SE 4C03 Winter 2002

02. Physical Networks

Instructor: W. M. Farmer

Revised: 10 January 2002

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
   - Example: 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**
   - Example: 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: 10 Mbps to 2 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 155 Mbps
  - The physical network is composed of **communication lines** and **packet switches**, computers that 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
  - Thin-wire, ring topology
  - Twisted pair, star topology
- Transmission speeds: 10 Mbps, 100Mbps, or 1Gbps
- Wireless Ethernet
  - Communication is via radio waves
  - Transmission speeds 11 Mbps (IEEE Std 802.11)

Twisted Pair Scheme

Network consists of:

- **Network interface cards (NICs)** on each host
- **Hubs**
- Twisted pair **patch** and **crossover** cables
  - Each cable can be no longer than 100 meters

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

Ethernet Hardware Addresses

- Each Ethernet network interface card 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 network card is changed
- The host network interface card (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 network interface card
- A host network interface card can be programmed to also accept packets with the broadcast address (all 1s) and multicast addresses

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)

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 basis of the destination address of the frame
  - Decrease the number of collisions by creating multiple **collision domains**
  - Decrease the danger to privacy caused by Ethernet broadcasting

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

ARPANET (1983–1987)

- WAN consisting of about 50 **Packet Switching Nodes (PSNs)**
- PSNs were connected by leased serial data lines
- One PSN was at each network site with 22 ports for connecting local hosts to the network
- Conceptually, addresses were pairs (P, N) where:
  - P is a unique integer denoting the PSN
  - N is the integer denoting the port on the PSN

NSFNET (1987-1990)

- Three-level topology:
  - U.S. backbone
  - Regional networks
  - Campus networks
- The backbone was a WAN consisting of interconnected packet routers
- Each packet router at a site was connected to a local Ethernet as well as to other sites

Other Network Technologies

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