

GT 206.02

T

8-10

TH

8-11

mm

data comm

2/12/86

101 Lib

chapter 1

• Front end processors

bit serial, timed constants, comm line

modem: digital: FEP → modem to analog

synchronization function: modem

digital to analog

MUX: Tdm

Fdm

Sdm

300-3300 Hz Range for voice comm

add base freq to raise or alter spectrum for muxing

for data comm, a freq range is interpreted as

either a '0' or a '1' i.e.

400-0

800-1

1200-0

1600-1

etc

Full duplex: talk + listen at same time 4 wires usually $2 \times 2 \Rightarrow$

Half duplex

2 wires usually $\rightarrow \leftarrow$

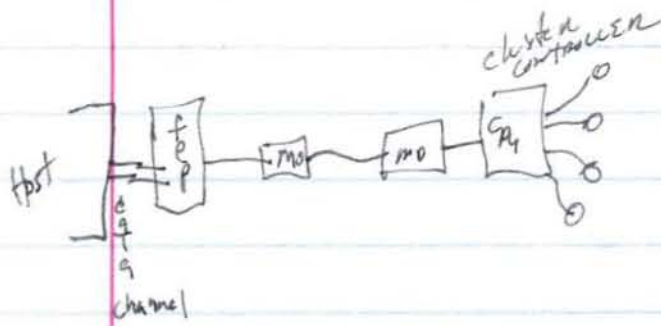
Simplex: only one direction at ~~all~~ times. \rightarrow



Fault isolation: Loop back route then path thru modem & back.

dial-up line up to 1800 bps

private line 9600 bps

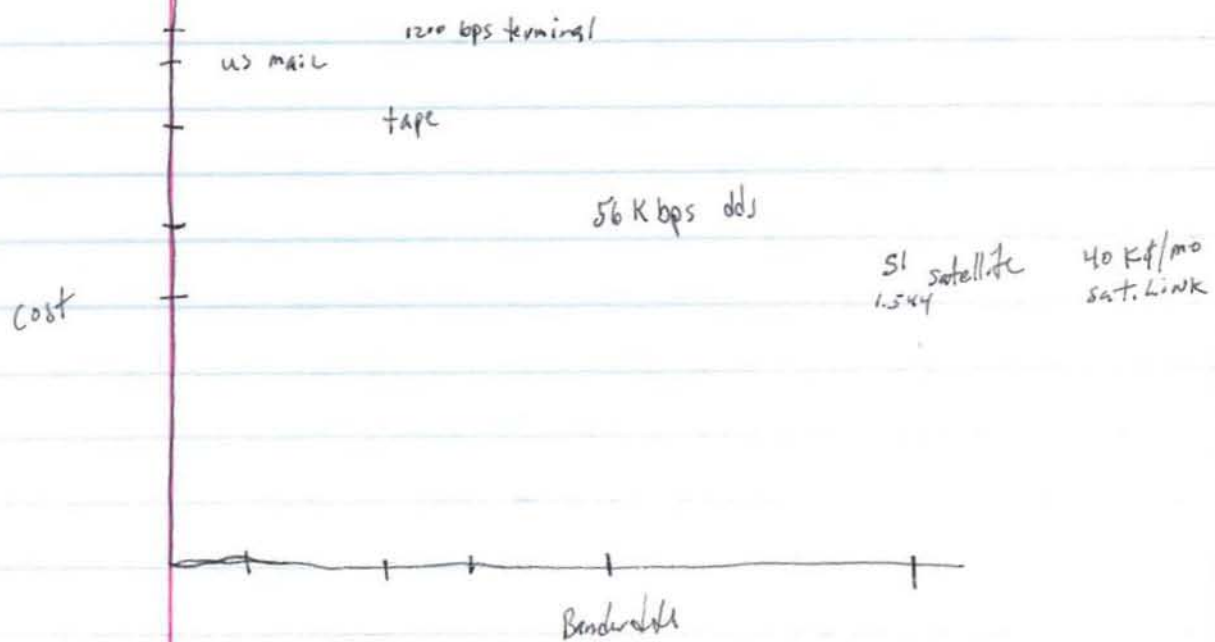
4/12/21



most not this way
 parallel data transmission :  →
 serial :  →

- Modulation
- * amplitude modulation
 - * frequency modulation
 - * phase modulation

Satellites
 Relatively slow data transfer 22.5 K m/s



2/19

370

1 MIP

15 MIP

6 MEG

32 MEG

4321 4331 4341 3031 3033 3083 3082 3081 3084

4 CPUs
(up to 98M)
real storage

| ← MVS → |

1 dos/VSE
old-limited

| ← MVS/XA → |
extended
architecture

| ← VM/SP → |
high productivity

NON 370 COMPATIBLE MACHINES

Series /1

System 36

16 bit mini

System 34

(IBM PDP-11)

8100

distributed processor

IBM PC

per. peripherals

Terminals 3270

3278-11

1,120 character CRT
(3277 old model)

3279

color

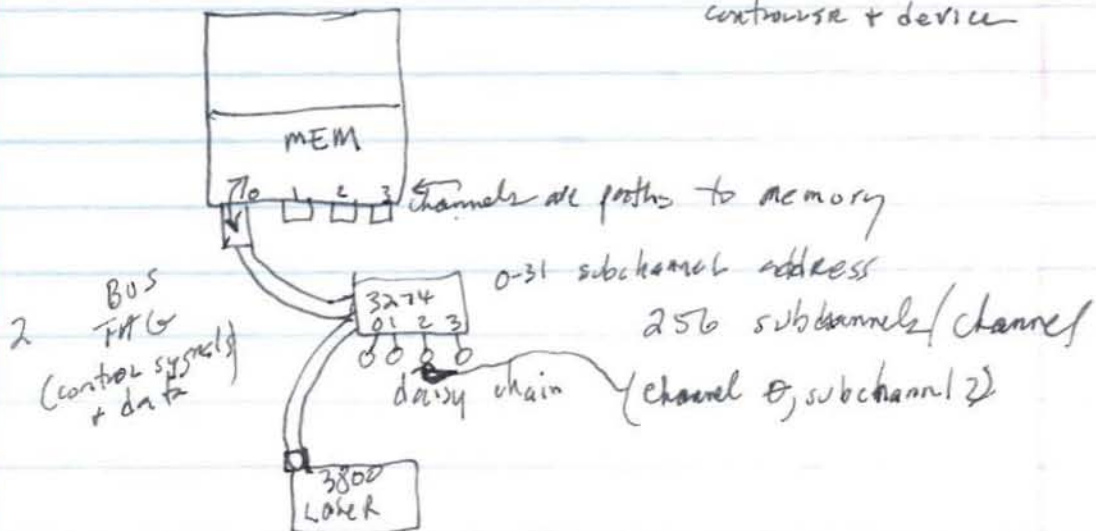
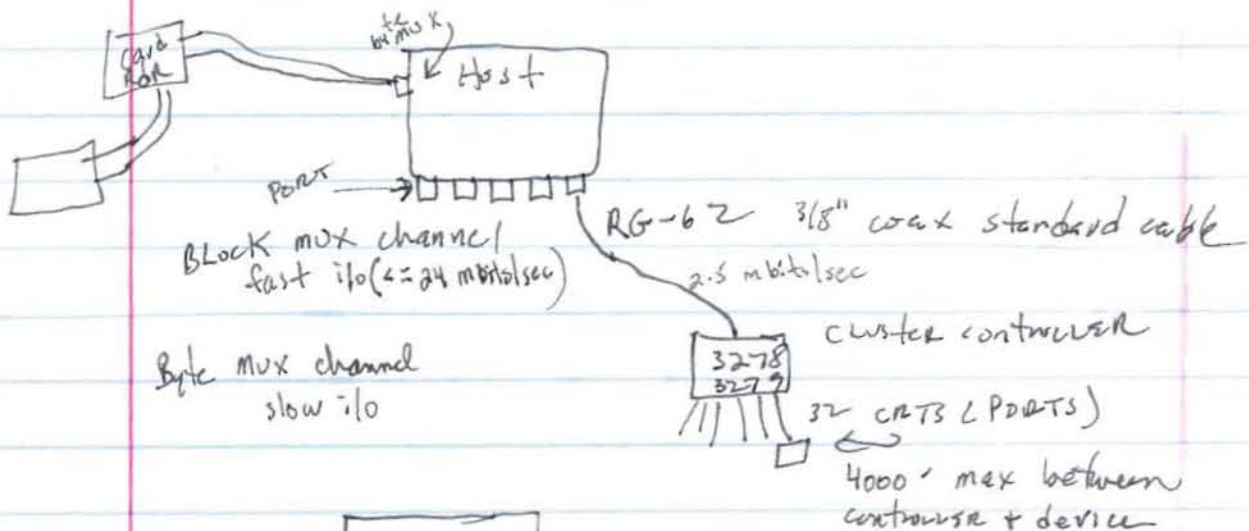
3178

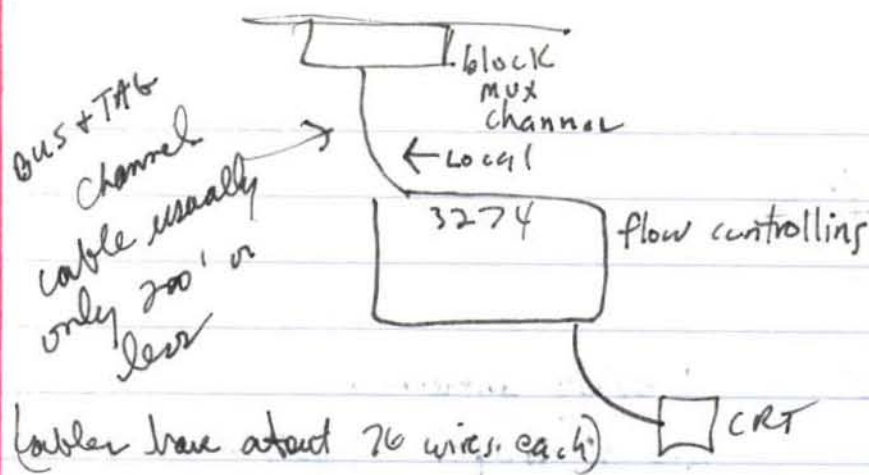
low cost 3278

3290

10 K character PLASMA display

* All attach to 3274 cluster controller
can connect 32 tubes to a 3274

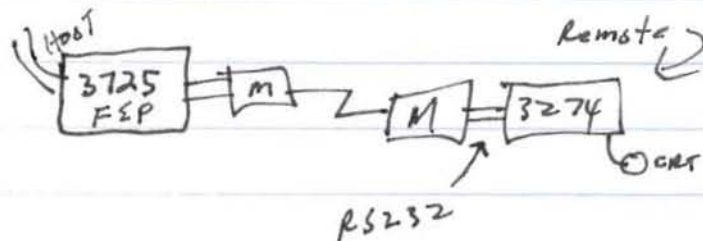




360's have a 'selected channel' (also 7090's)

4 types of cluster controllers

	SNA	new SNA (old bisync hdx stuff)
Local	A (i.e. bus + TAs)	D
Remote	B	C (3274-4LC)



New 3274-81C (more smarts for PC to controller applications)

Software
is
Network
Control
Program

FRONT ENDS
3705

3725

Recently announced

2.5 x throughput of 3705

2 x the price performance

MAX 230 Kbps Line speed
actually up to T-1

Front end takes handshaking, polling, error correction, etc from processor & does it.

\$ 12,500 for 3274

Amdahl makes a 4725

many companies make 'plug compatible' controllers

O.S.

MVS (MULTIPLE VIRTUAL STORAGE)

Large system O.S.

db/dc applications

subsystems

JES (Job entry subsystem)

JES2 (Rewritten HASP) ((HASP Auto Spool Pgm))

JES3 (Rewritten ASP)

For large loosely coupled multiprocessing configurations

Networking

SNA (Systems Network Architecture)

VTAM req. for SNA

Access methods (VTAM, RAM)

(prepares data to give to MVS for terminals, etc)

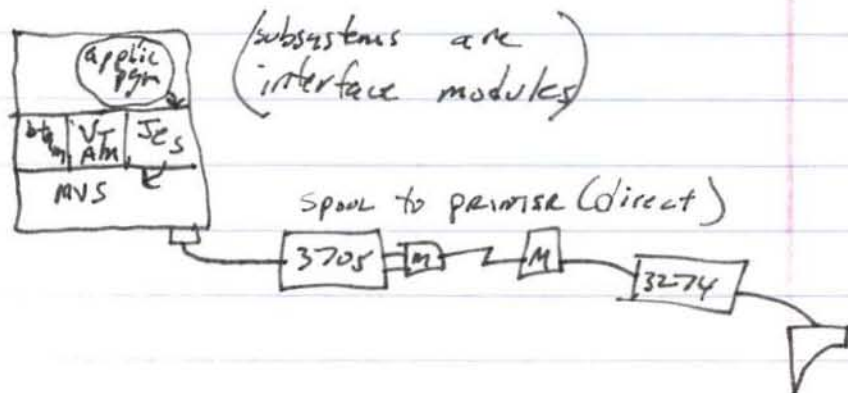
db / data comm

IMS (Inf Mgmt Sys)

CICS (cust. info. control sys)

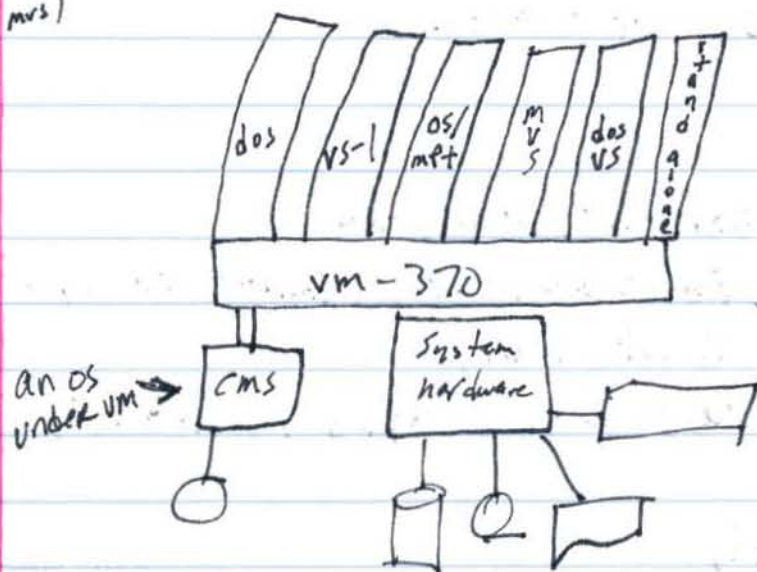
Timesharing

TSO (Time sharing option)



Can run several
OS under VM
(for SWA needs mvs)

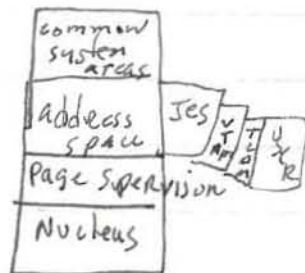
VM-370 (an operating environment)
virtual machines



Inter User Comm. Vehicle
db needs mvs (cms ^{etc.} send mvs to ...)

