Physical Network Concepts

- Basic Communication Concepts
- Local Area Networks
- Wide Area Networks
- Metropolitan Area Networks
- ISDN

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Communication Network Concepts

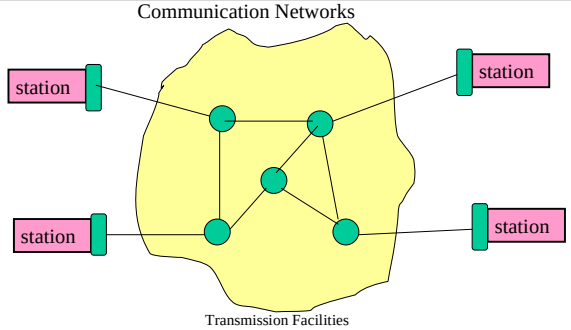
- **A communication system consists of:**
  . physical links
  . interfaces to computers and other devices
  . control devices (multiplexors, concentrators, etc)
  . software (access methods, communication managers)
- **Early systems were for voice (telecommunications)**
- **Data communications started with computers (1950s)**
- **Integration:**
  . voice, data and images
  . ISDN: integrated system digital network
- **Types of communication systems**

*** Wide area network (WAN): common carrier, long distance, typically 56 kbps (are getting faster)**

*** Local area networks (LAN): no common carrier, short distance, upto 100 Mbps**

*** Metropolitan area networks (MAN): LAN of a city**

Communication Networks



station = computer, sensor, TV,telephone, etc.

= Intermediate system (e.g., switch)

= Interface (converts station data to communication signals)

= Communication Links

Communication Media

Shanon's Formula (1948):

Max data rate (bps): CBWxlog2(1+signal/noise)

Different media have different bandwidth and signal/noise ratio

- twisted pair cable (multipair)

1. several wires are enclosed in sheath (6 to 3,000 pairs), used in telephones

2. signal loss is high, cross talk noise

3. good for short distance (5 km=1.5 mps, 30 km=2,4 kbps)

- coaxial cable

1. single wire conductor, high bandwidth, low loss at high frequencies (400 mhz)

2. high quality data transmission, data speed, channels

3. used in cable tv

- optical fiber

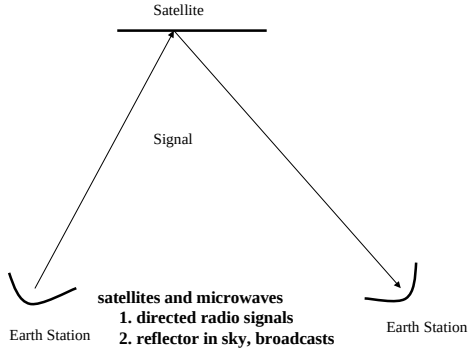
1. use light for messages, very high frequencies (1,000 mhz)

2. low loss, very light and small

3. more expensive, current investment

- - IBM cables: combine coaxial, fiber optics, microwave

Satelite



satellites and microwaves

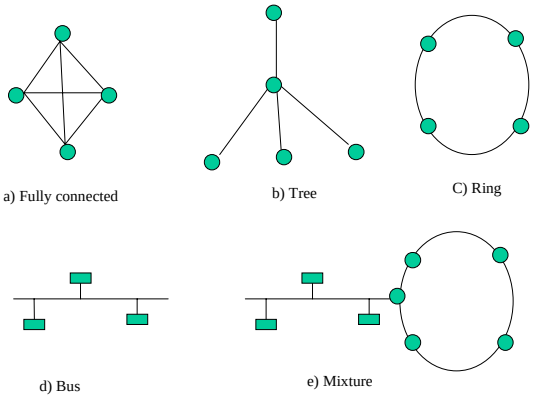
1. directed radio signals

2. reflector in sky, broadcasts

3. clark belt=22,300 miles, .25 sec delay

4. transmission cost is independent of distance

Network Topology: How to interconnect systems



DIGITAL DATA SERVICES

. Totally digital transmission of:

. voice: digitized

. video: digitized

. data

. Digitizing is done at twice the rate of highest freq.

. for voice (4k), sampling is 8k/sec.

