CHAPTER 1

Overview of Data Communications

The scope of this course is broad, covering three general areas: data communications, networking, and protocols.

Data communications deals with the transmission of signals in a reliable and efficient manner.

Networking deals with the technology and architecture of the communications networks used to interconnect communicating devices.

A discussion of **communication protocols** includes a treatment of protocol architectures as well as analysis of individual protocols at various layers of the architecture.

- *The fundamental problem of communication is that of reproducing at one point either exactly or approximately a message selected at another point - The Mathematical Theory of Communication*, Claude Shannon

This quote of Shannon raises the key issue, which we wish to study.

"Frequently the messages have *meaning*; that is they refer to or are correlated according to some system with certain physical or conceptual entities. These semantic aspects of communication are irrelevant to the engineering problem. The significant aspect is that the actual message is one *selected from a set* of possible messages.

One of the key additions that Shannon made to the earlier work of Nyquist and Hartley was the formal integration of noise into the communication model. Noise is introduced into the channel between the transmitter and the receiver and acts to changes messages so that what is received differs from what is transmitted.

Sources may be discrete or non-discrete. A discrete source generates ``the message, symbol by symbol. It will choose successive symbols according to certain probabilities depending, in general, on preceding choices as well as the particular symbols in question" [SW49]. Coding takes place at the transmitter. The source of the message does not transmit the message; the coded form of the message is what leaves the transmitting process and moves to the receiving process. The representation of the original message moves to the next process that transforms it, with the process continuing.

Between the source and the channel, the data being transmitted must be encoded, that is, it is represented in some form that can be transmitted by the medium supporting the channel. Transmitting data inherently requires that a change of medium take place, as the information moves from the source to the transmitter to the channel. When a signal moves from one medium to another, it must be physically represented somewhat differently, making an encoder necessary.

Given a source producing symbols at a rate consistent with a set of probabilities governing their frequency of occurrence, Shannon asks ``how much information is `produced' by such a process, or better, at what rate information is produced?" For Shannon, the amount of self-information that is contained in or

associated with a message being transmitted, when the probability of its transmission is p, is the logarithm

$$I = \log 1/p$$

of the inverse of the probability."

Data communication and networking for today's enterprise

Effective and efficient data communication and networking facilities are vital to any enterprise. We first look at trends that are increasing the challenge for the business manager in planning and managing such facilities.

Trends

Three different forces have consistently driven the architecture and evolution of data communications and networking facilities: traffic growth, development of new services, and advances in technology.

In terms of computing, this means more powerful computers and clusters of computers capable of supporting more demanding applications, such as multimedia applications. In terms of communications, the increasing use of optical fiber has brought transmission prices down and greatly increased capacity.

Both voice-oriented telecommunications networks, such as the public switched telephone network (PSTN), and data networks, including the Internet, are more "intelligent" than ever. Two areas of intelligence are noteworthy. First, today's networks can offer differing levels of quality of service (QoS), which include specifications for maximum delay, minimum throughput, and so on. Second, today's networks provide a variety of customizable services in the areas of network management and security.

The Internet, the Web, and associated applications have emerged as dominant features of both the business and personal world, opening up many opportunities and challenges for managers.

There has been a trend toward ever-increasing mobility for decades, liberating workers from the confines of the physical enterprise. Innovations include voice mail, remote data access, pagers, fax, e-mail, cordless phones, cell phones and cellular networks, and Internet portals.

Significant change in requirements

The Emergence of High-Speed LANs: The speed and computing power of personal computers. MIS (management information systems) organizations have recognized the LAN as a viable and essential computing platform, resulting in the focus on network computing. This trend began with client/server computing, which has become a dominant architecture in the business environment and the more recent Web focused intranet trend.
Corporate Wide Area Networking Needs: typical business environment, about 80% of the traffic remains local and about 20% traverses wide area links. Just as in the local area, changes in corporate data traffic patterns are driving the creation of high-speed WANs.
Digital Electronics: The rapid conversion of consumer electronics to digital technology is having an impact on both the Internet and corporate intranets.