OS/VS-2, Rel. 2 → 3.8

MVS

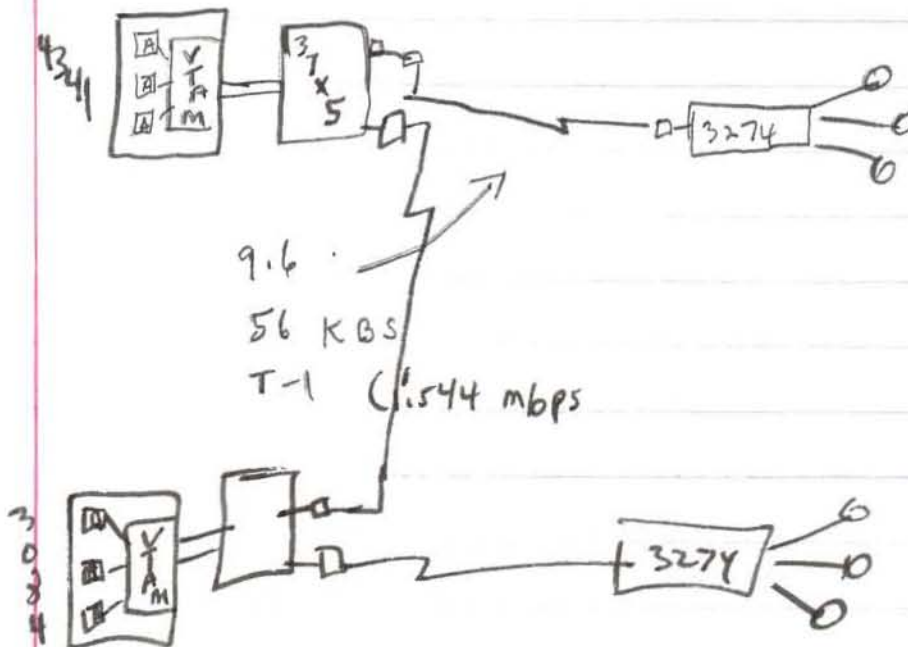


(control point of control) JCL
 operator communication
 data management
 access methods
 "upward compatible"



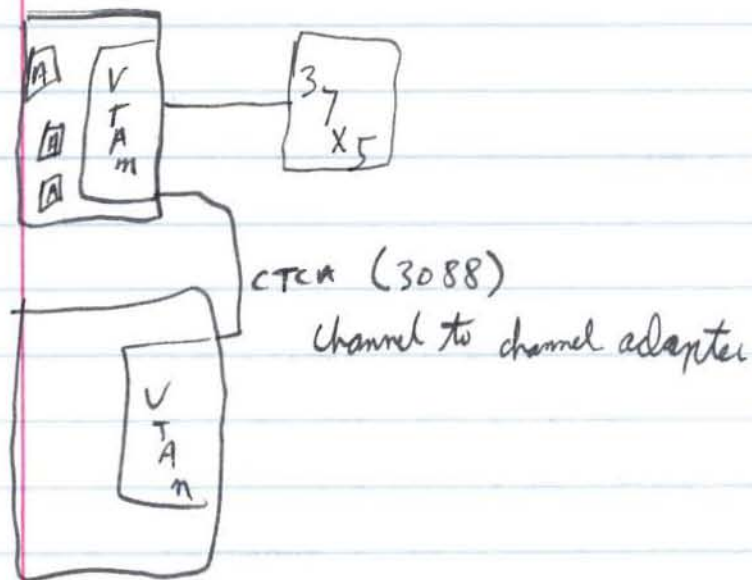
SNA cross domain communication

ANY TERMINAL TO ANY APPLICATION



SNA Cross domain communication

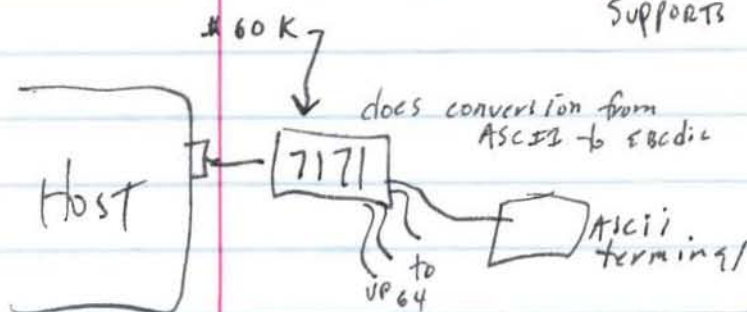
Any terminal to any application



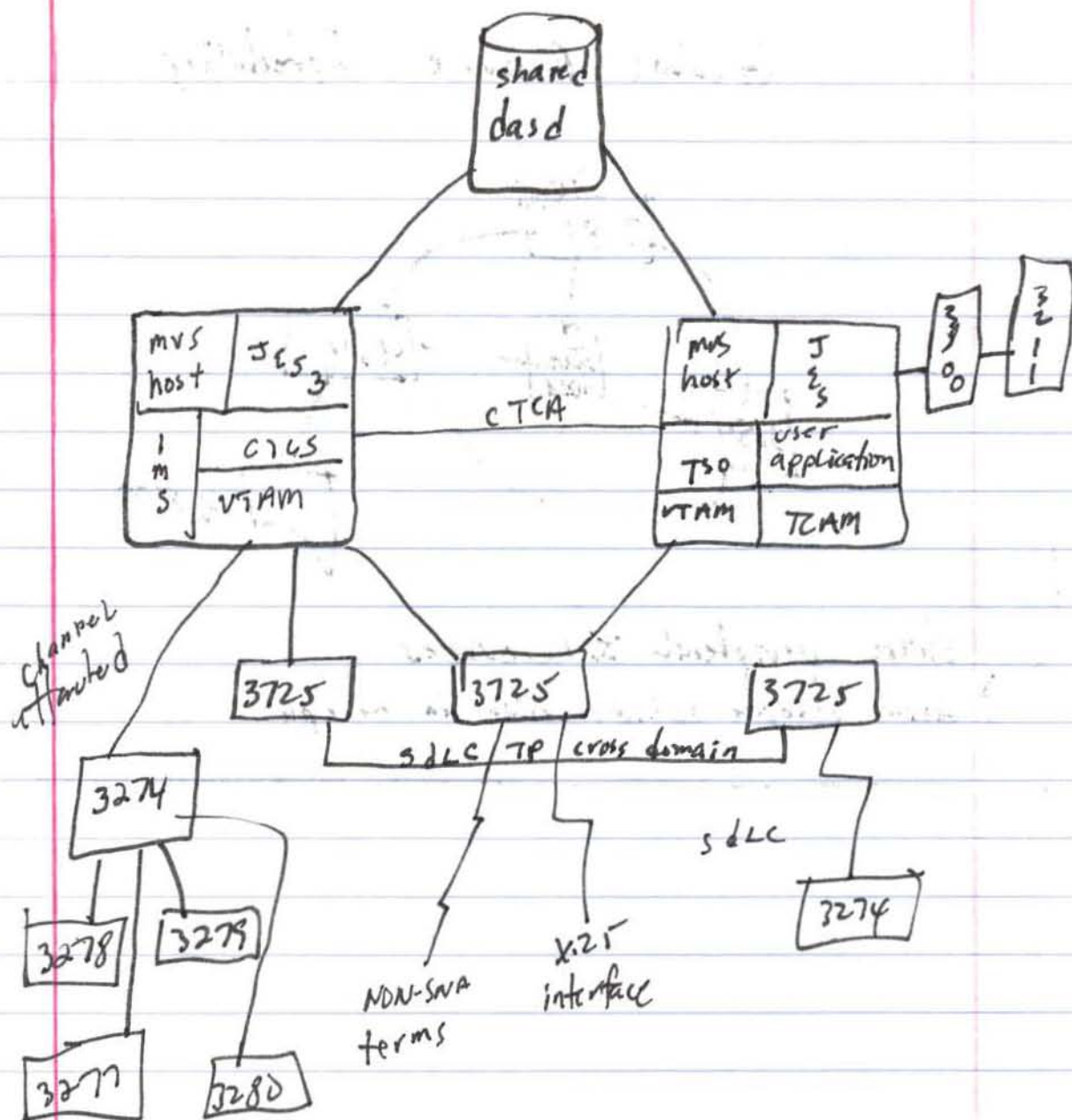
If bottle neck on previous figure, then install a 3088 for high speed

RG-62 coax cable up to 1 mile

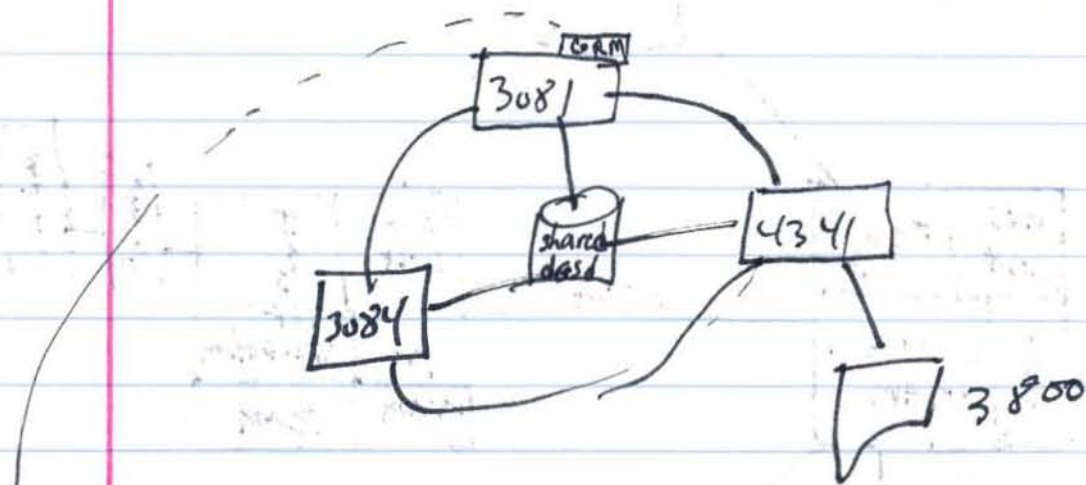
3299 (cable eliminator)
Supports 8 terminals



Access method thinks he talking to a 3274 C.C.



Global Resource Scheduling



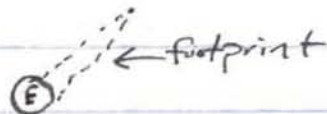
share peripheral resources

Global Resource manager resides in one cpu

March 12

Geostationary above equator (all sats) ~~25.5~~ km
> 21 Kmph @ 25.5 K miles
Actually $\frac{1}{2}$ degree off equatorial center (wobble?)
 2° off from one another (715 miles apart)

- term, modem, mux, uplink, downlink, modem, controller, FEP, host
- a lot of points of failures for a connect between a term & a sat.
-
- very reliable, extremely low error rate (satellites)
- very expensive (100,000 x 2)
- satellites are slightly off equator, so a device is needed on dish to track change in azimuth.
- transponders, receive, amplify, change freq. \leftarrow
up frequency & down frequency
- fdx sat com



- 600 μ sec for signal to transverse from earth to sat + back. Large time delay
 - protocol saying cannot send a block without receiving an ack is violated.
- IBM came out with SDLC protocol in reply to this
count added a each synchronous block of data

^m
000.600.

- FEP will ACK several blocks at once
in stead of each separate block ack.
more efficient
- disaster Recovery is major concern for failures
 - critical files identified. usually sat's used
 - for BdT. failures cause restart of BdT
 - banks must not lose computers for more than 2 days
- mainly suitable for batch



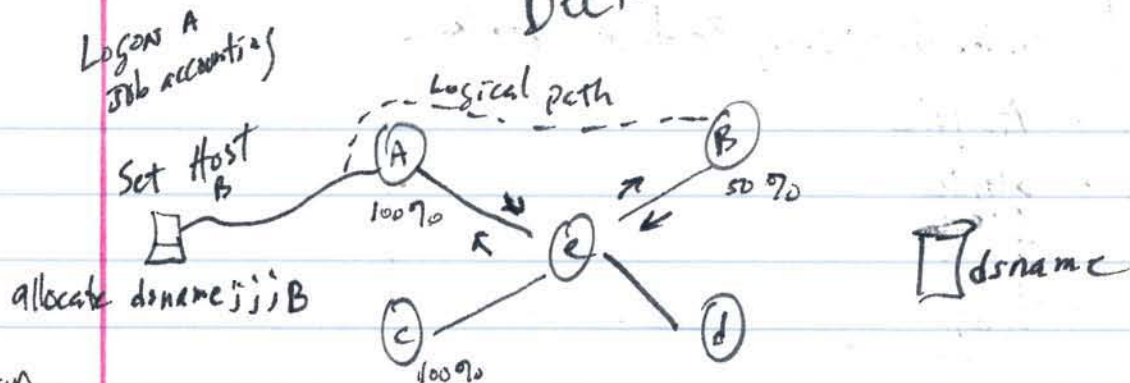
- comm line prices stable, hardware prices dropping
- can bypass letta's with microwave, etc.
 - LED's & lasers can be used because FCC has no control over them.
 - Leased terrestrial lines
- interface standards
 - RS232 std electrical interface Recommended Standard talks about cable & pin connections
 - interface stds at the modem or terminal level (i.e. V.24 V.31 V.35) ATT306 V.35 interface
- data compression

missed topics, Read in book

- ASYNC
- SYNC
- fdx
- hdx

- Read article on 'economic values of Rapid Response'
- pbx in book

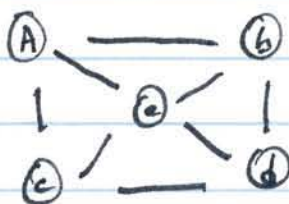
DECNET (load balancing)



Implementation one →

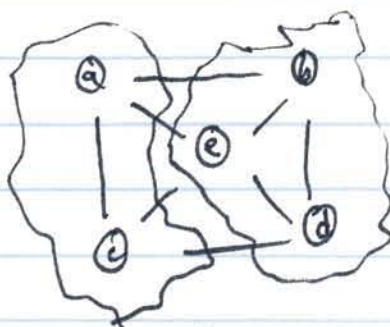
- Node balancing purpose of decnet.
- can allocate a file on another HOST.

Later implementation (Route table)



		cost
A	B	9
	1	7
	2	12
	3	32
	4	
A	C	15
	1	64
	2	47
	3	
A	D	

- Alternate path taken if one in use is interrupted.
- can add on cpu's + decnet will begin identifying new node + updating tables.



establish domains when system gets large cutb costs.

ethernet used to interconnect systems often.

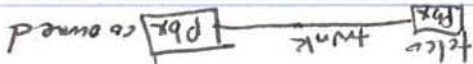
Terminal Pass thru: physical term can be logically connected to any host.
 MSNF: similar to decnet (IBM)

Private Branch Xchange

- all a phone co. is, is a pbx
- a big switching computer used to create a circuit
- trunk, a high speed line going from Pbx to Pbx

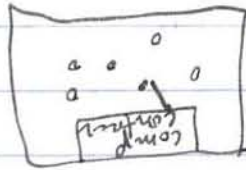
Centrex

- a pbx owned by telco.
- a company can now buy a pbx and buy trunk line from telco



ATT has 33% of installed pbs

MITEL	18%
Room/len 8	7%
6+2	6%
Itavris	4.7%
MTL	4%



Private Automatic Branch Exchange
 computerized branch exchange
 Electronic Private Automatic Branch Exchange

TL 1 1/2 m

Buy a Pbx, you buy speed, # of incoming lines, # of outgoing lines etc
Any terminal to any computer (pbx)

- Network Performance -

- Response time (User seen)

serial events make up a transaction

• faster LINES (modems)

• send smaller blocks of data or data compression

• terminal population

• message size

• control overhead

• Error Probability

• cpu capacity

• data base efficiency

• traffic volume & distribution

• polling methodology

Computer Performance Monitoring

bottleneck determinations

- tsomon

- omegamon

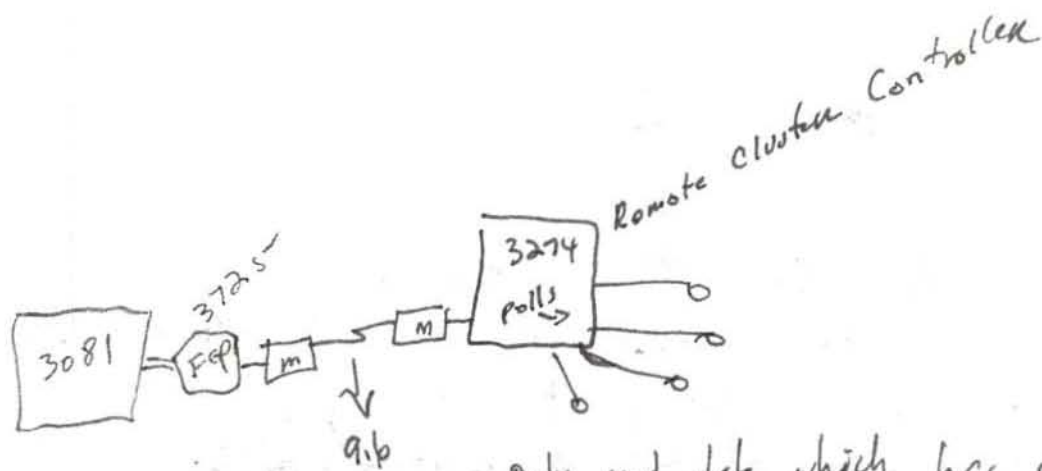
- Resource Monitoring Facility

- VMAP vm performance monitor

80
24
160
1920

consideration for incoming response time

IBM



only send data which has changed

network induced delay can be around 4 sec's on a large network.



MID TERM

Read
Networking
Protocols
for
next week

4-2-86

- Local Area Networks : handout

1. single user owned + admin; not subject to FCC controls
2. limited distance; usually within building
3. wide bandwidth ~~not 1 to 10 megabits/sec~~

Lots of people connected

4. fast 1-10 + megabits/sec

5. low error rates (short, high resolution cables)

individual terminal users have CONNECTIVITY to a wide

range of equipment / other terminals

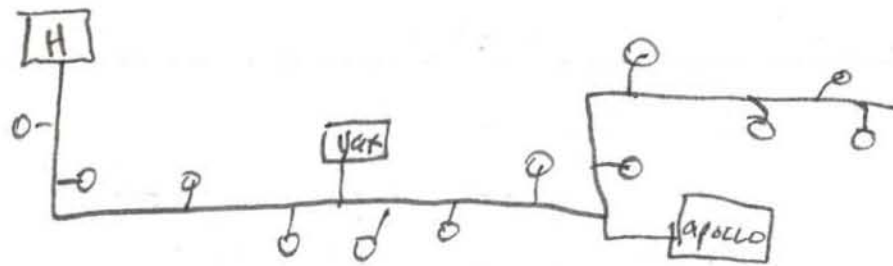
- bypass host as a switch

LAN Benefits

- Resource sharing
- distributed processing
- high speed + bandwidth
- alternative to telco (Pbx) (twisted pair voice cable)
- simplicity, flexibility
- lower error rates
- distribution of hardware
- integration, compatibility

INSTALLATION OF CABLE IS MOST EXPENSIVE part
of establishing a LAN.