. Several advantages over analog systems:

1. Error free due to digital signals (Repeaters)
2. One facility can multiplex voice, data, video
3. Easier to regenerae and reliable
4. Decreasing cost due to VLSI

. Digitizing (pulse code modulaton -PCM):

. sampling (8000 per second)

. quantizing: each signal amplitude is quatized - 128 levels

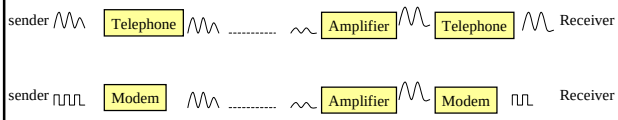
. encoding: represent amplitude by bits - 7 bits for 128 levels, 1 bit for supervisory, etc

.Example: 1 minute voice signal to be stored
. samples: 60x8000 = 480,000
. each sample = 8 bits (1 byte)
. storage= 480k

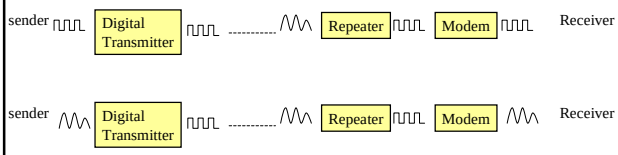
. Common carrier digital services:
. T1 = 24 voice graded channels 1.54 Mbps
. T2 = 96 channels, 6.3 Mbps
. T3 = 672 voice channels, 44.7 Mbps

Analog and Digital Networks

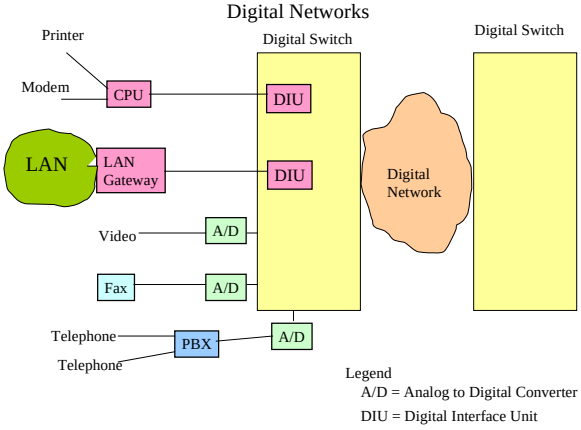
a. Examples of Analog Communication Networks



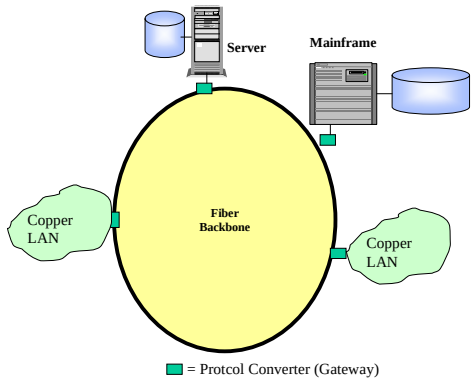
b. Examples of Digital Communication Networks



