ECE 333: Introduction to Communication Networks
Fall 2002

Lecture 1: Introduction

- Examples of communication networks/uses
- Course Goals
- History
- Classification of networks
- Related courses

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Notes:

This is an introductory course on communication networks.

This course is still being developed in places; I hope you will forgive any "rough edges" that are still present in the course. Also I hope you will provide me with feedback during the quarter on what you like/dislike about the course and how it can be improved.

Administrative details about the course are contained in the course information sheet handed out during lecture and available at

http://www.ece.nwu.edu/~rberry/ECE333/infosheet01.pdf

Please read over this sheet carefully before next lecture.

The first couple of lectures will be very descriptive and at a high level; after these lectures, the course will become more technical and go into greater depth.

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Questions:

- What is a communication network?
- Examples/Uses?

A communication network is a system that allows ***users*** to exhange ***information.***

- Users?
- Information?

  (analog vs. digital)

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Notes:

A "user" can be a variety of things including a person, a computer program or a wireless sensor. Examples of "information" include data files, speech and video.

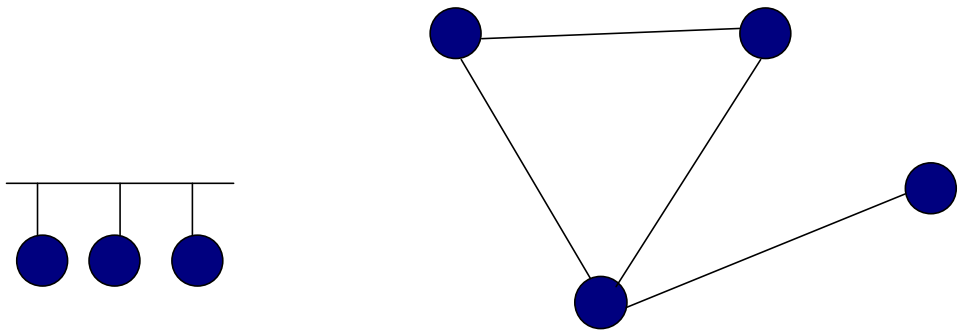
We are primarily interested in networks where the information is represented ***digitally,*** i.e., as a sequence of binary digits (bits). Of course, some information signals, such as speech are inherently analog, however this information can still be represented as a digital sequence through sampling and quantization. Details of analog-to-digital conversion will not be dealt with in this class, but is covered in detail in other classes such as signals and systems (ECE 222), digital signal processing (ECE 359), etc.

Some common examples of communication networks include cable TV networks, the public telephone network and computer networks such as a local area network in an office or the Internet - which is actually a "network of networks."

Early communication networks were designed for a single purpose, e.g. telephone networks, cable TV networks, and computer networks. The trend in modern networks is towards networks that can satisfy a variety of different uses - these are sometimes called ***integrated service networks***. A key reason for this trend is economic considerations - it is thought to be more cost effective to build and maintain a single multi-purpose network, than several single-purpose networks. Another fundamental reason behind this trend is the above fact that all information can be represented as bits, this allows a single network deigned to transfer bits between users to handle a variety of different information signals.

Network components

Networks consist of "Nodes" that communicate over "links"



Nodes -

Links - (point-to-point vs. broadcast)

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Notes:

Nodes are computers, switches, routers, servers and other devices. Some nodes are classified as ***terminal nodes*** (often called ***hosts*** or ***end-users***), which provide the interface between the "users" and the network - for example a users' desktop computer or a set-top box in a cable TV network. Other nodes, e.g. switches, routers, etc. are not identified with any user but handle information as it is sent between users. Still other nodes may provide various "helper" functions, such as directory services.

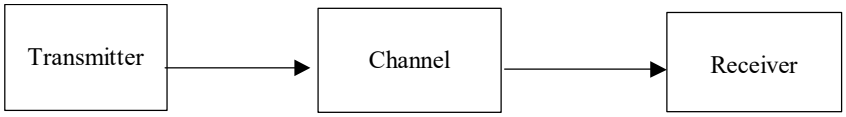
The "links" are physical "channels" over which information is sent in the form of electromagnetic waves. One example of a link is an optical fiber where information is sent as a sequence of light pulses generated by a laser diode or LED. Another example is a radio link, where information is transmitted through the atmosphere as an electromagnetic wave radiated from an antenna.

Links can be classified as either ***point-to-point*** or ***broadcast***. Point-to-point links connect only two nodes, while broadcast links connect more than two nodes, i.e. when a signal is broadcast by one node on a broadcast link, all the other nodes on that link can receive it. Two issues become important - how to decide which node or nodes a signal is meant for and how to decide which node(s) can transmit at any time - this last problem is referred to as the ***medium access control problem***.

The arrangement of links and nodes is called the ***topology*** of the network.