BUS TOPOLOGY ✓



idea of this is to lower cost of moving personnel from Room to Room.

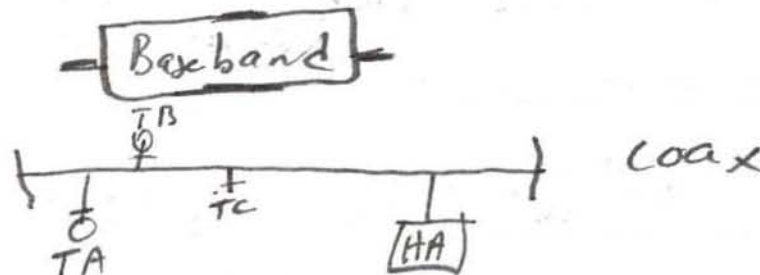
\$1500 / move tradition

~300 / move with a LAN installed.

Anyone can talk with any host. (dial up)

connection cost of new terminals to LAN should not exceed \$500 (3-500)

can Bridge baseband + broadband (see handout)



- one thing happens at a time, one T at a time
No two transmissions at once
- bit serial (one bit at a time in one direction)
- COAX inexpensive
- data transfer across cable is very fast (10 mbits/sec), data thrown into a term buffer & is fed to terminal at 9.6 Kb/sec or less.

Baseband techniques

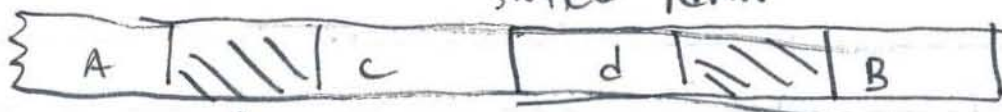
Transmission arbitration on BUS

- time division mux



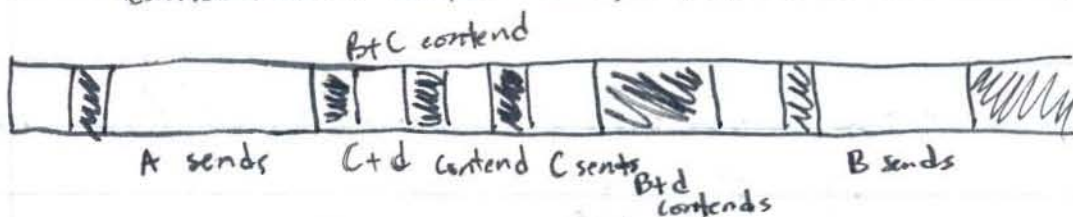
time slices allocated

slotted TDM



- clocks have to be resync'd every so often

Carrier Sense Multiple Access / Collision detection - ethernet



1) Nodes contend when they want to send

2) Packet length variable

Ethernet has Cable length max of 2400 meters

- listen for carrier on cable, if silent, grab carrier & send

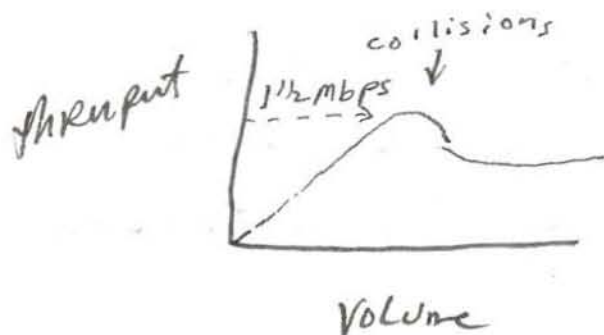
Token passing



term - can only send when he has the token

IBM's token passing network for PCs

Ethernet Cable Curve



- Clocking rate is 10 mbps
- actually two ethernet slots (A+B)

Broadband

- same as baseband but with 20 channels.
- fdx simile (send + receive at same time)

Transmission Media

- | | |
|--------------------|---|
| 1 • twisted pair | 10's |
| 2 • baseband coax | 100 nodes |
| 3 • broadband coax | ← 1000 |
| 4 • fiber optic | 1000 nodes 10's (point to point) |

$$T_1 = 1.54 \text{ mbps}$$

$$T_2 = 6.4 \text{ mbps}$$

$$T_3 = 44.7 \text{ mbps (fiber, hr, short haul (a few miles))}$$

MAXIMUM data error RATE

- 10^{-7} typical leased phone line = $\frac{1}{10,000,000}$ OR
1 in 10 million bits will be wrong
 - 10^{-8} conditioned line 1 in 100 million bad
- Broadband seems to have less errors than baseband

- fiber is very secure
- 3 to 5 Km, ~~amplifier~~ amplification is needed.
 - buy fibers in bundles of 6 to 24 each.
 - fibers are only one way channels (simplex)
two fibers per circuit

Data Link Layer Selection

See handout

o RG-62 cable used by IBM is 92 μ

IEEE standards group

came up with 802 std

- Read OSI reference model functionalities in book -

- A session can be considered a program

LAN consists of program to program communication

A multi vendor network.

IBM aiming at OSI standard

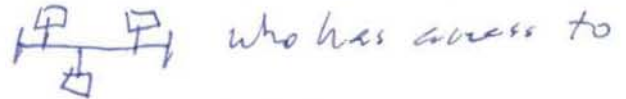
4-16-86

7171 protocol converter for Ascii terminals

3710 protocol converter for host to host

LAN Review

baseband: one thing can happen at a time. One terminal.



cable at any one time.

broadband: channels 1-20, frequency modulation.

1 channel dedicated to one path. better utilization of channels. Interconnection - nodes more expensive.

Ungermann-Bass, Sytek ! manufacturers.

• baseband bus topology

- ethernet lower level (physical & data link)
popular



Packet Networks

pages 152-153

- Packet Switched -

Private

BOAmerica

military

Public

Telenet

Tymnet

Foreign

Transpac - France

ITALCable - Italy

datapak - Australia

telexnet - Sweden

packet network is data network.

Advantages of Packet Based Networks

- cost effective for low to intermediate traffic volumes
- billing is independent of distance; variation by remoteness density
- single physical link can support many logical functions under software control
- not sensitive to different types of equipment
- network provides added values
- mux'd / demux'd + ROUTING
- flow control (speed device diff)
- error control
- network maintenance
- message accounting
- international service thru gateways

- * data and control info is packetized. structure depends on backbone
- virtual circuit between 2 dte's

- virtual call $\hat{=}$ path for point A to destination.
- permanent virtual call - like a leased line

Statistical muxing used to share lines

dynamic allocation of bandwidth

- links assigned when data transfer occurs
- paths between endpoints may vary

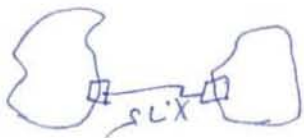
book

! if nodes have minimal intelligence, so super-intellects
 must be established.
 fynet has super nodes - supervisors

6TE-TRENET

- o value added service
- o 275 cities
- o \$1.55 per thousand packets irrespective of distance
- o public ~~land~~ dial (110-12,000 BPS)
- o dedicated port
- \$1,000 installation
- \$1,000 monthly - 2400 BPS
- \$1,500 monthly - 5600 BPS

X.75 connects two networks together



Packet Assembly
 X.25 Protocol

- electrical interface std
- a multi-packeted message arrives in proper order.
- nodes are equal which function as a switch & a Pkt.

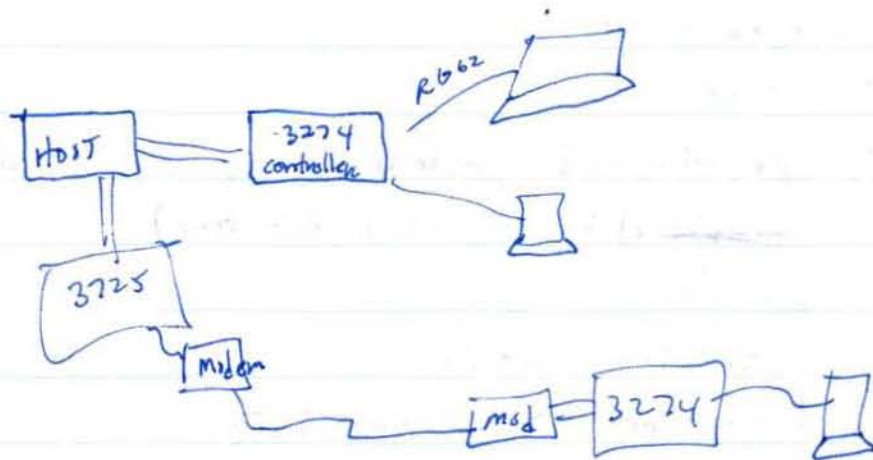
OSI

- X.21 std defines physical layer } layer of OSI for
- frame X.25 data link
- packet X.25 Network

PS network

ASI - videotapes for packet switcher
Advanced Systems Inc.

4-23-86 SNA

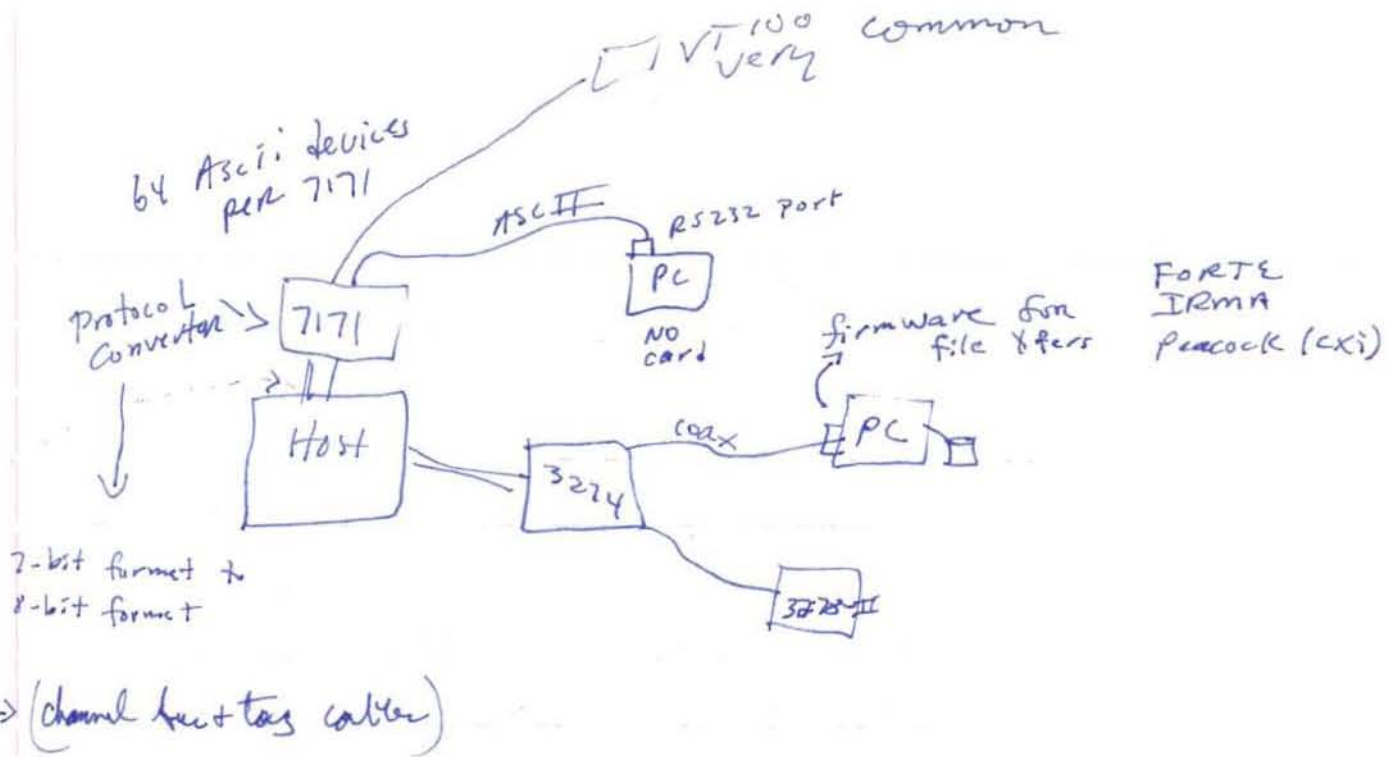


cluster controllers	NON SNA	SNA resources
Local	A	d
Remote	B	C

15,500 3274 - 41 d = Local SNA Controller
3274 - 81 d = more intelligence & routing ability, not going thru host
to talk to another terminal

Logics Vee 6.2

Terminal profiling to ports.



Electronic Erasable Programmable Read Only Mem

Super computer

Cray 2 Current largest
3 under construction

CDC 205 sold to ETA ETA 10 sold to NSF

NEC SX-6 Houston Automatic Research Computing
Equivalent to 4 CRAY 2's

- Possibly better to recompute data rather than store on slow disks. disks may disappear with extremely fast cpu's

Understand SNA's Layered Architecture

SNA has 6 layers

- only talk between applications at the physical layer

- 'likes' talking to 'likes'

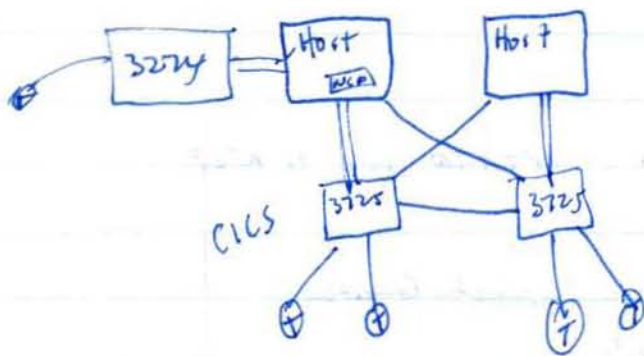
end user talking to end user

appl. pgm talking to appl. pgm

network ~~can~~ talking to network

Network Addressable Unit

- Path Control Layer routing function



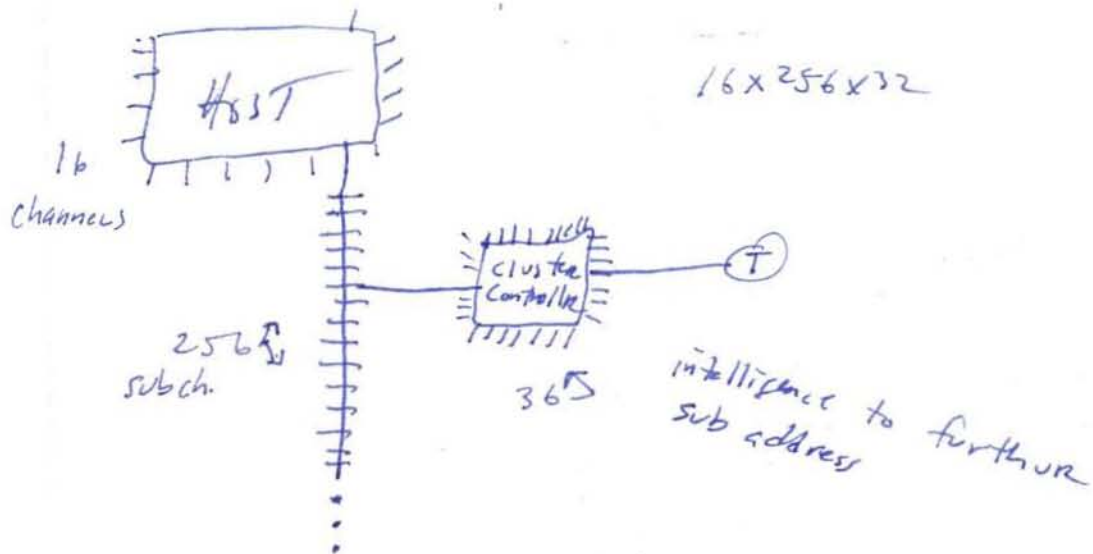
Data Link control Layer within 3275,
rather links

Network Control Program. Runs in Front End Processor.

Connect tables + Vram in host (NCP)

Updating Routing tables major task.

16 channels
 256 sub ch/ch
 $256 \times 16 = \text{TOTAL \# of addressable devices}$
 -



Virtual Terminal Access Method

- Bisync is a hdx protocol
- hdx done with SDLC
- presentation layer is functionally a dset
- application layer is a program

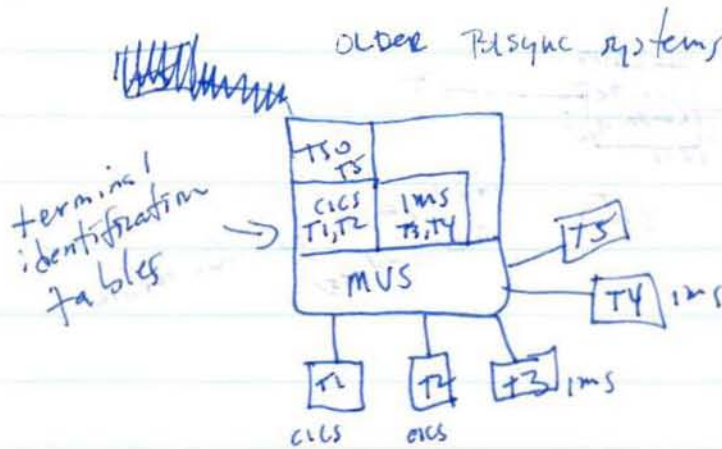
For Next Week

Problem sheet.