- trends
  - traffic growth at a high & steady rate
  - development of new services
  - advances in technology
- significant change in requirements
  - emergence of high-speed LANs
  - corporate WAN needs
  - digital electronics

A COMMUNICATIONS MODEL

The term **telecommunication** means communication at a distance. The word data refers to information presented in whatever form is agreed upon by the parties creating and using the data. **Data communications are the exchange of data between two devices via some form of transmission medium such as a wire cable.**

Figure 1.2b presents one particular example, which is communication between a workstation and a server over a public telephone network. Another example is the exchange of voice signals between two telephones over the same network. The key elements of the model are as follows:

• **Source.** This device generates the data to be transmitted; examples are telephones and personal computers.
• **Transmitter**: Usually, the data generated by a source system are not transmitted directly in the form in which they were generated. Rather, a transmitter transforms and encodes the information in such a way as to produce electromagnetic signals that can be transmitted across some sort of transmission system.
For example, a modem takes a digital bit stream from an attached device such as a personal computer and transforms that bit stream into an analog signal that can be handled by the telephone network.
• **Transmission system**: This can be a single transmission line or a complex network connecting source and destination.
• **Receiver**: The receiver accepts the signal from the transmission system and converts it into a form that can be handled by the destination device. For example, a modem will accept an analog signal coming from a network or transmission line and convert it into a digital bit stream.
• **Destination**: Takes the incoming data from the receiver.

Communications Tasks

Transmission system utilization
Interfacing
Addressing
Routing
Signal generation
Recovery
Synchronization
Message formatting
Exchange management
Security
Error detection and correction
Network management
Flow control

Transmission system utilization, refers to the need to make efficient use of transmission facilities that are typically shared among a number of communicating devices. Various techniques (referred to as multiplexing) are used to allocate the total capacity of a transmission medium among a number of users. Or congestion control.

To communicate, a device must **interface** with the transmission system.

Signal generation is required for communication. The properties of the signal, such as form and intensity, must be such that the signal is (1) capable of being propagated through the transmission system, and (2) interpretable as data at the receiver.

Not only must the signals be generated to conform to the requirements of the transmission system and receiver, but also there must be some form of **synchronization** between transmitter and receiver.

There is a variety of requirements for communication between two parties that might be collected under the term **exchange management**. If data are to be exchanged in both directions over a period of time, the two parties must cooperate.

In all communications systems, there is a potential for error; transmitted signals are distorted to some extent before reaching their destination. **Error detection and correction** are required in circumstances where errors cannot be tolerated.

Flow control is required to assure that the source does not overwhelm the destination by sending data faster than they can be processed and absorbed.

Addressing and **routing**. When more than two devices share a transmission facility, a source system must indicate the identity of the intended destination. The transmission system must assure that the destination system, and only that system, receives the data. Further, the transmission system may itself be a network through which various paths may be taken. A specific route through this network must be chosen.

Recovery is a concept distinct from that of error correction. Recovery techniques are needed in situations in which an information exchange, such as a database transaction or file transfer, is interrupted due to a fault somewhere in the system. The objective is either to be able to resume activity at the point of interruption or at least to restore the state of the systems involved to the condition prior to the beginning of the exchange.

Message formatting has to do with an agreement between two parties as to the form of the data to be exchanged or transmitted, such as the binary code for characters.

Security in a data communications system: The sender of data may wish to be assured that only the intended receiver actually receives the data.

A data communications facility is a complex system that cannot create or run itself. **Network management** capabilities are needed to configure the system, monitor its status, react to failures and overloads, and plan intelligently for future growth.

DATA COMMUNICATION

Comm. System example: Fig. 1.2 Electronic mail transfer

Data Communication Networking

It is often impractical for two communicating devices to be directly, point to point connected. Because;

1. The devices are very far apart. It would be too expensive to have a dedicated link between these two devices.
2. There is a set of devices, each of which may require a link to many of the others at various times.

The solution to this problem is to attach each device to a communication network.

