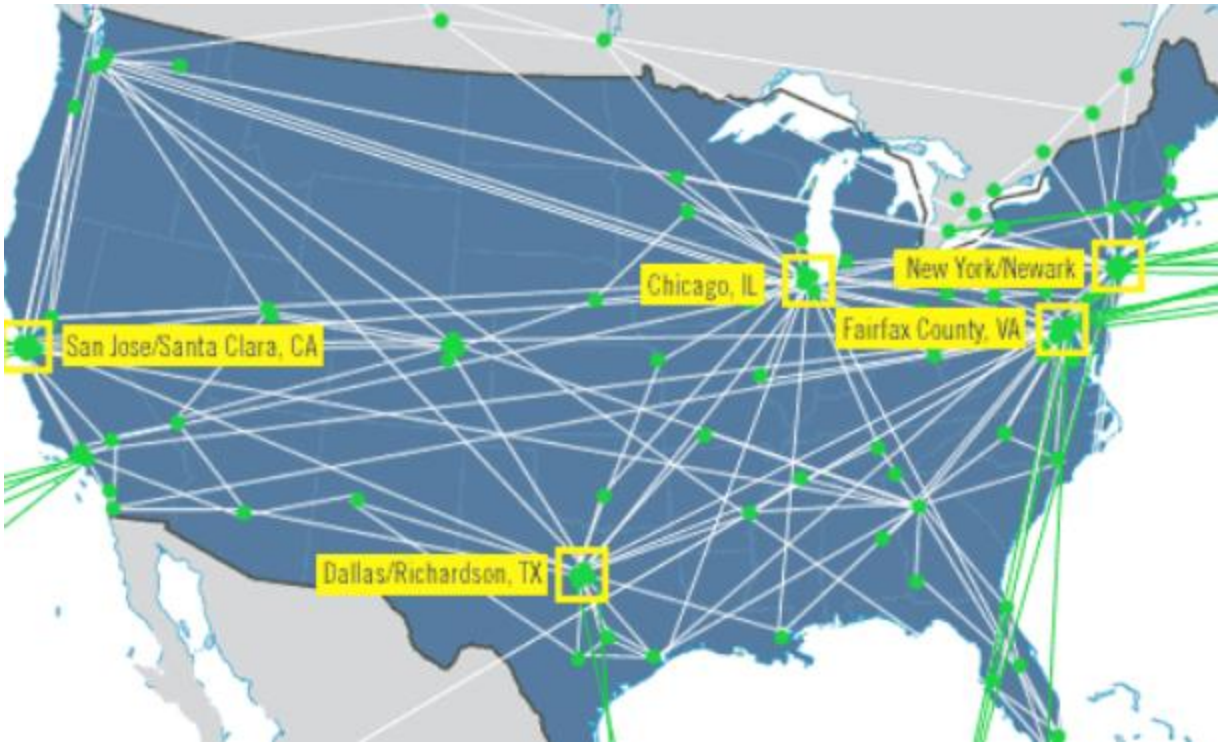
Address Resolution Protocol (ARP)

- Resolving an IP address to a data link layer addresses.
- Done by broadcasting an ARP request to all computers on the same subnet that asks the computer with the requested IP address to respond with its data link layer address.



Routing

- Process of selecting route or path through network that a message will travel from the sending computer to the receiving computer.
- Could be:
  - Dynamic
  - Static
  - Centralized



Dynamic Routing

- With dynamic routing, a goal is to improve network performance by routing messages over the fastest possible route;
- An initial routing table is developed by the network manager but is continuously updated to reflect changing network conditions, such as message traffic.
  - Examples of dynamic routing protocols
    - BGP
    - RIP
    - ICMP
    - EIGRP
    - OSPF