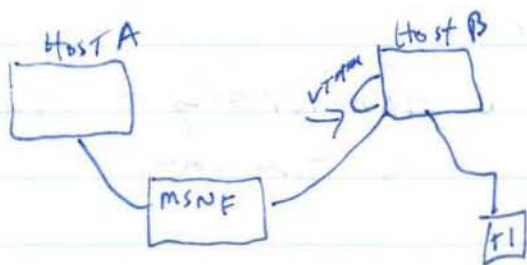
identify the components of dp/dc system.

- 1) procedures
- 2) components, etc

~~4-30~~

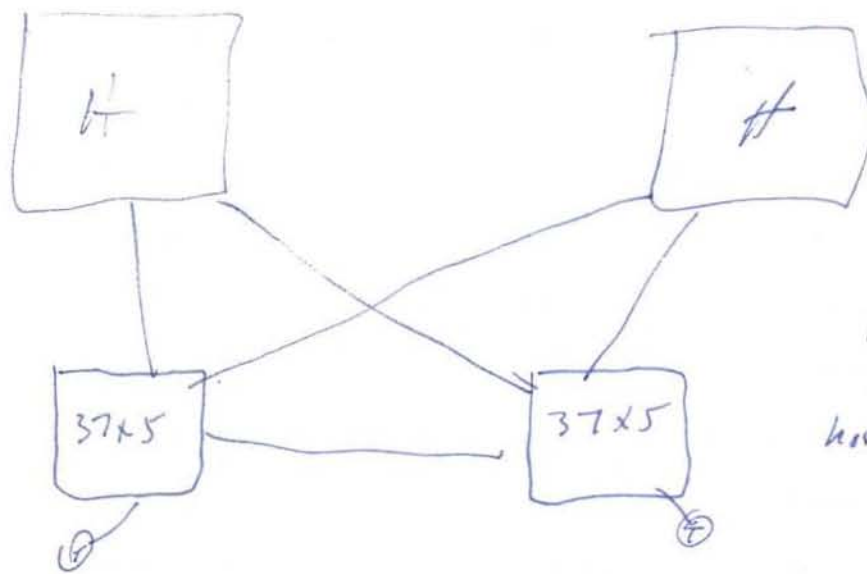


SNA allows T1 to access any access method desired.



→ This terminal physically connected to Host B, logically to Host A, via VTAM & MSNF

multiple
system
networking
function



MSNK
Resides in
host + 37x5.

SNA

connecting a logical user to a logical user.

Rich Hamer
Network Systems
4010 Moorpark Suite 106
San Jose 95117

5-7-84

two modes in ITM land

- SNA
- ✓ NON-SNA bisync - hdx

FINAL TEST

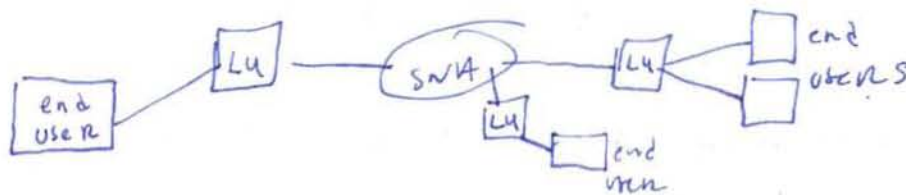
- pgs 1-197
- LANS
- Pbx's
- IBM hardware Config. 3274, 3725, 3033's etc
- OSI ← important
- a very little SW
- a little X.25 (essay)

Lots of essays, study midterm, lots of 3's come from that

- Univ. Santa Clara course on protocol 7am

• compare an IBM network (know #'s ie 3033 etc)

Logical Unit : the interface between a user & the network

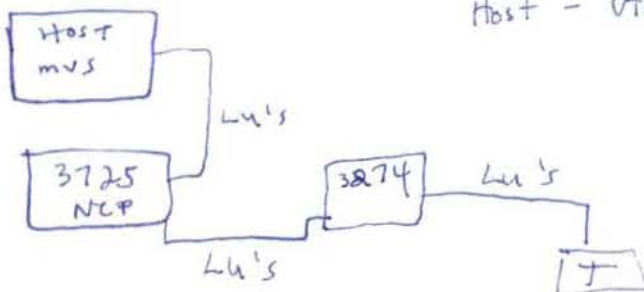


Network Addressable unit : unique network address

The higher an LU # is, the more intelligent it is.
1 - 6.2 is #'s for LU's

LU can be considered a 'virtual circuit'.

Host - VTAM - 3725 - NCP - controller - terminal

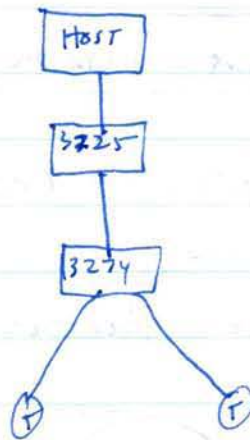


6.2 says LU can talk to LU.

SNA has no central point of control.

IBM traditionally designed central control. i.e. T talk to
T via host. Then came 6.2

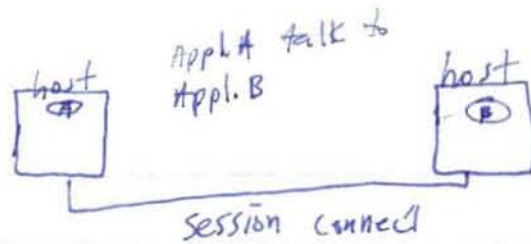
SNA controller = 3274-81 this controller will
support communications from T to T via 3274, instead of
going thru host.



For the Trana peacock & file transfer control for PC's & hosts:

IBM's thrust is to go to OSI standards. Their thrust is
slightly different.

- 1 - flow control. host power w i/o slow speed
- 2 - character differences. ascii, ebcdic
- 3 - character arrangement



Path control & data link layers handle 1, 2, & 3,

Nodes usually contain other components besides PUs. In most cases, nodes also contain LU's. LU's are used to interface end users to the network. This is necessary because end users are outside the network. Their structure & implementation.

host nodes

7033

NCP nodes

3725
Comm
controller

peripheral nodes

3274
~~3270~~
control
unit

presentation medium

Termi
nal

end user

person

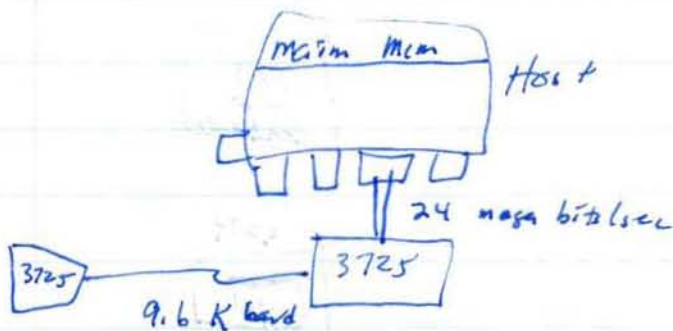
$$T1 = 1.544 \text{ Mbi/s}$$

channel is data path from main memory to controller.

channel programs data handshake with controller.

One byte transfer at a time.

channel speed = 24 mega bits/sec / channel



SNA Gateway: A number of vendors have these.

Tandem's SNA-X is one.

Also Honeywell, Dec, Prime, Xerox

The gateway addresses the SNA protocol.

Tandem looks like a 3270 to SNA. via SNA-X.

Modems & Multiplexers

An Introduction to Basic Concepts & A Guide To Applications

■ INTRODUCTION

Modems and multiplexers are essential components of data communication networks. In most instances they form the digital path between the communicating parties, whether they be terminals or host computers, using the voice or "analog" facilities of the phone system as a base. Modems actually perform the conversion between the digital signals used by computers and the audio tones which can be carried by the telephone lines. Multiplexers allow multiple data conversations to share a line, reducing the cost of providing a communication connection to each user pair. Both services are so fundamental to successful and economical data exchange that particular care must be exercised in evaluating the products and features and applying them to a user environment. This tutorial provides a basic understanding of modem and multiplexer technology, explains the essential features and operating parameters, and describes the application of both products to the real user communication world.

■ THE PURPOSE OF MODEMS

Computers and terminals exchange data as a series of pulses which represent binary digits, or bits. These bits are grouped into larger units called characters or bytes, and each letter, number, or symbol used has a unique binary code. The particular set of codes being used must be agreed upon by both the sender and the receiver and is called the code set. The most common code sets used today are Extended Binary-Coded Decimal Interchange Code, or EBCDIC, and the American Standards Code for Information Interchange, ASCII. EBCDIC was devised by IBM and is used almost exclusively by the larger IBM mainframes and devices which must communicate with them. ASCII and international versions of it are widely used by nearly all other communication devices.

Binary data in digital form is useful for directly connected devices such as local terminals, but digital data does not pass through the telephone system efficiently. Figure 1 shows why. The digital signal consists of a series of pulses with very short rise (leading edge of signal) and fall (trailing edge) times. Technically, these quick transitions are a result of high-frequency harmonic signals—often over 10,000 cycles per second. Since the telephone system is designed to carry human voice and not high-fidelity music it cannot reproduce these signals and they are lost in the path to the receiver. The result of this loss is a blurring of the digital pulse, making it difficult to see exactly when it begins and ends. This in turn makes timing the bits difficult or impossible and thus prevents proper location of characters. Data communication cannot occur using digital signals over telephone lines. To use the phone system, it is necessary to "speak its language"—analog.

Modulation • Since the phone system operates on audio tones or analog signals, the first task in using them is the conversion of the digital signal to audio, a process called modulation. The receiving station must then reverse the process: demodulating the analog signal and recapturing the digital pulses. The "MODulation/DEModulation" combination creates the acronym for the device used to perform this process—a modem. Both functions are combined in the modem, allowing either party to send and the other to receive.

The technique used for modulation varies as the requirements of the application change. Simple, low-speed, devices may use modems which employ a form of frequency modulation called frequency-shift keying (FSK). This represents changes in the binary bit pattern by changes in the frequency of an audio tone. The line is assumed to be in a steady binary-one or mark state when it is idle, and this state is represented by one frequency of

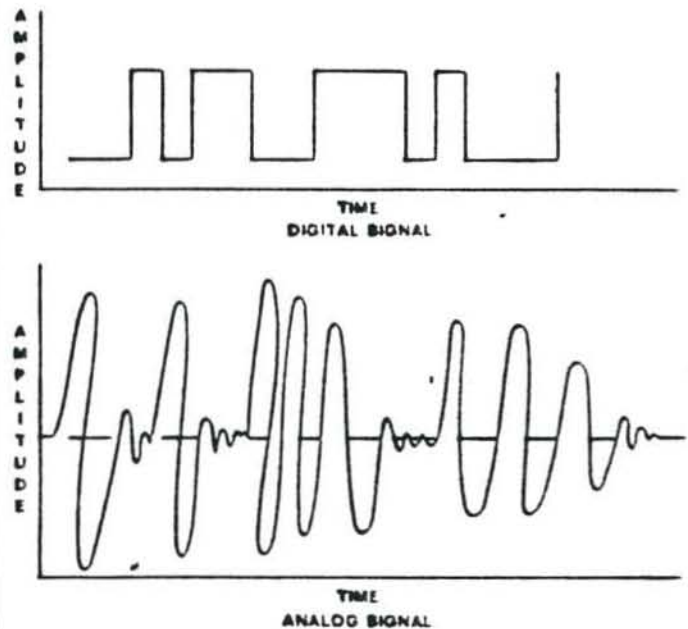


Figure 1 • digital vs analog signals

tone. When the data bit value "zero" is sent, the modem changes to another tone frequency. This causes a characteristic almost musical effect during the sending of data which many users of timesharing systems using this type of modem have come to identify.

FSK modulation works well for relatively low speeds, but as the speed of the digital signal increases the time allocated to shift frequencies reduces so that both the production and detection of the change become more difficult. At 1,000 cycles per second, a single complete cycle of an audio tone requires a thousandth of a second. Since changing frequencies in the middle of a cycle is difficult (to both sender and receiver), a single bit would have to take at least that long to send, resulting in a data rate of about 1000 bits per second. Since that speed is unacceptable for many applications, another modulation technique must be used for higher speeds.

One alternative is called phase-shift keying (PSK). This uses changes in the phase of a signal, or its timing relationship to a fixed reference, to indicate a change in the bit pattern. PSK is used in many medium-speed modems, and is combined with amplitude modulation (AM) in high-speed applications to form quadrature amplitude modulation (QAM), the prevailing standard at 9600 bits per second and higher.

Modulation techniques may use all of or part of the frequency range or bandwidth of a telephone channel. If the modulation uses less than half of the bandwidth to carry the data signal, the unused bandwidth may be used to carry the transmission of the other station, permitting both stations to send and receive simultaneously; this is called full-duplex operation. Figure 2 shows some examples of bandwidth use by popular modems.

Baud vs Bits Per Second • Even high-performance modulation schemes cannot accommodate a fast enough transition in signal

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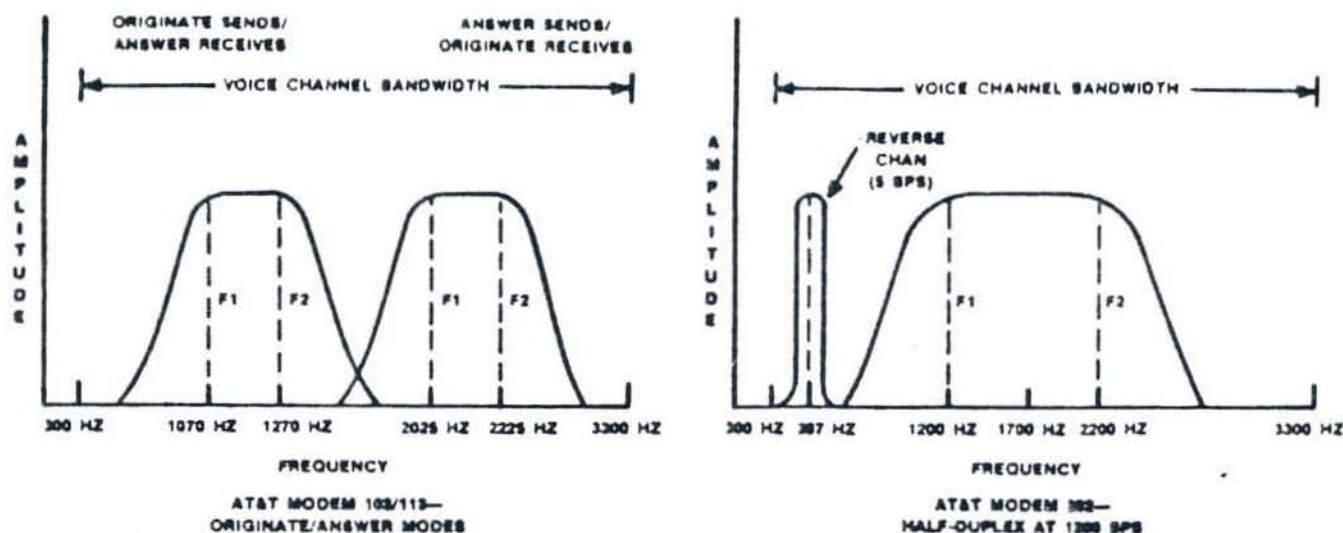


Figure 2 • modem bandwidth usage

values to track individual bit changes at high speeds. The maximum rate of signal change that can be dependably used is a function of the spectrum of frequencies which the telephone system will pass—the bandwidth. This limit is approximately 2400 signal changes per second. Since signal changes per second is an inconvenient unit of measurement, this figure is normally represented using the old telephone term "baud." The baud rate of a line is equal to the bit-per-second rate if the modulation represents every bit change as a signal change. Higher speed modems, however, combine bits into groups of two, three, or even four and assign each pattern a unique signal value. For two-bit groups, a total of four possible bit patterns exist (00, 01, 10, 11), each having its own signal indication. In phase shift modulation, for example, a shift of 90 degrees could represent "01," 180 degrees could be "10," 270 degrees as "11," and no shift as "00." Other values are normally used for engineering reasons, but the principle is the same. Using the bit-pattern encoding technique, a change rate of 2400 baud can support 9600 bits per second (bps) through grouping into 4-bit groups. While the term baud is thus rarely equivalent to bits per second, incorrect usage of it by the computer industry has corrupted the original definition.

Full- & Half-Duplex • Many communicating users exchange data in much the same way as people converse—each taking a turn being the sender while the other receives. This mode of communication is called half-duplex while the mode which permits both users to simultaneously talk and listen is called full-duplex. At low operating speeds, the portion of the phone line bandwidth which is required to send the data in either direction is small enough that both directions can simultaneously use the same line. This split-band operation over a two-wire line, common at 300 and 1200 bps, is now usable up to 4800 bps with some newer modems.

To send data full-duplex at higher speeds, a second line is required. This so-called four-wire service provides the user with the equivalent of two telephone circuits. It is normally requested as a part of private leased line service, but some modems will permit the use of four-wire operation over two dial-up connections.

Higher speed modems are operated on two-wire connections, the communication must be half-duplex. This means that the modems must alternate between sending and receiving. Each time the direction of transmission changes, called turning the line around, there is an interval required for the path to electrically stabilize and the modems to train (adjust) to the new direction. Modem turnaround delays can be a significant factor in cases where the direction of the line changes often, such as with polled lines.