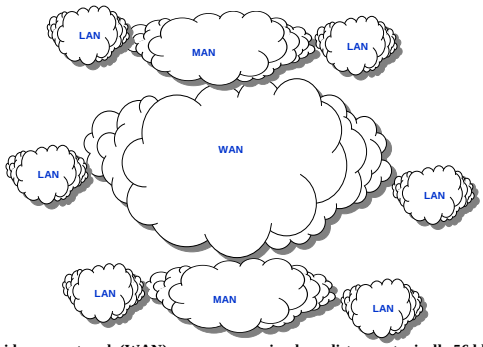
Digital Networks



A Corporate Network

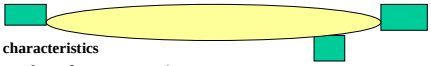


Network Categories

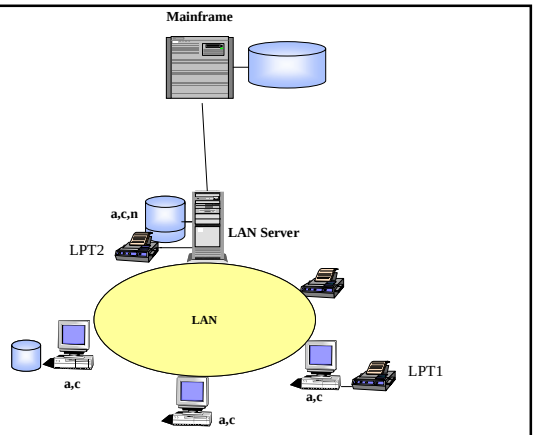


*** wide area network (WAN): common carrier, long distance, typically 56 kbps**
*** local area networks (LAN): no common carrier, short distance, upto 100 mbps**
*** metropolitan area networks (MAN): LAN of a city**

LOCAL AREA NETWORKS



- Major characteristics
. independent of common carriers
. private ownership
. high data rates (1 to 100 Mbps)
. short distances (1 to 5 miles)
. low error rates
- Tremendous growth in number of LANs
- Common applications of LAN:
1. printer sharing (print server)
2. disk sharing (disk server)
3. file/database servers
. one file/database for several users
. file server coordinates access to common files (locking of multiple users)
. database server handles database calls (e.g. SQL)
"LAN server": All or most of the above



Link Control Protocols for LANs

*** Link Control Protocols show how messages are recognized**
*** Token passing and CSMA/CD are common in LANs**

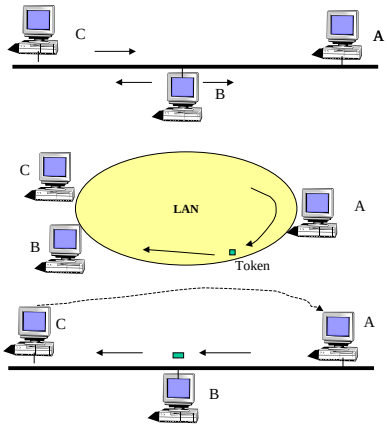
***CSMA/CD (carrier sense multiple access / collision detect)**

1. **Used in Ethernet LANs**
2. **All secondary stations transmit at "will" to the master (destination)**
   . if collision, then wait a random time, retransmit
3. **CSMA first "listens" for another transmission (carrier freq)**
4. **If nobody, then transmits**
5. **If collision, then (garbled message):**
   . transmit immediately or wait and transmit
   . random waits are becoming fancier
6. **Suited for bus topologies**

a): CSMA/CD (Ethernet)

b): Token Ring

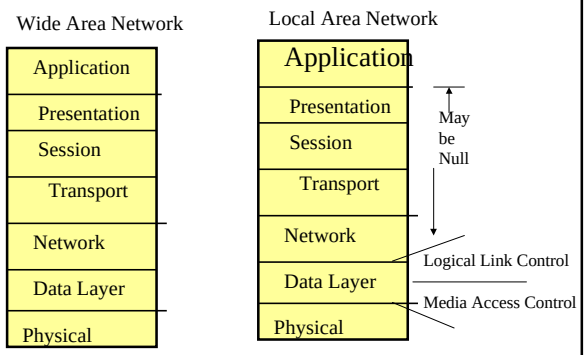
c): Token Passing



Link Control Protocols for LANs (cont.)

Token passing (single token)

1. **A token is a packet that moves around the network**
2. **An "empty" token is detetced by a node raedy to send then:**
   - **. the message is put on the token**
   - **. the token is marked "busy"**
   - **. the destination address is put on the token**
   - **. the token is sent back into circulation**
3. **The token passes every node and is checked**
4. **If this is the destination, then:**
   - **. the node receives the message**
   - **. puts an "ack" or "ack"**
   - **. sends the token out**
5. **The originator gets the "ack" or "nak" and frees up the token**