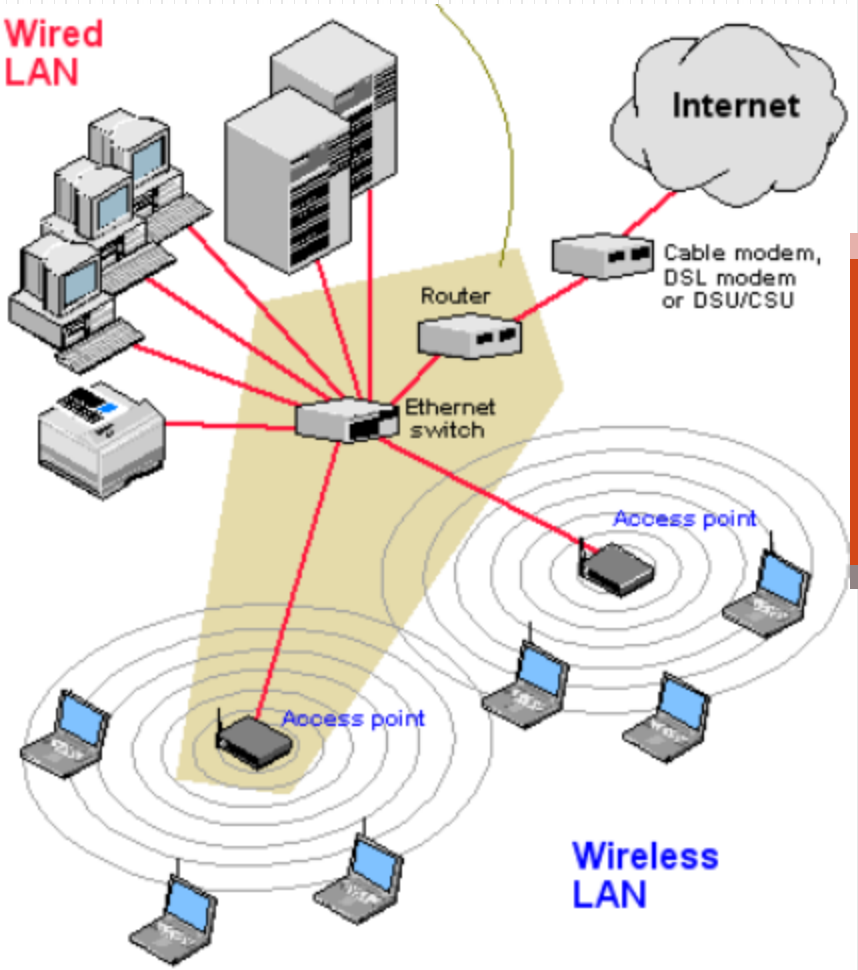
Static Routing

- With static routing, the routing table is developed by the network administrator and remains unchanged unliess the network administrator updates it.
- With centralized routing, one computer performs all the routing decisions.

Frame

- Frame contains the data link layer address of the current computer sending the packet and the data link layer address of the next computer in the route.
- The data link layer frame is removed and replaced with a new frame at each computer at which the message stops as it works its way through the network.
- Thus, the source and destination data link layer addresses change at each step along the route whereas the IP source and destination addresses never change.

Questions???



Wired and Wireless Local Area Networks

Chapter 6

Why Use a LAN?

- Two basic reasons for developing a LAN:
  1. Information sharing
  2. Resource sharing.
- Information sharing refers to business needs that require users to:
  - Access the same data files
  - Exchange information via email
  - Search the Internet for information.

Resource Sharing

- Resource sharing refers to one computer sharing a hardware device (e.g., a printer) or software package with other computers on the network.
  - Main benefit of resource sharing is cost savings
  - Main benefit of information sharing is improved decision making.

Dedicated-Server versus Peer-to-Peer Networks

- A dedicated-server LAN has one computer that acts as the network server.
- It can connect with almost any other network, handle very large databases, and use sophisticated LAN software.
- Moreover, high-end dedicated-server LANs can be interconnected easily to form enterprise wide networks or, in some cases, replace the host mainframe central computer.
- Common types of dedicated servers include Web servers, application servers, file servers, database servers, print servers, and remote access servers.
- All computers on a peer-to-peer LAN run special network software that enables them to function both as a client and as a server.

LAN Components

- NIC enables computer to be physically connected to the network and provides the physical layer connection among the computers.
- Wired LANs may use UTP, STP, and/or fiber-optic cable.
- Network hubs and switches provide an easy way to connect network cables and act as repeaters.
- Wireless NICs provide radio connections to access points that link wireless computers into the wired network.

LAN Components Two

- Network Operating Software (NOS) performs functions associated with the data link and the network layers.
  - Interacts with application software and the computer's own operating system.
- Every NOS provides two sets of software: one that runs on the network server(s) and one that runs on the network client(s).
- Network profile specifies what resources on each server are available for network use by other computers and which devices or people are allowed what network access.

Ethernet (IEEE 802.3) CSMA/CD

- Ethernet, the most commonly used LAN protocol in the world.
- Uses contention-based media access technique called CSMA/CD.
  - Many different types of Ethernet that use different network cabling (e.g., 10Base-T, 100Base-T, 1000Base-T, 10 GbE).
- Switches significantly faster than hubs.
- Wireless Ethernet (Wi-Fi) is most common wireless LAN.
- Uses physical star/logical bus topology with both controlled and contention-based media access control. 802.11n, the newest version, provides 200 Mbps over three channels or faster speeds over fewer channels.

Best Practice LAN Design

- Most organizations install 100Base-T or 10/100/1000 Ethernet as their primary LAN.
- Provide wireless 802.11n as an overlay network.
- For SOHO networks, best LAN choice may be wireless.

LAN Bottlenecks

- Every LAN has a bottleneck.
  - Narrow point in the network that limits the number of messages that can be processed.
  - Generally speaking, bottleneck will lie in either the network server or the network circuit.

Performance

- Server performance can be improved:
  - With faster NOS that provides better disk caching
  - Buying more servers and spreading applications among them
  - Upgrading server's CPU, memory, NIC, and the speed and number of its hard disks.
- Circuit capacity can be improved by:
  - Using faster technologies (100Base-T rather than 10Base-T)
  - By segmenting the network into several separate LANs
  - By adding more switches or access points.
- Overall LAN performance also can be improved by reducing the demand for the LAN by moving files off the LAN, moving users from wired Ethernet to wireless or vice versa, and by shifting users' routines.

Questions???