Synchronous & Asynchronous • Whatever the method used for converting between digital and analog, all modems need a way in which the sampling of bit values and the separation of characters can be controlled. If the sending station begins to change the line state with digital bit values, the receiver must begin sampling the output at the proper time or data may be lost or misinterpreted. One way to assure proper data recognition is to begin each character with a dependable transition from the mark or binary one state to the space or binary zero state. This is called a start bit. The receiver, seeing the change, begins the timing of its bit samplings at the end of the start bit. At the end of the character, a "quiet" period of marking line may be assured by defining a stop bit interval. This framing approach allows the sender and receiver to operate their stations without a strict synchronization of their bit sampling, or "clocking" as it is called. The start/stop bit transmission method is called asynchronous because the clocking is not synchronized between stations.

Asynchronous transmission, or "async" is relatively inexpensive to implement in both terminals and computers. For cases where the terminal and the computer are directly connected, it often provides the best overall means of attachment. But for communication lines, async poses some special problems. The bursty nature of its traffic makes it difficult for the modems to adjust themselves to the conditions of the telephone circuit, "training" for the least possibility of error. To overcome these difficulties, another method of data transmission called synchronous was devised. In synchronous transmission, the data bits of one character follow the bits of the previous character without any intervening space and without start or stop bits. So that the receiving station knows when the data block has begun and can properly "count off" groups of bits into characters, a special pattern of bits called a sync character is sent preceding the data. Since the data is now sent in a continuous stream, the modem can better train for its correct reception. In order to use the synchronous modem techniques, the communicating devices must be capable of sending their data continuously as a block, called buffering the data. The buffering capability and its associated cost are the price of the speed advantage of synchronous devices; most asynchronous links are limited to 1200 bps while synchronous communication over the telephone system at up to 16,000 bps can be achieved and is now supported by modem vendors such as Paradyne.

MODEM APPLICATIONS

As the previous discussion on synchronous and asynchronous transmission of data shows, there are variations in modem design based on application of modems to business communication. The variations are intended to optimize the cost/performance ratio of

Modems & Multiplexers

the modem, and reflect the different ways that modems might be used. For example, modem use can be classified in the following groups:

- point-to-point (two-party) use or multipoint (three or more parties)
- dial-up (DDD) or private (dedicated) leased lines
- voice-grade or wide-band lines
- two-wire or four-wire lines
- full-duplex or half-duplex communication
- conditioned or unconditioned lines

The categories shown are interrelated so that, for example, the choice of conditioned or unconditioned lines is available only for private leased lines. Figure 3 shows the relationship in these alternatives.

Modems, Medium-Distance Modems, Limited-Distance Modems & Line Drivers • By convention, the term "modem" has come to apply to devices used for modulation/demodulation of a digital signal to permit its passage over conventional dial-up or leased telephone circuits. These devices must operate without a copper path (metallic circuit) between users because telephone company equipment including repeaters, switching offices, and microwave or satellite links interrupts the copper path. At least one vendor provides "medium distance" modems designed for telephone circuits at distances up to 50 miles. Medium distance modems do not equalize undesirable line conditions to the extent of regular modems, and are, therefore, cheaper. Less expensive devices called limited distance or short haul modems can be used where there is an assurance of a copper path between the modem devices. These devices operate in pairs like conventional (long-haul) modems but rely on the more dependable electrical characteristics of the copper path to simplify the modulation scheme. The transmission range is limited by transmission speed and the wire size of the conductors in the copper path. Distance is proportional to the diameter of the conductors and inversely

proportional to transmission speed. Wire size (conductor diameter) is specified by American Wire Gauge (AWG) numbers. Conductor diameter diminishes as the numbers become larger. Typical wire size for private lines up to about 15 miles ranges from AWG 19 through to AWG 26. Private lines are also available from the telephone company. Users should realize, however, that conventional telephone circuits are equipped with loading coils for voice transmission and restrict data rates to 9600 bps, unloaded Telco circuits or user-provided metallic circuits support much greater data rates. Some limited distance modems are designed for unloaded circuits only, and can operate at rates up to 19,200 bps at a very reasonable cost. AT&T specifications for transmission over private lines are detailed in AT&T Technical Reference Publication 43401. Most limited distance modems meet this specification, which requires the units to filter transmitted signals so they will not cross over and interfere with adjacent wire pairs in the same cable.

For connections of several thousand yards or less another device called a line driver is employed. Properly speaking, this is not a modem at all but a means of sending the digital pulses further than the normal 50-foot limitation of the RS-232C interface. The extra distance is achieved by amplification and other digital techniques. The line driver may also be called a null modem, local distribution unit, or modem eliminator, but should not be confused with devices used only to supply proper external data clocks and proper control signal values to permit a device which normally operates through a modem to connect locally. Line drivers are typically used with synchronous terminals connected to a host computer in the same room. Unlike modems, they are not connected in pairs (back-to-back).

Simultaneous Voice/Data Modems • Because of a trend to combine voice and data capabilities in a new generation of "executive workstations," modem vendors have developed modems that accommodate both voice and data communication over the same wire pair. Most of these units use a technique called data over voice, whereby data signals are communicated at a higher frequency than voice signals so that the two do not

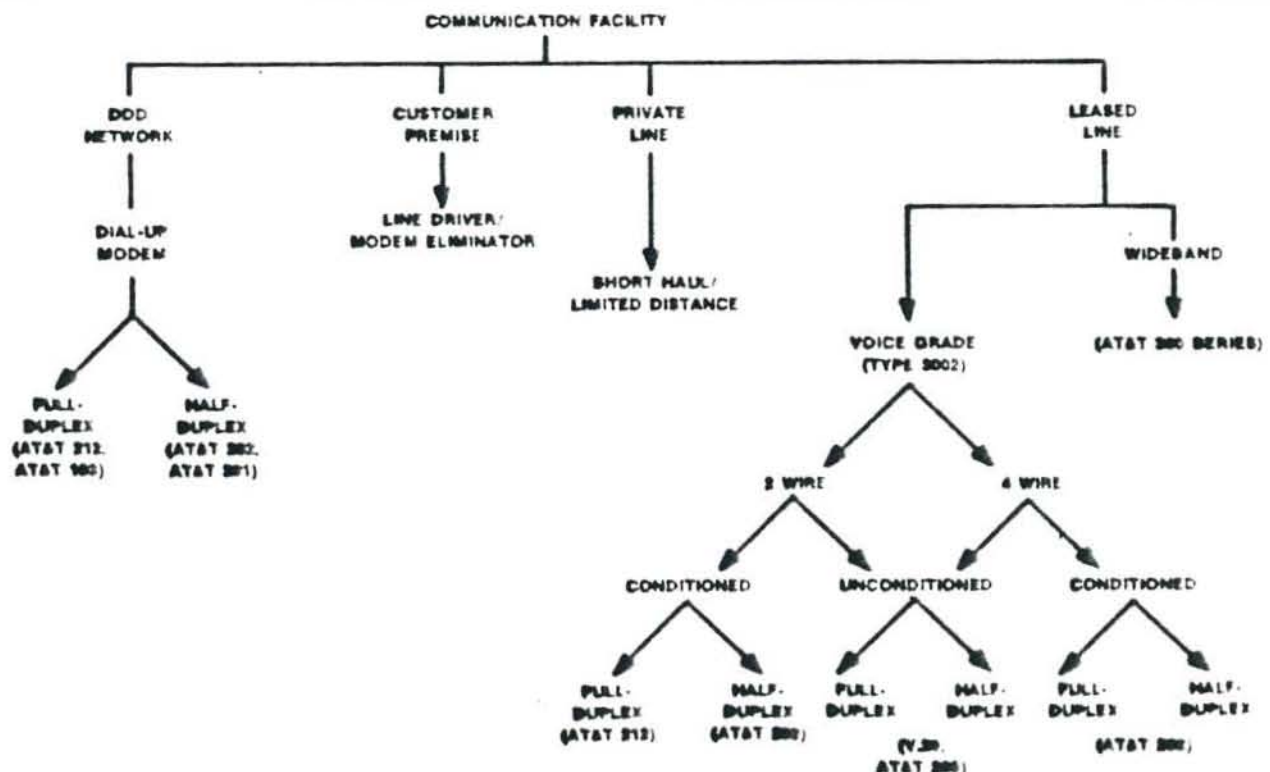


Figure 3 • communication facility vs. modem type

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interfere. Simultaneous voice/data modems tend to be short-haul devices only, and are useful in PBX environments where users can take advantage of existing telephone wiring and save the expense and hassle of adding dedicated data cables.

Dial-Up vs Leased Lines • Dial-up connections are those made through the normal switched telephone system (DDD or PTN). The paths taken by such connections are not predictable and vary significantly in terms of noise and other important characteristics. Furthermore, a series of echo suppressors are present to prevent the annoying reflection of the speaker's voice. In addition, the local loop from the central office to the connection is always two-wire. This means that both sending and receiving of data at a communicating station must share the same wires. Unless the modems are low-speed models, the bandwidth required for either sending or receiving will fully utilize the single pair connection, so the modems must operate alternately sending and receiving or half-duplex. Turnaround delay on dial-up lines is significant—typically 150 milliseconds.

The connection between the modem and the dial-up circuit may be made directly if the modem is certified by the FCC for direct connection (FCC Docket 19528 Part 68), or via a **Data Access Arrangement (DAA)** if it is not. Either direct-connect or DAA attachment may support automatic dial and answer or may require an instrument for manual dial and answering. Some modems connect to the line by providing a rubber cup set for the insertion of the telephone handset itself. This technique is called **acoustic coupling** and is useful when a modem is to be used with a line normally used for voice, such as in a PBX environment, or where a modem and terminal are to be carried from phone to phone. Acoustic couplers are common at 300 bps and available up to 1200 bps, but the variations in the quality of the handset can create unfavorable error performance. The units are almost always less expensive than the combination of a modem and a DAA, but direct-connect modems are now available which are actually less expensive than an acoustic coupler of the same speed.

Leased line modems do not require dial/answer logic since the leased path is fixed. A leased line may have the same bandwidth of a dial-up line, called a **voice grade** or **Type 3002** line, or it may have a greater bandwidth (**wideband**) such as AT&T Communications Series 8000. Since the path of a leased line is fixed, the circuits involved may be preselected for a particular level of transmission characteristics, called **conditioning**. Leased lines may also be **multidrop** or **multipoint**. This means that the line has intermediate stations or "drops" between the two endpoints. Multidrop circuits are actually formed by linking separate leased lines at the central exchange.

Line Conditioning & Transmission Errors • The telephone system is not a perfect electrical path even for voice communication, and as the speed of data exchange increases it becomes increasingly difficult for modems to manage the precise signaling required for accurate information transfer. There are a number of problems that affect the performance of a circuit. First, the line may fail altogether, normally because of a fault in the local loop or central office. Second, the line may become subject to unusual electrical interference or other sources of random noise, decreasing the ratio between the strength of the signal and the amplitude of the noise pulses, called the **signal-to-noise ratio**. A third source of problems is variation in the strength of the signal itself, independent of noise, called **amplitude distortion**, which may cause periods of "drop-out" when the signal becomes so weak that it cannot be properly decoded at the receiver. The fourth and final source of circuit problems relates to changes in the analog signal itself which is caused by uneven propagation of low and high frequencies. Called **phase jitter**, this condition severely affects modulation techniques that use phase shifts to represent bit patterns—the technique used by most high-speed modems.

One way to minimize problems with leased circuit transmission characteristics is to pay a premium for a line specially conditioned. The telephone company will then either select a path which meets the more stringent requirements of the conditioning or specially service a path to meet the standards. Conditioning is available in two types, C and D, and at several levels within each type; both are available for either point-to-point

or multipoint lines. Even with line conditioning, however, AT&T will not guarantee optimum bit-error rates.

Type C conditioning improves the frequency response of the channel and the propagation delay of various frequencies, called **attenuation distortion** and **envelope delay distortion**. Attenuation distortion results from uneven levels of transmission of the frequencies from 300 hertz to 3300 hertz. Type C conditioning assures what in high-fidelity terms is known as a "flatter" frequency response. This means that the difference in volume (amplitude) between two tones of different frequencies is minimized. Envelope delay distortion is caused by the fact that the time it takes for a tone to pass between sender and receiver may not be exactly the same for all frequencies. This delay can cause problems when multiple tones are generated for a series of bits and the tones arrive with a different time relationship from that of their generation. Type C conditioning equalizes propagation delay. Both envelope delay distortion and attenuation distortion can be conditioned to various levels by selecting C1, C2, C3, C4, or C5 conditioning. The higher numbers have the tightest controls on the distortion and thus the best transmission characteristics.

Type D conditioning minimizes line noise called **C-notched noise** and **harmonic distortion**. The former condition causes a poor signal-to-noise ratio on the line, generating random bit errors. Harmonic distortion results from the generation of multiples of an initial tone, similar to two notes an octave apart in music. This "harmonic" may cause the modems to lose tracking completely.

Modems operating at relatively low speeds may not require any conditioning at all, but nearly all 9600-bps modems require some form of line conditioning. If the modem is equipped with internal compensation providing what is known as **adaptive equalization**, Type C conditioning is not required, but Type D is often required. Some new 9600-bps modems will operate satisfactorily even on unconditioned lines. Figure 4 shows the effect of Types C and D conditioning.

Equalization neutralizes the undesirable electrical characteristics of a communication line that distort the transmission, increasing the error rate and degrading operating performance. Equalization and line conditioning are extremely important to optimize modem performance at rates above 2400 bps. Both act to minimize signal distortion, such as envelope delay and amplitude attenuation, which worsens with increased speed. Equalizers are essential because line conditioning does not totally neutralize distortion; it assures that distortion is reduced to specific limits defined in the specifications for each type of line conditioning. In some cases, equalization eliminates the need for extra-cost line conditioning. It is vital to high-speed communication over the DDD network.

MODEM SELECTION PARAMETERS

Modem features and operating parameters span a broad spectrum of applications, and it is necessary to thoroughly understand both the feature and the impact in order to match a modem to a specific application. Some parameters are dictated by the application equipment while others can be optimized through the proper selection of a modem or modem options.

Many modems are designed for either dial-up or leased-line operation, so one of the first issues in modem selection is the line type. Very high-speed data exchange requires leased line facilities, and leased lines are often the best choice where the amount of data to be exchanged is large enough to require connection for hours at a time. The decision to use leased lines is primarily one of economics—would it cost more to lease the line or to pay the dial charges for the time you expect to be communicating?

Another parameter which is normally not selectable is the question of synchronization. Synchronous devices (such as the IBM 3270 or 3780 terminals, all SDLC/SNA devices, and X.25) require synchronous modems. While it is possible to buy modems or devices (converters) that permit asynchronous devices to use synchronous transmission techniques, this is not normally cost justified and may have unwanted application impact unless the asynchronous device communicates in block mode rather than the normal character-by-character mode.

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SIGNAL IMPAIRMENT	TYPE B802 UNCONDITIONED	TYPE C CONDITIONING	TYPE D CONDITIONING
HARMONIC DISTORTION	C	NE	C
AMPLITUDE DISTORTION	C	C	NE
ENVELOPE DELAY DISTORTION	C	C	NE
NOISE	C	NE	C
PULSE NOISE	C	NE	NE
PHASE JITTER	C	NE	NE
FREQUENCY SHIFT	C	NE	NE
ECHO	C	NE	NE
PHASE HITS GAIN HITS DROPOUTS	UNCONTROLLED		

C: CONTROLLED AT LEVEL SHOWN

C+: ENHANCED CONTROL AT LEVEL SHOWN

NE: NO EFFECT

Figure 4 • effects of conditioning

Transmission mode is a modem parameter that may be selectable. As indicated previously, some communication takes place in two-way simultaneous mode (full-duplex) and some in two-way alternate (half-duplex). A very small number of devices communicate in one direction only, called simplex transmission. A full-duplex device **MUST** use a full-duplex modem, but some half-duplex devices can profit by being operated on full-duplex lines.

