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01 Physical Networks

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Structure of the Internet

- The Internet is a two-layered system:
 - ▶ Heterogeneous collection of underlying **physical networks**.
 - ▶ Homogeneous **virtual network** implemented using TCP/IP protocol software on top of the physical networks.
- Corresponding to the two layers of the Internet are two layers of addresses:
 - ▶ **Physical addresses** are assigned according to schemes which vary from one network technology to another.
 - ▶ **IP addresses** are assigned according to a scheme that is uniform across the Internet.

Two Kinds of Communication Networks

1. A **connection-oriented** network provides dedicated **connections** or **circuits** between communication points.
 - ▶ **Examples:** Telephone system, ATM computer networks.
 - ▶ **Advantage:** Guaranteed service once connection is established.
 - ▶ **Disadvantage:** A connection consumes resources independent of the level of traffic.
2. A **connectionless** network transfers data in the form of small independent **packets**.
 - ▶ **Examples:** Postal mail system, most computer networks.
 - ▶ **Advantage:** Resources are shared.
 - ▶ **Disadvantage:** Service is not guaranteed.

LAN and WAN Networks

- Local area networks (LANs) provide high-speed communication over short distances.
 - ▶ Typical transmission speed: 100 Mbps to 10 Gbps.
 - ▶ The physical network is often passive.
 - ▶ Scalability is low.
- Wide area networks (WANs) provide relatively slow-speed communication over long distances.
 - ▶ Typical transmission speed: 1.5 Mbps to 2.4 Gbps.
 - ▶ The physical network is composed of communication lines and packet switches, computers that route and forward packets.
 - ▶ Scalability is high.

Ethernet

- Most popular LAN technology, invented in the early 1970s by Xerox PARC.
- Uses different wiring schemes:
 - ▶ Coaxial cable, bus topology (obsolete).
 - ▶ Thin-wire, ring topology (obsolete).
 - ▶ Twisted pair, point-to-point or star topology.
 - ▶ Optical fiber, point-to-point or star topology.
- Transmission speeds: 10 Mbps, 100Mbps, 1Gbps, or 10Gbps.

Twisted Pair Scheme

- Network consists of:
 - ▶ Network interface cards (NICs) on each host.
 - ▶ Hubs and switches.
 - ▶ Twisted pair patch and crossover cables.
- Each cable can be no longer than 100 meters.
- Cables are usually half duplex but can also be full duplex.
- 10/100/1000 Ethernet NICs and switches automatically negotiate the maximum speed and type of cable of a connection.

How Ethernet Works

- Network acts as a **shared bus** for the connected hosts.
- Packets called **frames** are represented as electronic analog signals.
- Packets are **broadcasted** to all connected hosts.
 - ▶ Access to the network gives access to all communication between the hosts on the network!
- **Best-effort delivery**: no information about the delivery is sent back to the sender.
- At most one packet is transmitted on the network at a time which can lead to **collisions**.
 - ▶ Mechanisms are used to detect and avoid collisions.
 - ▶ The wide use of switches in place of hubs has greatly reduced the size of **collision domains** and the problems caused by collision domains.

Bridges and Switches

- Repeaters and hubs amplify electronic analog signals.
- Bridges and switches forward Ethernet frames.
 - ▶ Whether and where the frame is forwarded is decided on the basis of the destination address of the frame.
 - ▶ Automatically learn the addresses of the interfaces.
 - ▶ Create multiple collision domains.
- Advantages over repeaters and hubs:
 - ▶ Make multiple Ethernets behave like a single Ethernet.
 - ▶ Decrease the number of collisions and thus increases performance.
 - ▶ Allow an Ethernet network to have many more interfaces and to span much larger distances.
 - ▶ Decrease the danger to privacy caused by Ethernet broadcasting.

Ethernet Hardware Addresses

- Each Ethernet NIC is assigned a unique 48-bit (6-octet) number called an **Ethernet address** by the manufacturer.
- The Ethernet address associated with a computer can change if its Ethernet NIC is changed.
- The host NIC (normally) accepts a packet (and then passes it on to the computer) only if the destination address of the packet is the address of the NIC.
- A host NIC can be programmed to also accept packets with the broadcast address (all 1s) and multicast addresses.
- A NIC can even be programmed to accept **all** packets!

Ethernet Frame Format

- Preamble (8 octets).
- Destination physical address (6 octets).
- Source physical address (6 octets).
- Frame type (2 octets).
- Frame data (64-1500 octets).
- Cyclic Redundancy Check (CRC) (4 octets).

Wireless Local Area Network (WLAN)

- Communication is via radio or infrared waves.
- IEEE 802.11 is a popular set of protocols for WLAN.
 - ▶ Utilizes spread-spectrum modulation technology.
 - ▶ Transmission speeds: 11 Mbps, 54 Mbps, or 600 Mbps (planned).
- Advantages:
 - ▶ Ease of use.
 - ▶ Highly flexible configuration.
 - ▶ Low cost.
- Disadvantages:
 - ▶ Security: There are many security issues concerning WLANs, e.g., easy **sniffing** and **piggybacking**.
 - ▶ Range, reliability, speed.

Fiber Distributed Data Interconnect (FDDI)

- Based on optical fiber with packets represented as pulses of light.
- Transmission speed: 100 Mbps.
- The network is a pair of **token rings** with a self-healing capability.
- Advantages:
 - ▶ Optical cable is not bothered by electrical noise and has a higher transfer rate than wires carrying electronic signals.
 - ▶ An FDDI frame has a greater maximum size than an Ethernet frame.

How a Token Ring Works

- A **token ring** network employs a ring topology.
- Access to a token ring is controlled by means of a special frame called the **token** which is continuously passed around the ring.
- Each frame (except the token) goes all the way around the ring once.
 - ▶ The host with its destination address keeps a copy of the frame.
- A host forwards the token after it has sent a frame or if it has no frames to send.
- The token mechanism guarantees fairness.

FDDI Self-Healing Mechanism

- Each host is on both token rings .
 - ▶ The first ring is the primary ring.
 - ▶ The second ring is for accommodating failures.
 - ▶ Traffic on the two rings goes in opposite directions.
- When a host interface fails, the point of failure is bypassed by splicing the first and second rings together.

FDDI Frame Format

- Composed of 4-bit **symbols**.
- A frame can be large, up to 9000 symbols long (with about 4K of data).
- Contains source and destination physical addresses.
- Frame format is designed for supporting the self-healing mechanism.

Asynchronous Transfer Mode (ATM)

- High-speed, low-delay, low-jitter, high-cost, connection-oriented network technology for data, voice, and video.
- Transmission speed is measured in Gbps.
- ATM network consists of optical fiber connections and high-speed switches in a star topology.
- Can be used for both LANs and WANs.
- Frames (called **cells**) have a fixed length of 53 octets (but an ATM network can handle much larger packets).
- ATM cable consists of two fibers, one for each direction.

How ATM Communication is Performed

1. The source requests a connection to a destination.
2. The ATM network establishes a connection and returns a connection identifier to the source.
3. The source uses the connection identifier to send cells to the destination.
4. The destination may request a reverse connection to send replies to the source.
5. When finished, the source requests that the connection be closed.

Other Network Technologies

- LAN technologies:
 - ▶ Other token ring technologies.
 - ▶ Other wireless technologies via radio, microwave, or infrared.
 - ▶ Copper Distributed Data Interface (CDDI).
 - ▶ Powerline schemes.
- WAN technologies:
 - ▶ Various wired and wireless WAN services provided by long-distance telephone carriers.
- Point-to-point networks via the telephone system or wireless transmission media.