Lecture 5

Computer Networks
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Different Kinds of Networks
- Circuit switching:
  - One electrical circuit assigned to each communication.
  - Example: phone network.
  - Guaranteed constant quality of service.
  - Waste of resources, fault tolerance.
- Packet switching:
  - Messages are split into packets, transmitted independently.
  - Example: Internet, most computer networks.
  - Good resource usage, fault tolerance.
  - Variable quality of service, packets may be delivered in wrong order.

Multiaccess vs. Point-to-Point
- Multiaccess means shared medium.
  - many end-systems share the same physical communication resources (wire, frequency, ...).
  - There must be some arbitration mechanism.
- Point-to-point
  - only 2 systems involved.
  - no doubt about where data came from!

Local Area Networks
- Connects computers that are physically close together (< 1 mile).
  - high speed
  - multi-access
- Technologies:
  - Ethernet: 10 Mbps, 100Mbps
  - Token Ring: 16 Mbps
  - FDDI: 100 Mbps
  - Myrinet: 2 Gbps

Wide Area Networks
- Connects computers that are physically far apart (“long-haul network”):
  - typically slower than a LAN.
  - typically less reliable than a LAN.
  - point-to-point
- Technologies:
  - telephone lines
  - satellite communications
Metropolitan Area Networks

- Larger than a LAN and smaller than a WAN.
  - example: campus-wide network
  - multi-access network

Technologies:
- coaxial cable
- microwave

Internetwork

- Connection of 2 or more distinct (possibly dissimilar) networks.
- Requires some kind of network device to facilitate the connection.

OSI Reference Model

Layered model:
- 7. Application
- 6. Presentation
- 5. Session
- 4. Transport
- 3. Network
- 2. Data Link
- 1. Physical

Physical Layer

- Responsibility:
  - transmission of raw bits over a communication channel.

- Issues:
  - mechanical and electrical interfaces
  - time per bit
  - distances

Data Link Layer - Data Link Control

- Responsibility:
  - provide an error-free communication link

- Issues:
  - framing (dividing data into chunks)
  - header & trailer bits
  - addressing

Data Link Layer - MAC Sublayer

- Medium Access Control - needed by multiaccess networks.

- MAC provides DLC with "virtual wires" on multiaccess networks.
**Network Layer**
- **Responsibilities:**
  - path selection between end-systems (routing).
  - subnet flow control.
  - fragmentation & reassembly.
  - translation between different network types.
- **Issues:**
  - packet headers.
  - virtual circuits.

**Transport Layer**
- **Responsibilities:**
  - provides virtual end-to-end links between peer processes.
  - end-to-end flow control.
- **Issues:**
  - headers
  - error detection
  - reliable communication

**Session Layer**
- **Responsibilities:**
  - establishes, manages, and terminates sessions between applications.
  - service location lookup.
- Many protocol suites do not include a session layer.

**Presentation Layer**
- **Responsibilities:**
  - data encryption
  - data compression
  - data conversion
- Many protocol suites do not include a Presentation Layer.

**Application Layer**
- **Responsibilities:**
  - anything not provided by any of the other layers
- **Issues:**
  - application level protocols
  - appropriate selection of “type of service”

**Layering and Headers**
- Each layer needs to add some control information to the data in order to do its job.
- This information is typically pre-pended to the data before being given to the lower layer.
- Once the lower layers deliver the data and control information - the peer layer uses the control information.
Physical: no header - just a bunch of bits.

Data Link:
- address of the receiving endpoints
- address of the sending endpoint
- length of the data
- checksum.

Network Layer Header
- protocol suite version
- type of service
- length of the data
- packet identifier
- fragment number
- time to live
- protocol
- header checksum
- source network address
- destination network address

Summary
- Data-Link: communication between machines on the same network.
- Network: communication between machines on possibly different networks.
- Transport: communication between processes (running on machines on possibly different networks).

Protocol Suites
- Most computers use the Internet Protocol Suite.
- Base protocol: IP (Internet Protocol).
- Send packets of limited size (<8kB).
- Each packet sent to IP address: 130.37.192.18
- IP offers no guarantee:
  - Packets may get lost.
  - Packets may be delivered twice.
  - Packets may be delivered in the wrong order.
  - Packets may be corrupted during transfer.
- Usually, programs do not use IP directly, all other Internet protocols are built over IP.

UDP: User Datagram Protocol
- UDP is very similar to IP:
  - send/receive packets, no guarantee.
  - Packets are called ‘datagrams’.
- Each datagram is sent to IP address + port number (IP=130.37.192.15 port=1234).
- Ports allow to distinguish between several simultaneous programs on the same machine.
TCP: Transport Control Protocol

- TCP establishes connections between pairs of machines.
- TCP provides illusion of a reliable data flow.
- TCP guarantees that data sent will not be lost, unordered, corrupted, etc. (packets are numbered, receiver acknowledges packets, etc.).
- Communication is bi-directional (same connection can be used to send data in the two directions).

Connecting Networks

- Repeater: physical layer
- Bridge: data link layer
- Router: network layer
- Gateway: network layer and above.

Repeater

- Copies bits from one network to another
- Does not look at any bits
- Allows the extension of a network beyond physical length limitations

Bridge

- Copies frames from one network to another
- Can operate selectively - does not copy all frames (must look at data-link headers).
- Extends the network beyond physical length limitations.

Router

- Copies packets from one network to another
- Makes decisions about what route a packet should take (looks at network headers).

Gateway

- Operates as a router
- Data conversions above the network layer.
- Conversions:
  - encapsulation - use an intermediate network transducer
  - translation - connect different application protocols
  - encryption - could be done by a gateway
Byte Ordering

- Different computer architectures use different byte ordering to represent multibyte values.
- 16 bit integer:

```
Low Byte  High Byte
Addr A  Addr A+1
```

**Big-Endian**
- IBM 370
- Motorola 68000
- DEC VAX
- DEC PDP-11

**Little-Endian**
- IBM 80x86


Byte Order and Networking

- Suppose a Big Endian machine sends a 16 bit integer with the value 2:
  
  0000000000000010

- A Little Endian machine will think it got the number 512:
  
  0000001000000000

Network Byte Order

- Conversion of application-level data is left up to the presentation layer.
- But hold on! How do lower level layers communicate if they all represent values differently? (data length fields in headers)
- A fixed byte order is used (called **network byte order**) for all control data.