In the previous discussion of full- and half-duplex modems, the time required to train the modem pair after a change in transmission direction, or line turnaround, was noted. This time can be quite considerable—150 to 250 milliseconds is not

uncommon at high speeds. This turnaround time is equivalent to the time to transmit over 200 characters at 9600 bps! If a half-duplex batch transmission protocol such as IBM 3780 bisync is used at 4800 bps with a modem with a 200-millisecond turnaround, the result would look something like Figure 5

1. the sender transmits a block of 512 characters, requiring 860 milliseconds
2. the line turns around, requiring 200 milliseconds
3. the receiver sends an "ACK," or acknowledgement of reception, requiring about 6 milliseconds
4. the line turns around, taking 200 milliseconds

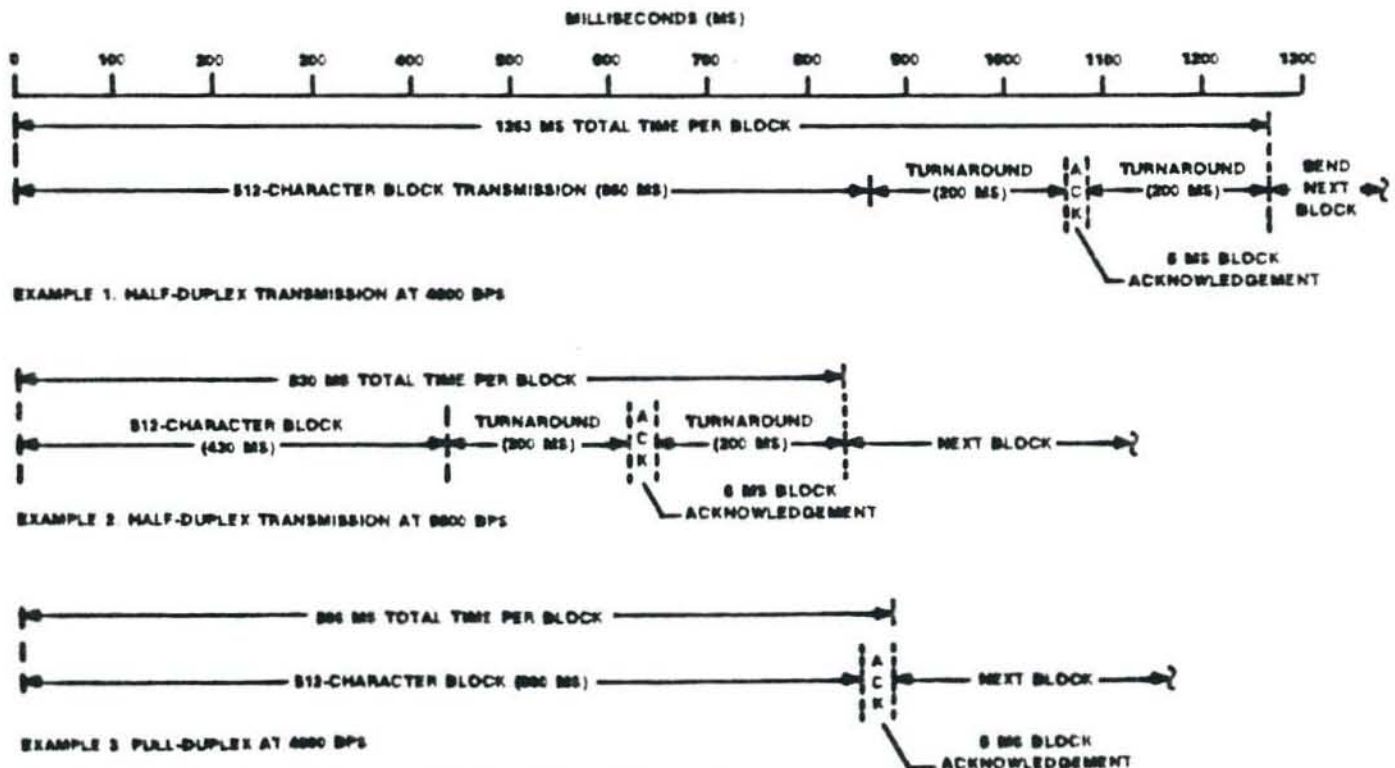


Figure 5 • effects of half-/full-duplex vs speed on transmission time

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The sending of one block of data thus required 1263 milliseconds. If we were to use a 9600-bps line and modem pair, the time would be cut to 833 milliseconds since the data and ACK would require only half the time, but the turnaround time would remain the same. But if we were to use a full-duplex modem and line pair we would eliminate the turnaround, since both stations can send at any time, no change in direction or training is required. This would allow us to send the block in 863 milliseconds, only 30 milliseconds more time than doubling the line speed. The difference is even more dramatic with shorter data messages, since the turnaround delay remains fixed while the transmission time for a data block becomes smaller. Thus, users of leased lines and half-duplex protocols should compare the costs of fast modems and half-duplex operation against slower modems and full-duplex operation. On multidrop lines, no single slave station can maintain full-duplex operation without taking the line from other slaves, but a four-wire circuit can still be used to advantage by having the master send continuously on one pair and the slaves send half-duplex on the other. This mode is called **running with constant carrier outbound** and eliminates half the turnaround training delays by allowing the master station to send without training or turnaround delay.

Fast Poll Modems & Clear-to-Send Delay • If half-duplex operation is required, it may still be possible to reduce the turnaround delay on a line through the use of fast poll modems. The name for these modems is derived from the fact that one of their prime uses is in a polling environment where a master station continuously polls a multidrop line with many slave stations attached. The time required to poll the entire line may be excessive if the modem turnaround delay is long, so the "fast poll" modem is designed to reduce training time to a fraction of the normal value (usually to less than 50 milliseconds). The term **clear-to-send delay** or **CTS** delay is usually associated with training time because the delay results from the fact that the modem, having received a request-to-send indication from the terminal or computer, waits until the training is complete before returning a "clear-to-send" or authorization to proceed with the message. This delay is often controlled by a timer in the modem rather than by actually detecting the successful training completion and may be adjustable to one of several values to accommodate changes in line conditions. Users with half-duplex operations, and protocols that require changing transmission direction often (bisync, for example), would normally run at the shortest delay possible and select modems with minimum delay characteristics.

Compatibility • Modems are used in pairs, and both modems in the pair must signal and modulate in precisely the same way or no communication is possible. When purchasing modems for new circuits it is usually best to buy a pair from the same manufacturer, assuring that the units and options are compatible. When replacing a modem or adding one or more modems to a multidrop circuit, or when adding new dial-up equipment, it may be desirable to use modems of a different make and model. This requires a standard to which all units in question are referenced as compatible, and two such standards exist: AT&T and the Consultative Committee for International Telegraphy and Telephony (CCITT).

AT&T modems are available for all speeds from 300 bps or less to 9600 bps. Each modem is designed for a particular combination of speed, line characteristics, and synchronization:

• **AT&T 103/113 modem** is a full-duplex dial-up modem operating at up to 300 bps in asynchronous mode. The 103 may either originate or answer the call. 103-compatible modems are available for direct connect, connection via DAA, or acoustic coupler connection. The 113, a variant on the 103, is identical in modulation and characteristics but is available either as an originate-only (113A/D) or an answer-only (113C) modem.

• **AT&T 202 modem** is a half-duplex, asynchronous modem operating up to 1200 bps on dial-up lines and to 1800 bps on leased, C2 or better conditioned lines. Because the 202 is half-duplex, it requires that the user devices be able to signal their intention to transmit via the RS-232C Request-To-Send (RTS) interface lead. Many terminal devices cannot generate this signal, so care in applying the 202 is indicated. The 202 is available for dial-up and in a single package as the 202C, or dial-up and

grouped in up to 8 channels in a single package as the 202S. Leased-line versions in single-channel packaging are Model 202D/R, and packaged in up to 8 channels per group as Model 202T.

• **AT&T 212 modem** is the solution for users who need more than 300 bps but must operate full-duplex or use terminals that cannot generate a Request-To-Send signal. It operates with either synchronous or asynchronous equipment at 1200 bps, and in 103-compatible mode at up to 300 bps. This dual-speed, dual-mode operation makes the 212 very useful for dialing into timesharing computers or for other applications where many users with different modem speeds may contend for the same set of dial-in ports.

• **AT&T 201 modem** operates at 2400 bps. This is a half-duplex, synchronous modem that can be used on either dial-up or leased lines. The dial-up models are the 201A (which operates only to 2000 bps) and the 201C. The 201B is a leased line version. The 201A is considered obsolete, and most new applications reject the 201 series in favor of newer and higher-speed modems that operate over the same types of lines and at comparable costs.

• **AT&T 208 modem** operates half-duplex at 4800 bps, synchronous only, over dial-up or leased lines. No line conditioning is required. The 208A is the leased-line version; the 208B is a dial-up line version. Point-to-point or multipoint lines are supported with the 208A, and the training time of the modem is selectable at 50 or 150 milliseconds.

• **AT&T 209 modem** operates synchronously full-duplex over leased, D1 conditioned lines at 9600 bps or as a multiplexer/bandsplitter that can allocate 2400-bps segments to four or fewer channels.

CCITT Compatibility • specifies modem compatibility with a specific recommended standard of the Consultative Committee on International Telegraphy and Telephony, Geneva, Switzerland. The CCITT organization is a world leader in establishing recommended standards for telegraph and telephone communication and data transmission. CCITT recommendations define modem operating parameters from less than 300 bps to 9600 bps, but the recommendations below 2400 bps are rarely used in the United States. The following CCITT recommendations define modems ranging in speed from 2400 bps to 9600 bps.

CCITT V.22 bis • defines 2400-/1200-bps modem standard for full-duplex, switched network operation or over a 2-wire leased line using a frequency division technique.

CCITT V.26 • defines 2400-bps modem standard for full-duplex operation over a 4-wire point-to-point or multipoint leased line; identical to AT&T 201 modem except that only 4-wire leased line operation is specified.

CCITT V.26 bis • defines 2400-/1200-bps half-duplex modem standard for switched network operation.

CCITT V.26 ter • defines 4800-/2400-bps full-duplex standard for switched network using an echo-cancellation technique.

CCITT V.27 • defines 4800-bps modem standard with manual equalizer for half- or full-duplex operation over a 4-wire leased line; similar to AT&T 208 modem specification.

CCITT V.27 bis • defines 4800-bps modem standard with automatic adaptive equalizer for half- or full-duplex operation over a 4-wire leased line or half-duplex operation over a 2-wire leased line.

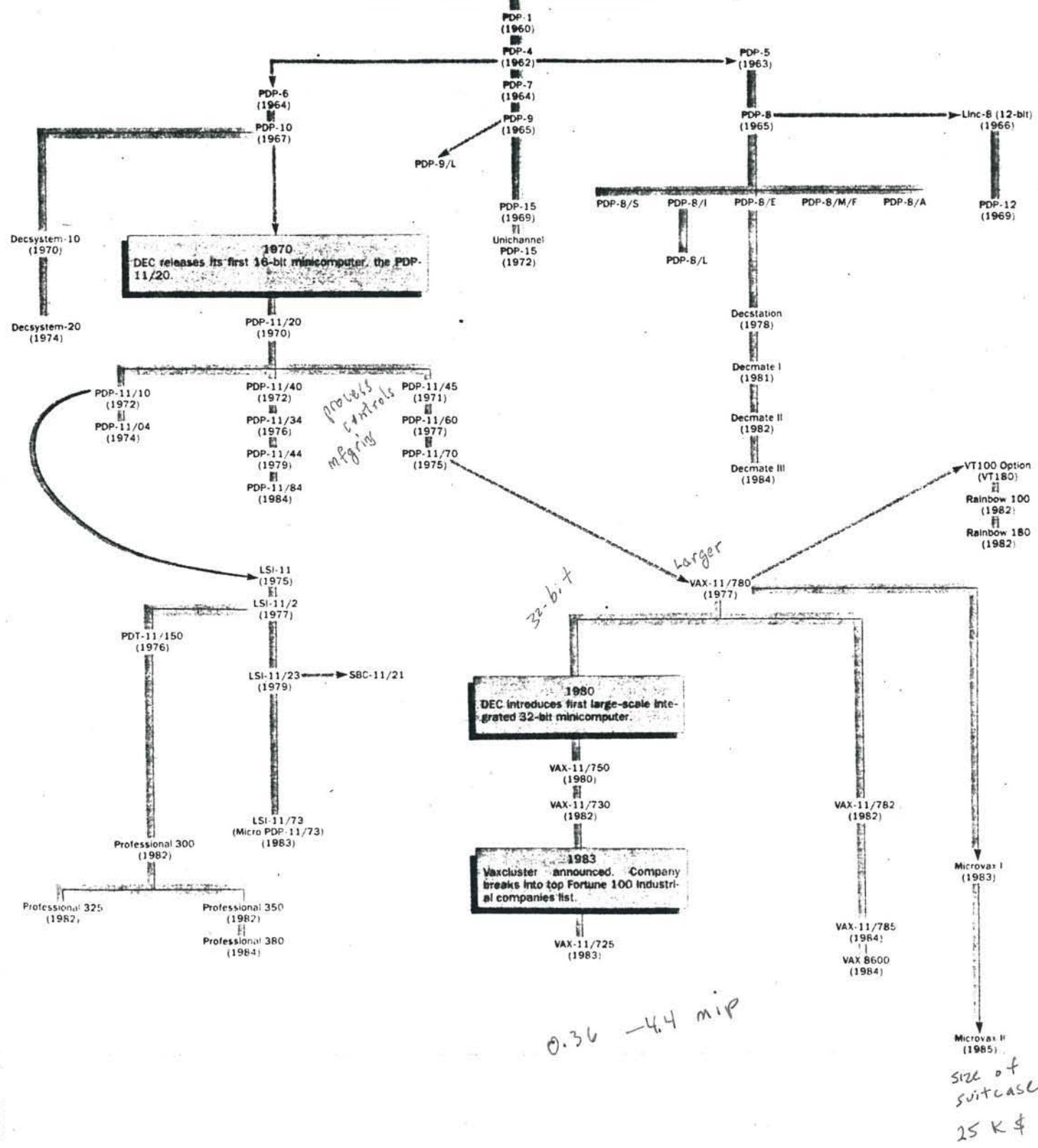
CCITT V.27 ter • defines 4800-/2400-bps modem standard with automatic adaptive equalizer for switched network half-duplex operation.

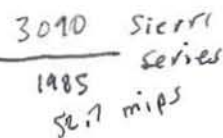
CCITT V.29 • defines 9600-bps modem standard with automatic adaptive equalizer for half- or full-duplex operation over a 4-wire leased line; defines point-to-point operation; although half-duplex operation is possible with V.29, the long training delay specified (250 milliseconds) makes half-duplex operation undesirable.

CCITT V.32 • defines 9600-bps full-duplex standard for switched network using full echo cancellation.

dec 2nd largest

1957 scientific & engineering environment





1. F ASCII is a five-level code.
2. F The bit positioning numbering system is identical between EBCDIC and ASCII.
3. T An eight-level code has 128 different combinations. ^{2^{5b} 2⁸}
4. T Open-wire pairs, wire cables, and coaxial cables are the same type of transmission media.
5. F Optical fibers are the primary circuit in cellular radio.
6. T The usable bandwidth of a voice grade circuit is 3,000 Hertz.
7. F DPSK and PSK are identical modulation techniques.
8. T Pulse code modulation can be used to convert an analog voice signal to a digital stream of pulses for digital transmission.
9. F Bits and baud are always identical.
10. T Polling and selecting perform precisely identical tasks, which is to see if the terminal has a message ready to transmit to the central site.
11. F Echo suppressors are not required in a dial-up data communication connection.

Fill-in

1. Multiplexing done by the telephone company for voice calls is pure multiplexing (not statistical), and it is totally transparent to the caller. In other words, there is no delay of your voice.
2. A mathematical model describes the entities of a system and their attributes are represented by mathematical variables.
3. Simulation is a technique to duplicate the behavior of the communication system or network.
4. Response time is viewed as an elapsed time incurred. It usually is viewed as the time between when the terminal operator types the send key and the return on the first character to the terminal.
5. When measuring throughput you might use a TRIB. For what does TRIB stand? Transmission Rate of Information Dits
6. Full call polling is when the front end communication processor consecutively works through a list of terminals, first polling terminal one, then terminal two, then terminal three, and so on until all are polled.
7. Bipolar is a digital signal.
8. Sine wave is a form of analog signal. Amplitude Modulation
9. A voice grade twisted pair is the most common communication circuit in use today.
10. 1 MHz (Megahertz) = 1 million cycles per second.