There are two major categories: LAN and WLAN

- **Local Area Networks (LANs)**
  - **Short distances**
  - **Designed to provide local interconnectivity**
- **Wide Area Networks (WANs)**
  - **Long distances**
  - **Provide connectivity over large areas**
- **Metropolitan Area Networks (MANs)**
  - **Provide connectivity over areas such as a city, a campus**

Wide Area Networks

- span a large geographical area
- cross public rights of way

- rely in part on common carrier circuits
- alternative technologies used include:
    - circuit switching
    - packet switching
    - frame relay
    - Asynchronous Transfer Mode (ATM)

Circuit Switching
- uses a dedicated communications path established for duration of conversation
- comprising a sequence of physical links
- with a dedicated logical channel
- eg. telephone network

Packet Switching
- data sent out of sequence
- small chunks (packets) of data at a time
- packets passed from node to node between source and destination
- used for terminal to computer and computer to computer communications

Frame Relay
- packet switching systems have large overheads to compensate for errors
- modern systems are more reliable
- errors can be caught in end system
- Frame Relay provides higher speeds
- with most error control overhead removed
- low error rates and higher data rates compared to packet switching

Asynchronous Transfer Mode (cell relay)
- ATM
- evolution of frame relay
- fixed packet (called cell) length whereas frame relay uses variable length packets, called frames.
- with little overhead for error control
- anything from 10Mbps to Gbps
- also an evolution from circuit switching. With circuit switching, only fixed data rate circuits are available to the end system. ATM allows the definition of multiple virtual channels with data rates that are dynamically defined at the time the virtual channel is created.
- constant data rate using packet switching technique with multiple virtual circuits which is very efficient technique.

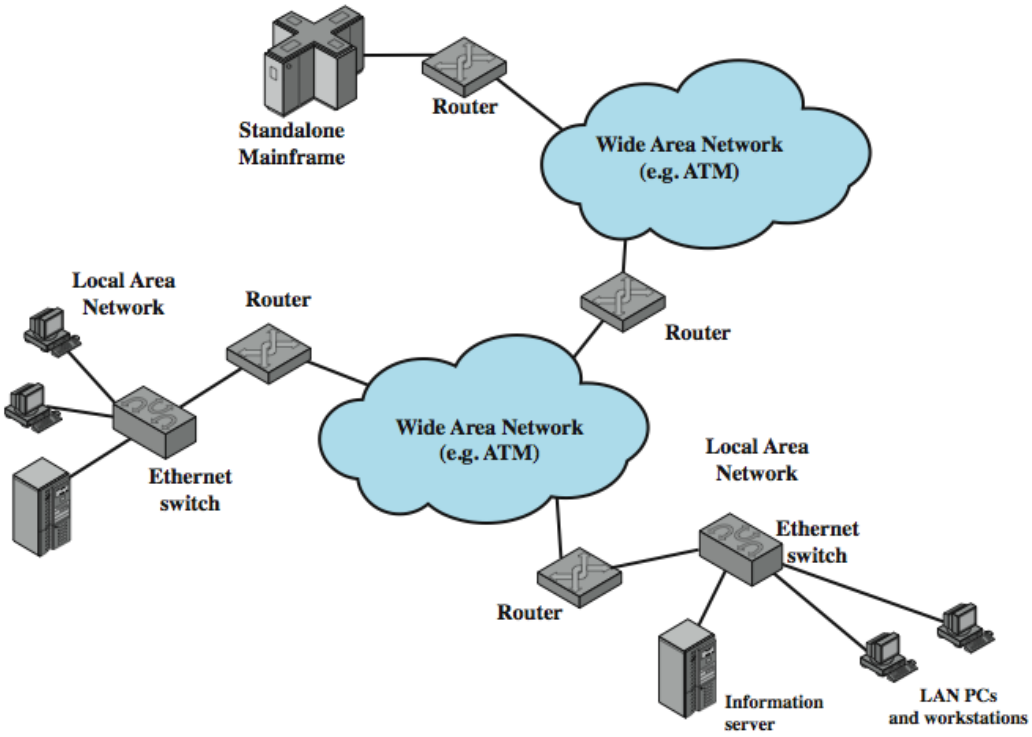
Local Area Networks
- smaller scope
    - Building or small campus
- usually owned by same organization as attached devices
- data rates much higher
- switched LANs, eg Ethernet
- wireless LANs

Metropolitan Area Networks
- MAN
- middle ground between LAN and WAN
- private or public network
- high speed
- large area

The Internet

- Internet evolved from ARPANET
  - first operational packet network
  - applied to tactical radio & satellite nets also
  - had a need for interoperability
  - led to standardized TCP/IP protocols

Internet elements;



PROTOCOLS AND PROTOCOL ARCITECTURE (CHAPTER 2)

will continue…

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