SE 4C03 Winter 2007

01 Physical Networks

William M. Farmer

Department of Computing and Software
McMaster University

7 January 2007

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, or 1Gbps.
- Wireless Ethernet.
  - Communication is via radio waves.
  - Transmission speeds: 11 Mbps (Wi-Fi), 54 Mbps, or 540 Mbps (planned).

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.
- 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).

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).
- WAN technologies:
  - Various WAN services provided by long-distance telephone carriers.
- Point-to-point networks via the telephone system or wireless transmission media.