DATA COMMUNICATIONS and NETWORKS

COURSE NUMBER : X414

INSTRUCTOR: Rich Hamer

Home (415) 794-7123

Work (408) 554-0770

COURSE OUTLINE

- 2/5 SESSION 1: CHAPTERS 1 AND 2
- 2/12 SESSION 2: CHAPTERS 1 AND 2
- 2/19 SESSION 3: CHAPTER 3; AT&T vs. PAC BELL
- 3/5 SESSION 4: CHAPTER 4; STATE of CALIFORNIA NETWORKS
- 3/12 SESSION 5: CHAPTER 5; SATELLITES, DECNET
- 3/19 SESSION 6: PBX'S, PERFORMANCE CONSIDERATIONS → pages 1-166
- 3/26 SESSION 7: MID-TERM, "NETWORK PROBLEMS" HANDOUT
- 4/2 SESSION 8: LAN'S, IEEE-802, ISO/OSI Pages 169-198
- 4/9 SESSION 9: LAN'S
- 4/16 SESSION 10: X.25 NETWORKS and STANDARDS Pages 152/153
- 4/23 SESSION 11: IBM SYSTEM NETWORK ARCHITECTURE (SNA) pages 191-196
- 4/30 SESSION 12: SNA
- 5/7 SESSION 13: CLASS PROBLEM DISCUSSION and NETWORK RISK ANALYSIS
- 5/14 SESSION 14: FINAL EXAM

CLASS TEXT: BUSINESS DATA COMMUNICATIONS
BASIC CONCEPTS, SECURITY, AND DESIGN
by: Jerry Fitzgerald

INTERCITY CABLE SYSTEMS

Type	Normal Range (Miles)	Transmission Medium	No. of VF Channels	Nominal Repeater Spacing (Mi.)	Line Frequency	Type of Modulation	Type of Multiplexing
43A1	4,000	2-W or 4-W Facility	17 "75 baud" or 6 "150 baud" telegraph chans. (1)	—	390Hz-3180Hz	FSK	FDM
43B1	4,000	2-W or 4-W Facility	17 "75 baud" or 8 "150 baud" telegraph chans. (1)	—	390Hz-3180Hz	FSK	FDM
L1*	4,000	1 Coaxial Pr.	600	8	60-2788	SSB-SC	FDM
L3*	4,000	1 Coaxial Pr.	1,800	4	564-8284	SSB-SC	FDM
L4*	4,000	1 Coaxial Pr.	3,600	2	564-17,548	SSB-SC	FDM
L5*	4,000	1 Coaxial Pr.	10,800	1	3,124-60,556	SSB-SC	FDM
L5E*	4,000	1 Coaxial Pr.	13,200	1	3,252-64,844	SSB-SC	FDM
T1	50	2 Cable Pr.	24	1	1.5 Mb/s	PCM	TDM
T1C	50	2 Cable Pr.	48	1	3,152 Mb/s	PCM	TDM
T2	500	2 Cable Pr. (2)	96	1 (3)	6,312 Mb/s	PCM	TDM
P140	4,000	1 Coaxial Pr.	2,016	2	104,448 Mb/s	PCM	TDM
T4M	500	1 Coaxial Pr.	4,032	5700 Ft.	274,176 Mb/s	PCM	TDM
FT3	250	1 Fiber Cable Pair	672	4	44,736 Mb/s	PCM	TDM
FT3C(4)	4,000	1 Fiber Cable Pair	1344	4 (7)	90,524 Mb/s	PCM	TDM
FT4E-144 (5)	4,000	1 Fiber Cable Pair	2016	8-12 Mi.	140 Mb/s	PCM	TDM
FT4E-432 (6)	4,000	1 Fiber Cable Pair	6048	8-12 Mi.	432 Mb/s	PCM	TDM

FSK Frequency Shift Keying
SSB Single Sideband
SC Suppressed Carrier
PCM Pulse Code Modulation
FDM Frequency Division Multiplexing
TDM Time Division Multiplexing
 * No Longer Manufactured

- (1) One-Half this capacity if 2-W facilities used
- (2) Separate sheaths/direction required
- (3) 2.5 miles on LOCAP cable
- (4) First system service date 1-1-83
- (5) Initial availability is 1Q85
- (6) First system service date is 1-1-86
- (7) Multi mode fiber. Single mode fiber available in 1985 will allow repeater spacing up to 27 miles

BUSINESS DATA COMMUNICATIONS NEWSLETTER

Basic Concepts, Security, and Design

Jerry FitzGerald

Volume 1, Number 2

In this, our second newsletter of a series specifically designed to accompany the textbook BUSINESS DATA COMMUNICATIONS: Basic Concepts, Security and Design, we will present pertinent news items and new lecture ideas for you to use in the classroom. Whenever possible, these lecture ideas will be keyed to specific figures or page numbers in the textbook. If you did not see the first newsletter, it presented a short synopsis of some of the unique features of this textbook plus new lecture ideas. The standard format will be to capitalize the first few words of each new lecture idea/news item; therefore, you will be able to easily pick those items that would enhance your lecture presentations.

AT&T PLANS HIGH-SPEED DATA ON VOICE CIRCUIT: AT&T will be implementing its Circuit Switched Digital Capability (CSDC) in more than twelve cities by the end of 1984. This capability will allow computers to communicate at high speeds over the same circuits used for telephone calls. This capability is part of the integrated networks, often referred to as Integrated Services Digital Networks (ISDN), by the newly deregulated AT&T. Developed by Bell Laboratories, CSDC will allow users to alternate between analog voice calls and digital data transmissions with the touch of a button. Speeds of 56,000 bits per second will be achieved for data. Because of the 56,000 bit per second digital transmission speed, a user will be able to utilize these circuits for teleconferencing, encrypted voice, and high speed facsimile transmissions at four seconds per page of data. To use the network, customers will dial into the service with a five digit code and then dial the site where the transmission is to be sent. Once a call is established, the connection can be alternated between voice and data transmission. CSDC will allow simultaneous, two-way traffic by alternating the signals going in each direction and sending them at high speeds. To accomplish this, a time compression multiplexer is used to send and receive alternative bursts of data. Multiplexers are installed at both the telephone office and the customer's premises. Rather than send signals in both directions at 56,000 bits per second, the multiplexers send signals at double that rate, but alternate at sending and receiving more than 700 times per second. Actually, this is a very high speed half duplex transmission that appears to the user as if it is full duplex transmission.

DEREGULATION AND THE TELEPHONE COMPANIES: During your discussion on the deregulation of communications, you might utilize the section, COMMUNICATIONS SERVICES OFFERED on page 271 of the textbook. The visual aid SEVEN REGIONAL HOLDING COMPANIES can be used to make a transparency. This transparency will serve as a bridge between Figure 9-2 (page 271 of textbook) and the deregulated changes. Notice how easily you can compare the previous structure (Figure 9-2) to the current structure of seven regional holding companies. As you already know, the seven holding companies represent the previous individual telephone companies that offered us local service. On page 271 of the textbook, it is stated that the regulated "half" is comprised of AT&T Information Systems (computer-based communication

Seven Regional Holding Companies



BELL ATLANTIC
 Bell of Pennsylvania
 Diamond State Telephone
 Four Chesapeake &
 Potomac Companies
 New Jersey Bell

AMERITECH
 Illinois Bell
 Indiana Bell
 Michigan Bell
 Ohio Bell
 Wisconsin Telephone

US WEST
 Mountain Bell
 Northwestern Bell
 Pacific Northwest Bell

BELLSOUTH
 Southern Bell
 South Central Bell

PACIFIC TELESIS
 Nevada Bell
 Pacific Telephone

SOUTHWESTERN BELL

NYNEX
 New York Telephone
 New England Telephone

products), AT&T Communications (formerly Long Lines), and Bell Laboratories. Now that divestiture is complete, AT&T has announced that Bell Laboratories and the manufacturing subsidiary, Western Electric Company, have been combined into an organization which will be known as AT&T Technologies. In addition, one other organization has been created. There is now an AT&T International which markets communication products outside of the United States. This means that the new AT&T, after divestiture, includes AT&T Communications, AT&T Information Systems, AT&T Technologies, and AT&T International.

ANOTHER SATELLITE SYSTEM: Hughes Aircraft Company is proposing to build a satellite communication system that will enable users to communicate at 1.5 million bits per second through low cost, small diameter dish antennas. This possibly could be the beginning of roof-top antennas for satellite transmission between private homes. Hughes Aircraft wants permission to launch two satellites that would operate in the 20-30 GHz band. This frequency is a great deal higher than all previously announced commercial satellites that operate in either the 4-6 GHz or the 12-14 GHz bands. Each of the new Hughes galaxy satellites would provide a total of 3,072 one-way 1.5 million bit per second T-1 channels through 32 transponders. The system is intended to support private and shared use voice, as well as video and data networks. May I suggest that you mention the new Hughes satellite system either when you discuss Figure 1-5 (page 15), or when you discuss satellites on pages 68-69 of the textbook.

UNIVERSITY CAMPUS NETWORK: San Diego State University is one of the first campuses to link the entire campus through a local area network. If you are considering this at your university, you might contact Mr. Robert Swanson who is the Manager of Technical Support at San Diego State University in San Diego, California. The university chose a broadband-based local area network developed by Sytek, Inc. Today the network has been expanded to over 300 ports for terminals and 11 major computer systems. Computer simulation predicts that over 32,000 terminals/computers could be connected to this local area network. The university plans to add off-campus areas such as off-site student dormitories and/or research centers that may be located off campus.

LOCAL AREA NETWORKS AND MICROCOMPUTERS: Digital Research, Inc. has announced a software package that can link microcomputers running its CP/M operating system to local area networks. Digital Research claims the package enables users to tie together diverse personal computer workstations using local area networks such as Xerox Corporation's Ethernet, Data Point Corporation's Arcnet, and Corvus Systems' Omninet. The software package will interconnect micros running any version of CP/M, CP/M 86, and concurrent CP/M operating systems. Users are able to share their files, transfer information, utilize password protection, and perform other tasks while running an application. The name of this package is DR SOFT/NET. The price of this package will be in the area of \$1,000. You might introduce this material when you discuss the section on MICROPROCESSORS on page 51 of the textbook.

MODEMS: The NEC America Company has a high speed modem that operates at 14,400 bits per second. It is a solid state modem that has various data rate combinations available through a six-port multiplexer. It also has a full complement of diagnostic features that include local and remote addressable loopback, bit error rate tests, polling tests, a built-in test pattern generator, and front panel error display. The cost of this modem is \$7,800.

SECURITY PACKAGE AVAILABLE FOR IBM'S CICS: TK Data Solutions has announced a software package designed as a security, performance, and menu system for CICS. The package was designed to accommodate a unique password and identification for each terminal operator and allows access only to the specific functions assigned to that operator. It can assign highly sensitive functions to a specific terminal or a group of terminals. It also offers encrypted security data, security sign-on fields, darkened password fields, and a complete log of terminal sign-ons including any security violations. Packages such as this, that are tied into teleprocessing monitors like CICS, cost between \$3,000 and \$5,000. Another similar package offered by Teltech is called COPS (CICS On-line Protection System). This system offers a computer-assigned password and the vendor claims this makes the password steal-proof where no one but the original user has access to it. It also offers additional features such as file security to the record/field level, terminal security, transaction security, batch reports on all activity, automatic sign-off of unattended terminals, immediate on-line notification of security violations, etc. As you can see, there are now specific software security packages that tie into teleprocessing monitors. Teleprocessing monitors are discussed on pages 170, 184 and 465 of the textbook.

TRANSBORDER DATA FLOW: The subject of transborder data flow is on pages 14-15 and 183 of the textbook. If you would like to augment these discussions with a few further comments of your own, you might add some of the following ideas. West Germany requires significant local processing of all data transmitted over communication circuits (private or public telephone facilities). In Canada, a 1980 Banking Act prevents the processing of bank transactions outside of Canadian boundaries unless some processing also is done within the country. Transmitting financial data outside of the country or subsequent manipulation of that data requires government approval. Brazil requires corporations to maintain copies of

most computer databases inside Brazil rather than connecting with existing databases outside the country. Most offshore processing of Brazilian data is prohibited. Whenever possible, companies must purchase Brazilian computer equipment and software rather than import it into the country. If you have further interest in transborder data flow, you might get a copy of the following article: Sardinas, Joseph and Susan Sawyer, "Transborder Data Flow Regulation and Multinational Corporations," Telecommunications, vol. 17, no 11, November, 1983, pp. 59+.

UNIX: Now that IBM has announced that it is going to base the operating system of its next generation of microcomputers on the UNIX system developed by Bell Laboratories, you might want to obtain a copy of a good book on UNIX. May I suggest the following book: Thomas, Rebecca and Jean Yates. A User Guide to the Unix System. Berkeley, California: Osborne/McGraw Hill Publishing Company, 1982, 508pp.

OUTSIDE READINGS: Here are some outside reading materials that you might place in the reserve reading room of your library. Each article is referenced to an appropriate section of the textbook.

Obtain a copy of the magazine Data Communications for January, 1984 (vol. 13, no. 1). During your lecture on front end communication processors (see page 22 of the textbook), utilize the article on page 143, "The Complexities of Choosing a Front End Processor." When you discuss IBM's System Network Architecture (see page 191 of the textbook), use the article on page 159, "Gateways: A Vital Link to SNA Network Environments." To augment the section on Canadian communication services (see page 281 of the textbook), use the article on page 179, "Canada Combines Voice, Data, and Images on National Satellite Network."

Obtain a copy of the January 18, 1984 issue of "Computerworld on Communications" (vol. 18, no. 03A). This special issue was published by CW Communications, Inc., Box 880, 375 Cochituate Road, Framingham, Massachusetts 01701. When you discuss cellular radio (see page 71 of the textbook), use the article on page 15, "Cellular Radio Technology." Your discussion on the automated office (see page 155 of the textbook), can be augmented by the article on page 33, "Workstation Wars." The divestiture of AT&T already has been mentioned in this newsletter and it is mentioned on page 271 of the textbook. To augment the divestiture discussion, use the article on page 49, "The New AT&T." Also, the Integrated Services Digital Networks (ISDNs) were mentioned previously in this newsletter. The ISDN discussion can be augmented further by the article on page 53, "Counting Down to ISDN Plug-In."

Obtain a copy of the magazine Data Processing & Communications Security for September/October, 1983 (vol. 8, no. 1). This magazine is published bi-monthly by the Territorial Imperative, Inc., P.O. Box 5323, Madison, Wisconsin 53705, (608) 231-3817. The September/October, 1983 issue was a special issue on access control and it contains numerous articles that would be of benefit when discussing security and control (Chapter 8 of the textbook).

Good luck and best personal regards,

Dr. Jerry FitzGerald
February, 1984
Newsletter No. 2

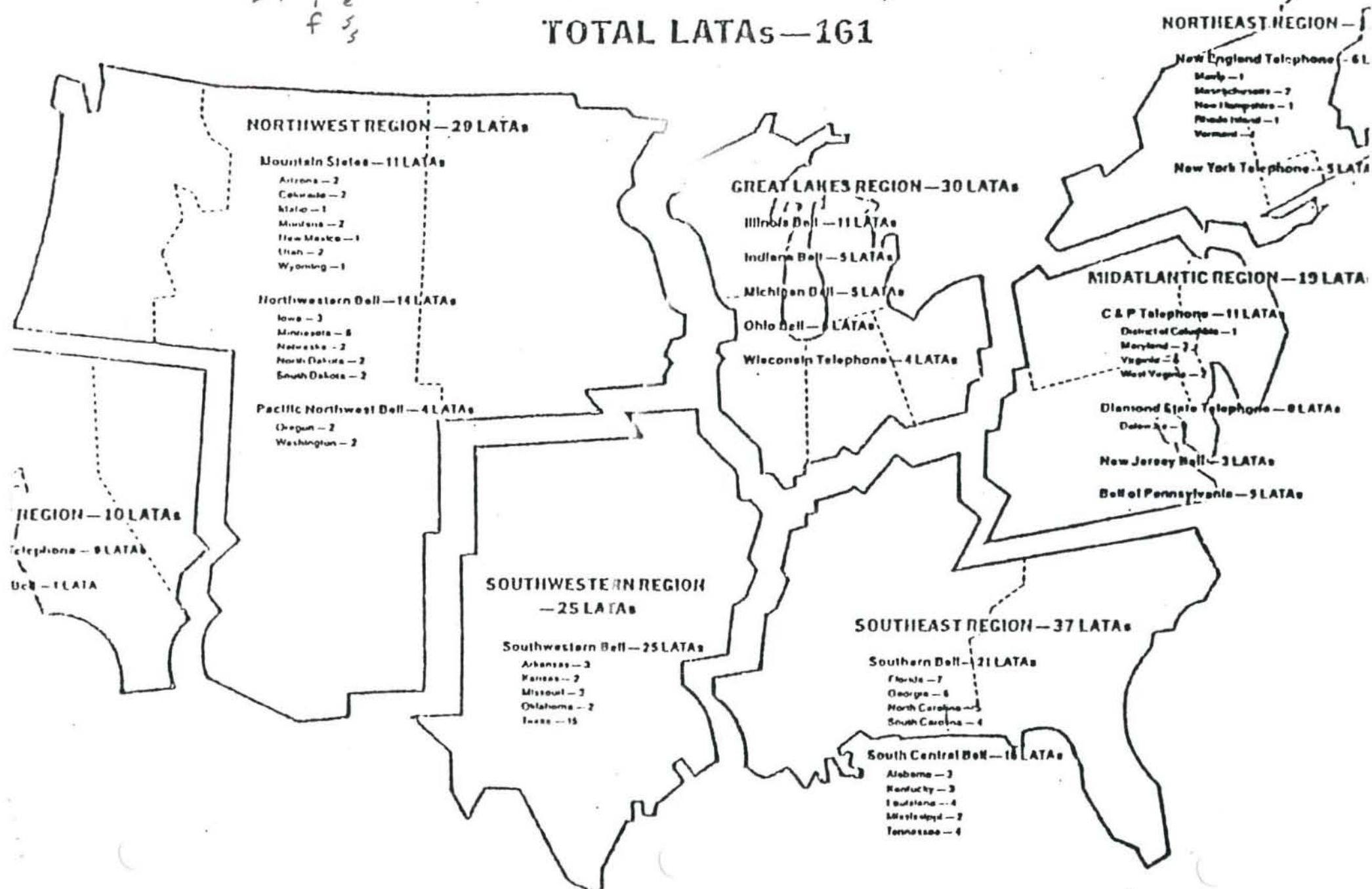


JERRY FITZGERALD & ASSOCIATES
MANAGEMENT CONSULTING
506 Barkentine Lane
Redwood City, California 94065
(415) 591-5676

LATAs BY REGIONAL HOLDING COMPANY, OPERATING COMPANY, STATE

LOCAL
AREA
CCE
ARRIF
S

TOTAL LATAs—161



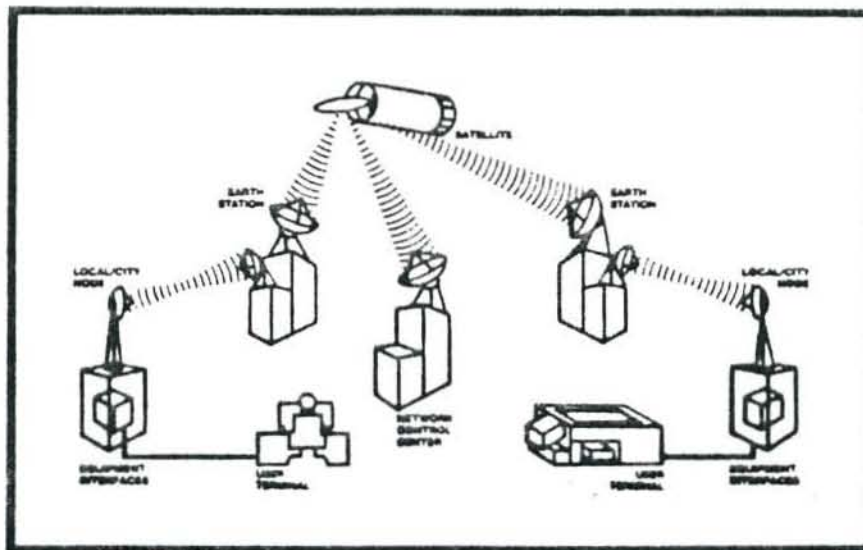
Randy Woolfel

Keep

THE TELEMARKETING COMPANY

highlight components of dpldc

Telemarketing Company is an on-line, real-time data communication-oriented concern. Its basic business purpose is to market products developed by other organizations. To accomplish this, it markets via direct mail advertising, television advertising, videotex, telemarketing (telephone calls) and cable television. Using the latest data communication network technology (typical network shown below), this organization is equipped to handle orders via telephone calls, direct response from a microcomputer, videotex orders, and hard-copy written orders delivered via the postal system.