LAN Components

. Computers

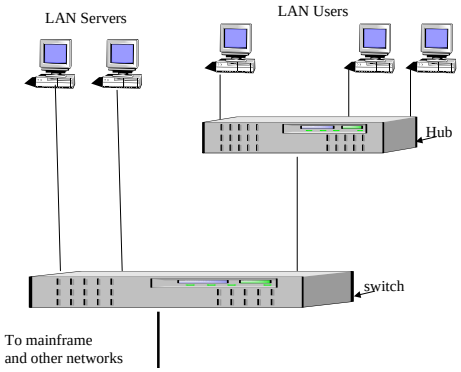
- **. Cables to interconnect**
- **. Adapter cards (Ethernet, Token Ring)**
- **. "Network Operating System": Installed on the LAN server**
  - **. Provides print, file and disk sharing**
- **. Workstation software: installed on each computer - directs user requests to the Server**

LAN Versus Other Connectivity Options

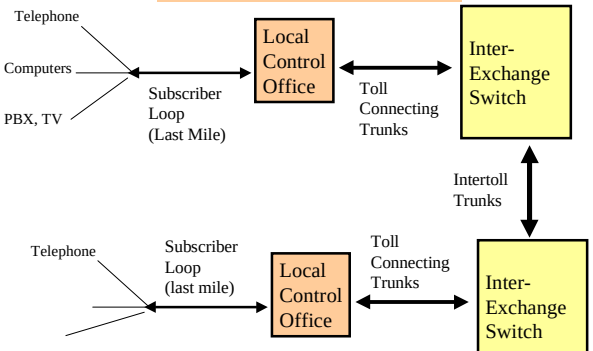
Givem N workstations, how to connect them to a Host

1. sneaker net: trade diskettes by hand or by mail
. good for occasional (once or twice a week) access
2. Use a controller
. no storage capacity at controller
. controller works as terminal/print server
. processing at two levels: workstation and Host
3. Use a LAN server
.the server : allows sharing of resources by remote pcs
. print server, file server, database server; SQL calls
.three levels of processing
4. Use a minicomputer:
. multiprogramming operating systems
. minicomputer can run complete applications
5. Use a "local" Host

Typical LANs - Hub and Switched LANs



Wide Area Networks



- WANs use common carrier facilities to interconnect
- Original systems were analog, current trend is digital

WAN Design

Mainly have to pick line speeds and types

Voice graded lines (dial up): 3000 Hz

- **Modems are used to transmit 1200 bps and higher (currently 56 Kbps)**
- **Squeeze data at high rate by using compression, etc**

Digital lines:

- **56 Kbps (digital Data Services - DS0)**
- **T1: 1.54 Mbps (Can be divided into 24 Ds0 lines)**
- **Fractional T1 (56, 128,,)**
- **T3: 44.74 Mbps**
- **Sonet - OC lines (51 mbps to 2.4 Gbps)**

Dial up/leased: end to end (voice graded or digital)

Packet switching network: rate= connection + usage

Interface devices:

- **Modems for voice graded**
- **CSU/DSU (channel service unit/digital service unit) for digital lines**

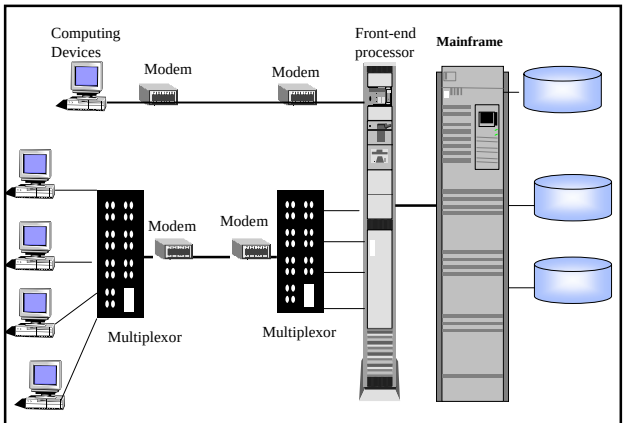
Digital Telecom Lines

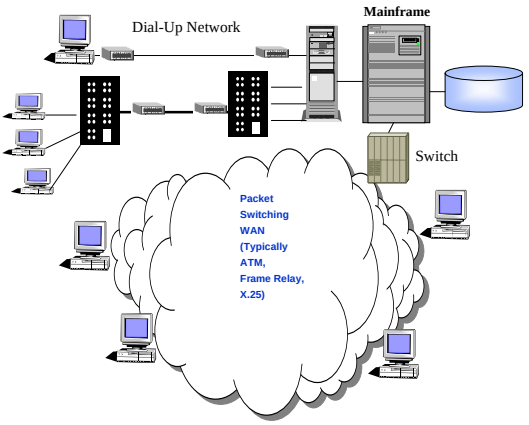
a) T-Carrier Services

Service Type	Carrier Type	Million Bits Per Second (Mbps)	No. of Voice Channels
Ds-1	T1	1.544	24
DS-3`	T3	44.736	672
Ds-4	T4M	274.176	4032

