CS 656

Introduction

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Communication

Transferring information over a distance.

- Requires a shared symbol set that can be transmitted as a signal a medium, received, and understood
- Medium can be anything capable of passing information.
  - Copper wire, glass fiber, radio waves, and so on
- Medium can be directional (point-to-point) or omnidirectional (broadcast).
- Some noise always exists to corrupt the signal.
networking

A set of hardware/software components that facilitates the communication among multiple (and potentially a large number of) users

- Complete mesh?
- Broadcast
- Switching

Broadcast-Based Networks

- All users share a broadcast medium, which is used even for one-to-one communications.
- Broadcast and multicast (sending a message to a subset of users) can be supported easily.
- Examples: Ethernet, token ring
- The main issue is medium access control (MAC).
  - When two nodes wish to broadcast simultaneously, who gets the “right of the road”?
- Performance is good with light traffic, but degenerates quickly when traffic is heavy.
Switching

- Use intermediate nodes, called switches or routers, to relay messages.

- One main issue is routing, the task of find a path from the source of a message to the destination.

Switching Technologies

- Circuit Switching: provides a continuous connection in the medium from sender to receiver over a path that is established a prior (consider the telephone network).

- Packet Switching: breaks information into discrete chunks, called packets, that are individually routed; different packets from a source may take different routes to reach the same destination.
Local Area Networks (LAN)

- Small area (e.g., a building)
- Privately owned media (twisted pair, coax, fiber)
- High capacity (1 mega bps to 100 mega bps)
- Few errors ($10^{-6}$ to $10^{-8}$)
- Typically based on broadcast, but switching is emerging (ATM LANs, switched Ethernet)

Wide Area Networks (WAN)

- Large area (country or global)
- Generally lower capacity (up to 1.5 mega bps), but broadband is coming (45 mega bps to 155 mega bps and beyond).
- Older circuits have higher error rates ($10^{-4}$ to $10^{-6}$).
- Due to the large area and the large number of users, WANs must use switching technologies.
Network Services

- Connectionless Service
  - each message routed and delivered independently
  - examples: email and datagram
  - could be reliable or unreliable

- Connection-Oriented Service
  - establish connection, use it, disconnect (like a phone call)
  - could be reliable (FTP) or unreliable (voice data)
  - * why is the transmission of real-time voice unreliable?

Standards

- Reasons for networking standards
  - allow different computers to communicate
  - increase markets for products adhering to the same standard
  - decrease price through economies of scale

- Disadvantages of standards
  - Tend to freeze technology — by the time the standard is developed, reviewed, agreed upon, and distributed, better technologies are available.
  - Often, multiple conflicting standards for the same thing.
Standards Organizations

• ISO (International Organization for Standardization)
  - a voluntary organization that produces standards for “everything,” including networking protocols

• ITU (International Telecommunication Union)
  - U.N. treaty organization comprising primarily the PPT (Postal, Telegraph, and Telephone) authorities of member countries.

• ANSI (American National Standards Institute)
  - nonprofit, non-governmental organization composed of manufacturers, users, and carriers

• IEEE (Institute of Electrical & Electronic Engineering)
  - professional society and member of ANSI
  - Known for standards for LANs

• IETF (Internet Engineering Task Force)
  - responsible for the development of Internet protocols
Network Software

- Network software is organized as a series of layers, in order to reduce complexity.
- Each layer builds upon the one below it and provide services to the one above it.
- Between each layer is an interface.
- Well-defined layering minimizes information flow across layer boundaries and encourage software modulization.

- A set of protocols is called a protocol stack.
- A set of layers and protocols is called a network architecture.

Understanding a general purpose network architecture, namely, the Internet, is the main purpose of this course.

OSI Reference Model

- ISO defined a seven layer model – Open Systems Interconnection (OSI) reference model

- Lower four layers are concerned with providing reliable end-to-end communication.

- Upper three layers provide common, user-oriented services.
Layering Principles

Service interface with Layer N+1

Layer N Module in Node A

Layer N

Peer-to-peer communication

Layer N Module in Node B

Service interface with Layer N+1

Service interface with Layer N-1

Service interface with Layer N-1

Physical and Data Link Layers

- Physical Layer
  Transmit and receive bits on the physical medium

  - analog or digital transmission
  - definition of 0 and 1 bits
  - bit rate (bandwidth)

- Data Link Layer
  Provide error-free bit stream across the physical medium

  - error detection/correction
  - reliability
  - flow control
**Network Layer**

Controls the operations of the network

- Routing: determining the path from the source of a message to its destination
- Congestion control: handling heavy traffic
- Internetworking of both homogeneous and heterogeneous networks.

**Transport Layer**

Provides reliable end-to-end (host-to-host) connections

- Packetization: cut the messages into smaller chunks (packets)
  - Why?
  - An ensuing issue is ordering: the receiving end must make sure that the user receives the packets in the right order.
- Host-to-host flow control
Upper Layers

- Session Layer
  - user-to-user connection
  - synchronization and checkpoint
- Presentation Layer
  - data representation/compression
  - cryptography and authentication
- Application Layer
  - file transfer, email, WWW, and so on

Shortcomings of OSI Model

Just because someone says it is a model/standard does not mean you will have to follow it.

- Standard development squeezed between networking research and the rush to turn technologies into products.
- All layers do not have the same size and importance
  - session and presentation layers are seldom present
  - data link, network, and transport layers are often very full
- Little agreement on where to place various features
  - encryption, network management
- Large number of layers increases communication latency.
**Internet Protocol Suite Reference Model**

Application  
Transport  
Internet  
Host-to-Network

**Internetworking: Building Networks of Networks**

Ethernet  
Token Ring  
Router  
Host  
ATM Switch  
ATM LAN
To-Dos of This Week

- Send an email to Dr. Huang.
- Request a password for http://bacon.gmu.edu/cs656.
- Download and setup Networking Workbench.
- Start working on Project WAN 1.
  - due 7:20pm, Feb. 11th.
  - see nw33/assignments/wan1.txt for details.