In many cases the non-terminal nodes and links are grouped together and called the "subnet" (this term has a different meaning in IP routing.).

Communication over single point-to-point link



- Studied in ECE 307, ECE 378, ECE 380, etc.

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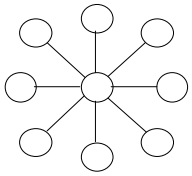
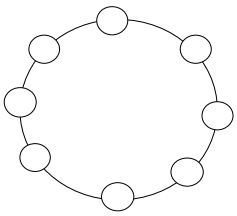
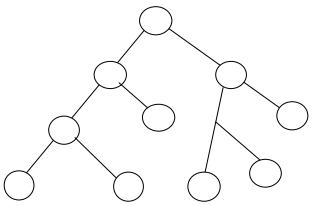
Some Common Network Topologies



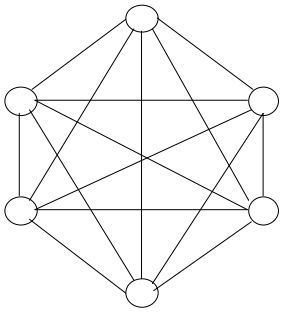
STAR



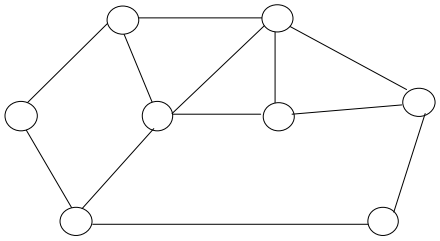
RING



TREE

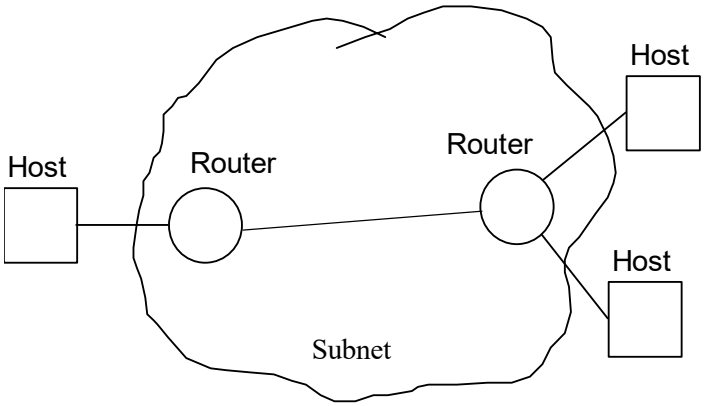


FULLY CONNECTED



IRREGULAR MESH

Additional Terminology



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Benefits of Communication Networks:

- Improved communication/convenience.
- Cost benefits - resource sharing.
- Reliability.

Course Goals

Understand some basic problems that all networks must address.

Understand how these problems are dealt with in current networks, what are the trade-offs between various approaches.

Learn some basic methods for performance analysis for networks.

Emphasis is on **conceptual understanding** of basic principles - **not** on learning detailed specifications of particular standards.

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Some History

I. Telephone Network:

- Telephone invented in 1876.
- Manual switching (1880's).
- Electromechanical switches (1890's).
- Computerized switches (1970's).

  Common channel signaling & digital transmission.

History

II. Computer Networks

1940's	Computers invented
50's - 60's	Central CPU with many remote job entry points
70's	Central CPU with shared communication links, Separate front-end processors.
Early 80's	General network with "subnet" at center, LAN's
Late 80's	General internetworks
Late 90's	Internet, multiple backbones, multimedia

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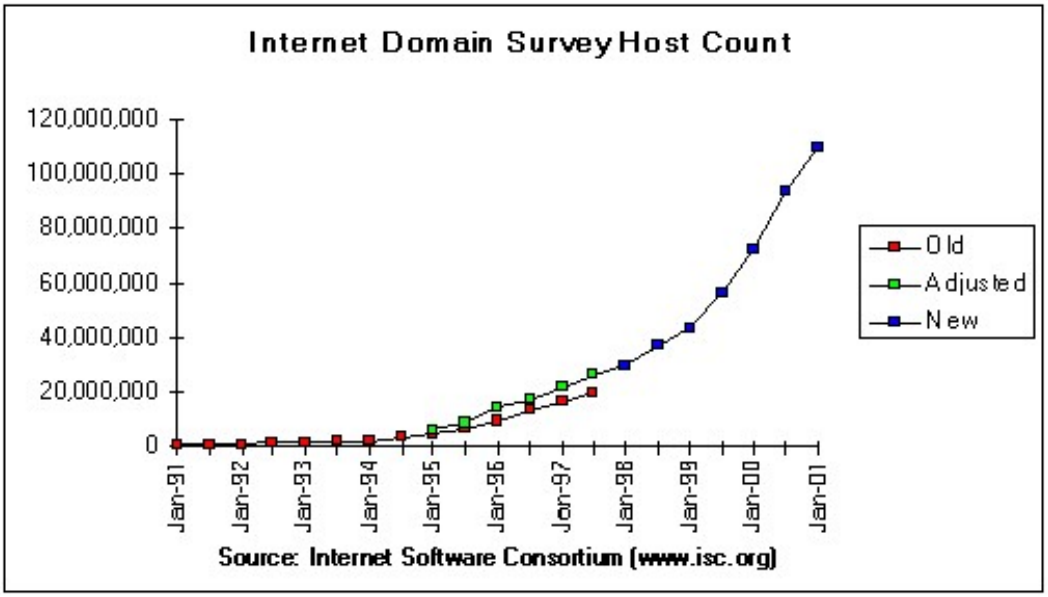
Recent Growth of Internet