b) The Sonet Hierarchy of Services

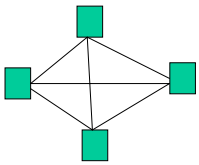
Level	Line Data Rate (Mbps)
OC-1	51.84
OC-3	155.52
OC-9	466.56
OC-12	622.08
OC-18	933.12
OC-24	1244.16
OC-48	2488.32



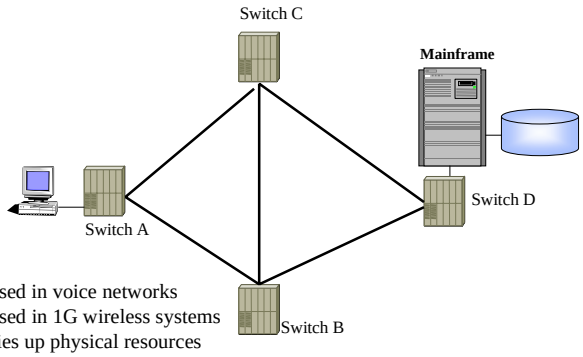


SWITCHING Systems

- Determine path between source and sink
- 1. Circuit switching (for telephone systems)
  - . same path during session
  - . if problem, need to re-establish session
- 2. Message switching (for data traffic)
  - . path is selected per message
  - . message is stored, then forwarded
- 3. Packet switching
  - . message is broken into "packets"
  - . path is selected per packet
  - . can reduce total time
    - i. break up int 5 packets
    - ii. route 5 packets simultaneously
  - . need sequencing control
  - . optimal route selection and packet size
- 4. Private branch exchange (PBX) - for individual private office

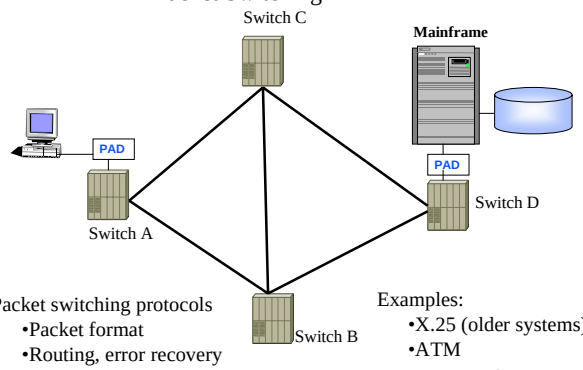


Circuit Switching



- Used in voice networks
- Used in 1G wireless systems
- Ties up physical resources
- Charging: connection time

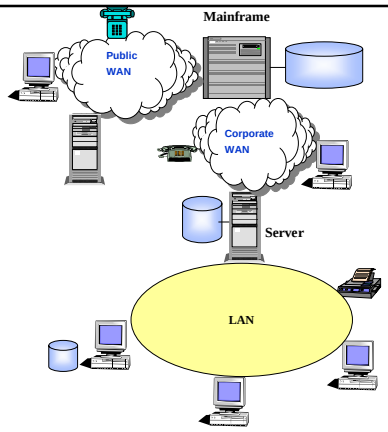
Packet Switching



Packet switching protocols
- •Packet format
- •Routing, error recovery

All partners must use the same protocol or use gateways (protocol converters)

Examples:
- •X.25 (older systems)
- •ATM
- •Frame Relay



SYNTHESIS

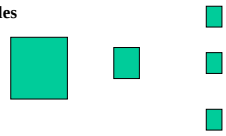
PC needs to access database

1. if within 50 feet, RS232c interface
RS449 (200 feet, 2 Mbps)

2. use limited distance modems - up to 10 miles

3. after 10 miles (within same area code)
- **a. dial up: acoustic coupler**
- **b. leased line:**
  - **i. point to point**
  - **ii. multipoint**

4. different area codes
- **a. dial up, long distance call**
- **b. leased line**
  - **i. multiplexor**
  - **ii. concentrator (minicomputer) need software on host**
  - **iii. choose packet switching from mini to front-end processor**



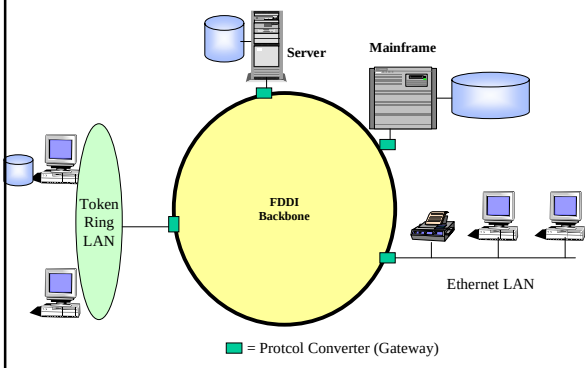
METROPOLITAN AREA NETWORKS

.LAN Extension (larger LAN)
.Initiated due to the use of Cable TV
.Common Characteristics: about 50 Kilometers, Over 50 MBPS
.Common Use: Backbone which connects many LANS

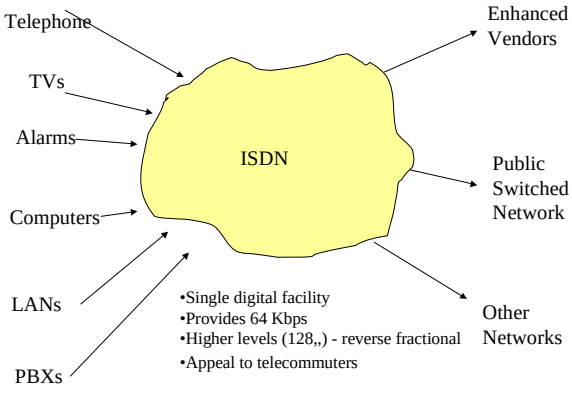
FDDI (Fiber Distributed Data Interchange)

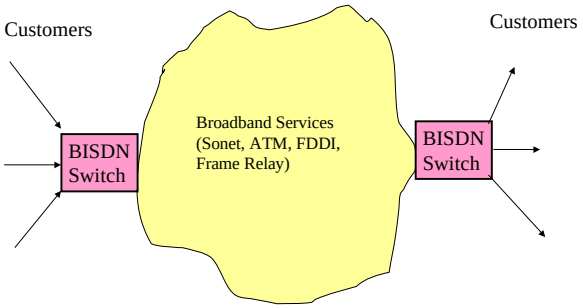
.Common standard for MAN
.100 MBPS, upto 200 Kilometer, 500 Stations
.Uses Token Ring type protocol (multiple tokens)
.Two cables (rings) for reliability
If one breaks, the other takes over
.Station connection is relatively expensive:

FDDI



ISDN (integrated Services Digital Network)





EVOLVING TECHNOLOGIES AND HIGH SPEED NETWORKS

- **Major Push: New applications**
  - **Example: Multimedia applications**
    - **. voice, data, images on one screen**
    - **. real estate example, "artificial life"**
    - **. require high speed networks:**
  - **Example: How much is 150 MBPS?**
    - **. 3,000,000 typists at 50 words/minute**
    - **. 30,000 FAX terminals**
    - **. 16,000 High speed asynch terminals**
    - **. 2400 High quality voice channels**
    - **. 100 High quality stereo audio channels**
    - **. 100 video teleconferences**
    - **. 15 High speed local area networks (ethernets)**
    - **. 6 high resolution color images/second**
    - **. 3 studio quality TV channels**
    - **. 1 High definition TV Channel**

Broadband (High Speed) WANs: at 100 MBPS and higher
- **. Broadband ISDN**
- **. SONET**
- **. ATM**
- **. Frame Relay**

Intelligent networks
Supernetworks