Source: Internet Software Consortium (http://www.isc.org/)

Aug. 1981	213 Hosts
Jul. 2001	117,288,000 Hosts

Some reasons for growth of communication networks:

1. Improvements in VLSI technology
   faster, cheaper small computers

2. Fiber optic communication
   high speed, low error rate links

3. Critical mass of users
   Economies of scale, increased user value

4. Applications
   e.g. web browsers

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Classifying Networks

I. By size or distance between communication devices.

PAN	Personal Area Network
LAN	Local Area Network
MAN	Metropolitan Area Network
WAN	Wide Area Network

Different economics.

Different technologies appropriate.

Classifying Networks

II. By Service Characteristics:

- Information formats
- Latency (Delay)
- Reliability
- Throughput
- Number of users
- Number of recipients
  - Multi-cast, broadcast, etc.

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Classifying Networks

III. By Basic Design Approaches:

- Broadcast vs. point-to-point
- Circuit switched vs. packet switched
- Connection-oriented vs. connectionless

Notes:

LANs cover a small geographic area such as a single room or a campus. Common LAN technologies include Ethernet and Token Ring networks. LANs often use broadcast links and have regular topologies such as a star, ring or bus.

MANs are city sized networks, or perhaps a large campus, they use similar technologies to LANs, but offer higher speeds. Examples of MAN technologies are FDDI and DQDB.

WANs cover a larger area, such as an entire country. They typically have an irregular topology and consist of switches or routers interconnected by point-to-point links.

The basic service a network offers is the ability to transmit information, however specific characteristics of this service can differ from network to network.

In a circuit-switched network, information is sent over a circuit or dedicated channel between the sender and receiver that is reserved for the duration of the session. In a packet-switched network information is sent as packets over a common channel, no resources are reserved & each packet must contain some information to identify it.

In a connection-oriented network, a connection must first be established between users before information can be sent. The network must keep "state" information so that it knows which connections are established. In a connectionless network, no connection set-up is required and no state is required in within the network. All circuit switched networks are connection oriented, packet switched networks may be either connection oriented or connectionless.

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Sessions, messages, packets,...

Users set up ***sessions*** (also called connections, conversations, etc.) to interchange information.

Sessions viewed as sequence of ***messages*** or possibly a single message.

101011 11100 10 001

Within the network, messages may be grouped or divided into ***packets*** of data (more about this next time).

Examples of sessions

Interactive: Short messages, small delay, high reliability.

File transfer: Long messages, moderate delay, very high reliability.

Digitized voice: Short messages, strict delay, moderate reliability, regular data rate.

Image transfer: Long messages, small delay, moderate reliability.

Real-time Video: Long messages, strict delay, variable date rate (if compressed), moderate reliability.

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Comments on modeling

In modeling networks, there are a variety of sources of ***uncertainty***:

- Arrival times of packets, sessions, ...
- Lengths of packets, sessions, …
- Destination of packets.
- Whether errors occur in packets.
- When a link or node fails.

The main tool used for modeling this uncertainty is **probability theory.**

Modeling uncertainty

Simple Example: Consider a sequence of packets that are sent across a link in a network. When packets cross a link various errors can occur causing the packet to not be received correctly.

Suppose that each packet independently arrives correctly with probability p and is arrives in error with probability $1-p$.

What is the probability that n packets are in error out of 100?

What is the average number of packets that will arrive correctly out of 100?

What is the fraction of packets that will arrive correctly over a very long period of time?

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Related (undergraduate) courses:

EE curiculum

Systems –

Communication systems & networking

ECE 307 Communication systems
ECE 378 Digital Communications
ECE 380 Wireless Communications

Also courses in photonics (ECE 383 fiber optic communication), digital signal processing, etc.

CE curriculum

High performance computing -

Parallel and distributed computing

ECE 358 Intro. to Parallel Computing
ECE 362 Computer Architecture Projects

CS - CS 340 Intro to Networking