The initial objective of this case is to identify any controls that already have been implemented in the Telemarketing Company's data communication networks. After the basic in-place controls have been identified, you are to identify and document further controls that might be lacking. The tasks to be performed are:

- Identify the threat areas and component parts of this system.

- Risk rank these threats and components in order to obtain an indication of the sensitivity of each.
- Identify and document the known, in-place, controls for this network.
- Evaluate the known, in-place controls and identify any further controls that may be necessary.

The Telemarketing Company application systems and central host computer are located in New York City. From there a data communication network emanates throughout the world; although, most of its business is done in the United States and Canada. The network has a wide variety of equipment such as video terminals, microcomputers, multiplexers, modems, remote intelligent controllers, and front end communication processors. The system uses telecommunication access software, a teleprocessing monitor, and a X.25 packet switching protocol. There are all types of communication circuits in this network. For example, at various points both analog and digital transmission are utilized over microwave, satellite, and terrestrial-based cables/wires/optical fiber cables.

At the host computer there is a software security package to limit access to various programs/data files, along with partitioned data sets and unique program passwords. The Computer Security Administrator controls these passwords and conducts a continuous review of the overall security at the central system and on the data communication networks. A minicomputer-based badge reader system, fire detection/suppression, stringent sign-in procedures for guests, and a quarterly security newsletter are several of the control features at the central site.

On-line merchandise orders arrive at the Telemarketing Company over both leased private circuits and dial-up circuits.

The dial-up circuits are routed through a minicomputer which verifies such things as the personal identification number (PIN) and other information with regard to orders. For orders in excess of \$200.00 a call-back is required.

All billing and other related processing is performed in the evening and the bills are mailed or sent back to the purchaser via the telecommunication circuits.

During any manual input of data into the system, the dollar effect on accounts receivable is determined manually for all input transactions. The terminal operators enter their work in small batches of 1 - 25 items, as they see fit.

Sales, returns, adjustments, cash receipts, and other entries to the accounts receivable file are entered via on-line terminals. Control totals for dollar amounts are accumulated by terminal and operator password during the day and then compared with manual input totals. Out-of-balance batches are noted on the transaction balance report and subjected to clerical review, correction and reentry. Detail transactions in the out-of-balance batches are not posted to the master file until the batches are corrected and reentered.

The accounts receivable report shows all the postings to the master file. This report is used to provide a transaction trail, to facilitate the answering of inquiries, and to resolve error situations.

There are also reports on over-extension of credit, new accounts, deleted accounts, transactions requiring special authorization, and accounts referred to collection.

At the end of each accounting period, or on request, the master file is analyzed to produce an aged trial balance. This trial balance is compared with the manual control totals and also with the accounts receivable control totals on the last accounts receivable output master file.

For orders placed directly from microcomputers or videotex, it is planned to confirm each order with an immediate billing sent back to whoever placed the order.

Negative files are developed on an as-you-go basis in order to identify credit risks and/or potential system hackers.

The network itself uses data line monitors, breakout boxes, and modem loopback testing for fault diagnosis. The network control staff maintain on-line statistics with regard to errors, other faults, and the character-per-hour usage for each of the circuits.

When the host computer is down, the front end processor intercepts incoming messages, stores them, notifies the senders that the system is not in operation, and then calls them back to confirm the order. This is part of the front end processor system log. Once a week the front end system log is matched against the data base log in order to look for any discrepancies of lost orders.

Within the central facility in New York City, there is a local area network using optical fiber cable. This network interconnects all of the terminals used by the Telemarketing Company in the conduct of its daily business. Terminal operators have individual passwords. Both the operator password and the physical terminal identification are transaction coded with regard to the specific transactions authorized for each employee and department. Any transaction that authorizes either the

shipment of goods or payment of a credit balance must be preceded with an individual user's password.

The main communication circuit between the New York order entry/billing operation and the distribution warehouse (located in Chicago) is encrypted. Also, the polling scheme gives this distribution center a priority for message transmission.

The New York site has a contingency plan arrangement with two other similar organizations that have compatible computer hardware. This arrangement specifies what computer resources Telemarketing Company could expect from the other organizations should any type of disaster occur. Quarterly meetings are held to discuss the numerous changes in hardware/software configurations and/or to the contingency plan arrangement.

While the contingency plan provides backup resources for most of the batch systems, it does not provide backup for the critical on-line transaction systems that require telecommunication links and other data communication oriented facilities.

The electrical power backup for the computer facility includes uninterruptable power supply (UPS) batteries with diesel generators for backup, and it is tested monthly.

There is an EDP disaster plan that spells out: Who will be the decision-making manager in charge of a disaster recovery operation, the availability and training of sufficiently experienced backup personnel, and recovery procedures for the data processing media (including location of, and who to contact for, backup data, files, programs, run manuals, and documentation). The recovery procedures include pre-established priorities as to which data processing media will be reconstructed

first. Finally, there is a small quantity of unique forms stored off the premises for emergency use.

At this organization, both fire and flood are a low probability, because of the type of building construction, early warning flood detection indicators and proper pumps, adequate drainage, and special emergency shutoff valves for overhead water.

As far as fire is concerned, the organization has a HALON 1301 fire suppression system and both ionization smoke detectors and rate-compensated fire detectors. There are also portable fire extinguishers around the room and emergency cutoff switches for both the fire suppression system and all electrical power to the room. Indicator panels show the location of all detectors and switch-status for both the fire and flood devices.

At the New York facility, circuits are brought in from both NYNEX and BELL ATLANTIC. During the system design, it was determined that the primary concerns of the Telemarketing Company were improper distribution of physical goods, abnormalities in the billing/receiving functions, and privacy such as loss of customer files to a competitor.

The following figures are for your use in completing this case.

T H R E A T S	C O M P O N E N T S

SYSTEMS APPROACH TO DESIGN

- **MAKE A FEASIBILITY STUDY**
- **PREPARE A PLAN**
- **UNDERSTAND THE CURRENT SYSTEMS**
- **DESIGN THE DATA COMM NETWORK**
- **IDENTIFY THE GEOGRAPHICAL SCOPE**
- **ANALYZE THE MESSAGES**
- **DETERMINE TRAFFIC/CIRCUIT LOADING**
- **DEVELOP A CONTROL MATRIX**
- **DEVELOP NETWORK CONFIGURATIONS**
- **CONSIDER SOFTWARE**
- **CONSIDER HARDWARE**
- **DO A COST ANALYSIS**
- **SELL AND IMPLEMENT THE NETWORK**

NETWORK DESIGN FUNDAMENTALS

- **THROUGHPUT (TRIB)**
- **RESPONSE TIME**
- **MODELING NETWORKS**
- **SYSTEMS APPROACH TO DESIGN
[13 DESIGN STEPS]**

REVIEW Performance Considerations

Performance

- o Response time and net data throughput

Response Time Factors

- o Terminal population
- o Data throughput
- o Processing time for request
- o Access time to data base
- o Polling methodology

Response Time Components

- o Message input time
- o Application process time
- o Message output time

Net Data Throughput Factors

- o Total bits per character
- o Total characters per transaction
- o Transmission speed
- o Propagation time over network
- o Central site processing time
- o Terminal processing time
- o Transmission factor

Block Length Effects

- o Small message size
- o Excessive overhead
- o Large message size
- o Retransmission excessive

Transfer Rate of Information Bits

- o Estimates efficiency of a proposed protocol

PERFORMANCE CONSIDERATIONS

- Performance
 - Response Time Factors
 - Response Time Components
 - Net Data Throughput Factors
 - Block Length Effects
 - Transfer Rate of Information Bits
-

The basic requirements to establish, maintain and terminate communications without error are similar whether verbal or computer communications are being used.

7. **Application Layer Concerns** - Am I talking to the right person? Who is paying for this call? Is this the best time to talk, or should I call back later? Does the other party have a pencil and paper to take notes?
6. **Presentation Layer Concerns** - Are we talking the same language and dialect?
5. **Session Layer Concerns** - Can this situation be handled in one call or several? Will other people need to be brought in at different times? Who will control the discussion in a multiparty conversation? Who will re-establish the call if we're cut off?
4. **Transport Layer Concerns** - What is the most cost-effective way to handle this call (or these calls) consistent with priorities? What long distance carrier(s) should be used?
3. **Network Layer Concerns** - Dial the number and listen for call-progress signals. Redial if you get a busy signal or if cut off. Disconnect when the conversation is completed.
2. **Link Layer Concerns** - Talk when you're supposed to and listen when you're supposed to. Ask for a repeat if there is something you don't understand. Tell the other party to slow down if he's talking too fast.
1. **Physical Layer Concerns** - These are the actual sounds being uttered into the mouthpiece and heard from the receiver.

Anyone who has used a telephone in everyday business situations can relate to all seven levels of the reference model just described. By reflecting on X.25, the reader should be able to identify the analogies to the packet, link, and physical layer protocols.

WHAT HAVE WE LEARNED?

1. When protocols are layered, the higher level layers are embedded inside fields of less intelligent layers.
2. Packet switching involves fast store-and-forward computers at each network node.
3. X.25 is an international standard packet switching architecture specifying three layers of protocols at the network gateway.
4. When properly used, X.25 networks provide a fast, reliable, accurate, flexible, and cost effective data communications alternative.
5. X.25 specifies two services: Virtual Call service is analogous to a telephone call; Permanent Virtual Circuit service is analogous to a private line.
6. X.25 doesn't provide for dial access or for start-stop transmission, but enhanced services do.
7. A single X.25 interface can handle many logical channels at the same time.
8. X.25 is but a part of a larger group of CCITT standards on public data networks.
9. X.25/X.121 provides for an extremely large worldwide population of terminals.
10. Open Systems Interconnection is a reference architectural model which is revolutionizing the way we view telecommunications.

4-2

5-10-5
5-11-5
5-12-5

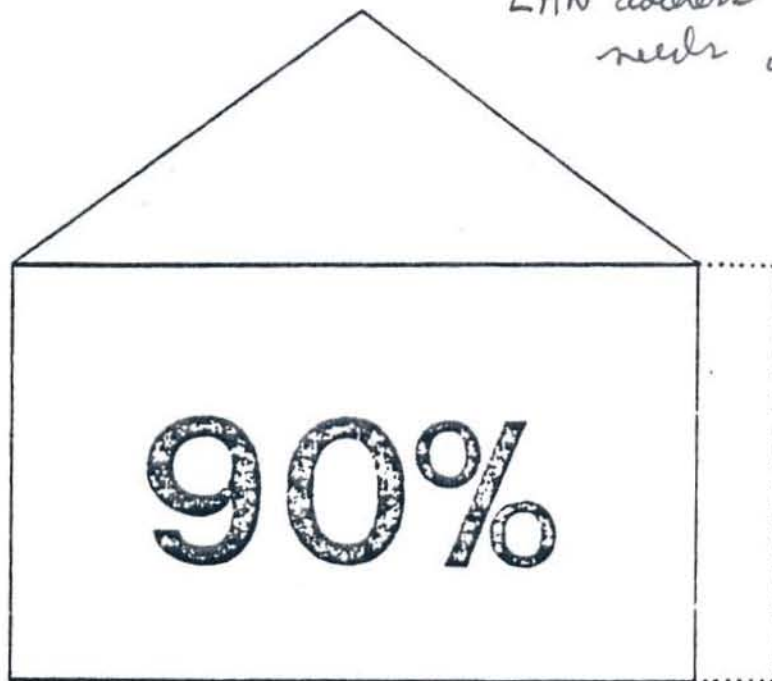
LOCAL AREA NETWORKS

LOCALITY OF COMMUNICATIONS

60% OF COMMUNICATIONS WITHIN A DEPARTMENT

30% WITHIN A BUILDING

10% OUT OF THE BUILDING



*LAN address the 90% common
needs within a small
cluster*

0 Do you need a Local Area Network ?

- CONSIDER THE FOLLOWING REQUIREMENTS:

0 0 LARGE NUMBER OF TERMINAL DEVICES

- COMPUTER TERMINALS
- FACSIMILE MACHINES
- WORD PROCESSING TERMINALS
- PC users

0 0 RESOURCE SHARING NECESSARY

0 0 MULTIPLE, INDEPENDENT DP SYSTEMS

0 0 HIGH BANDWIDTH REQUIREMENTS

- GRAPHICS
- VIDEO
- CAD/CAM
- TAPE TO TAPE

0 0 HIGH RATE OF CHANGE AND GROWTH

0 0 MULTIPLE VENDOR ENVIRONMENT

Base band
Lot's of data transfer
broad band
two types of LAN

INFORMATION DENSITY

KEYBOARD/PRINTER TERMINAL

100 CHARACTERS PER LINE

300 BPS

2.7 SEC

CRT DISPLAY

5000 CHARACTERS PER SCREEN

9.6 KBPS

4 SEC

FACSIMILE

50,000 CHARACTERS PER PAGE

56 KBPS

7 SEC/PAGE

BIT PER PEL HIGH RESOLUTION GRAPHICS

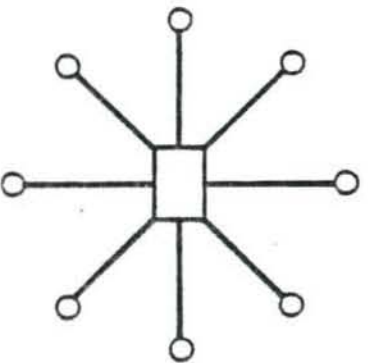
500,000 CHARACTERS PER DISPLAY

1 MBPS

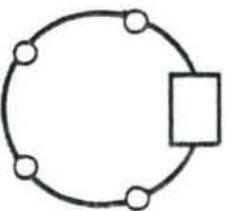
4 SEC

Topologies *(configurations)*

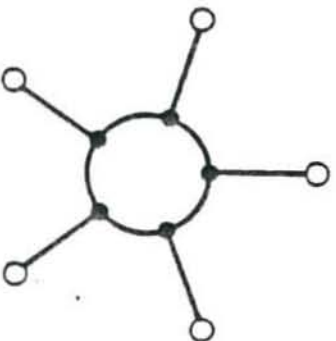
• STAR



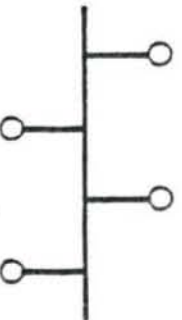
• LOOP



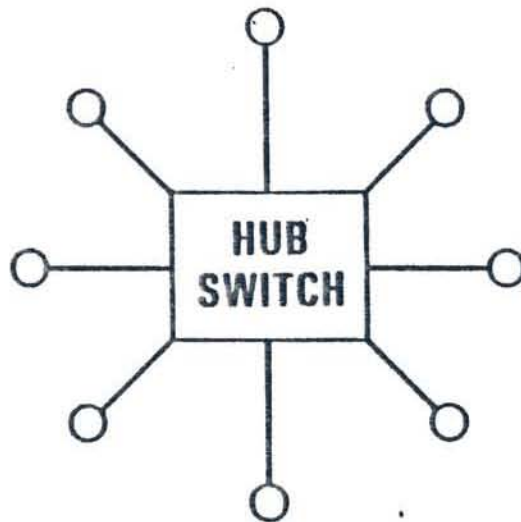
• RING



• BUS



Star Topology

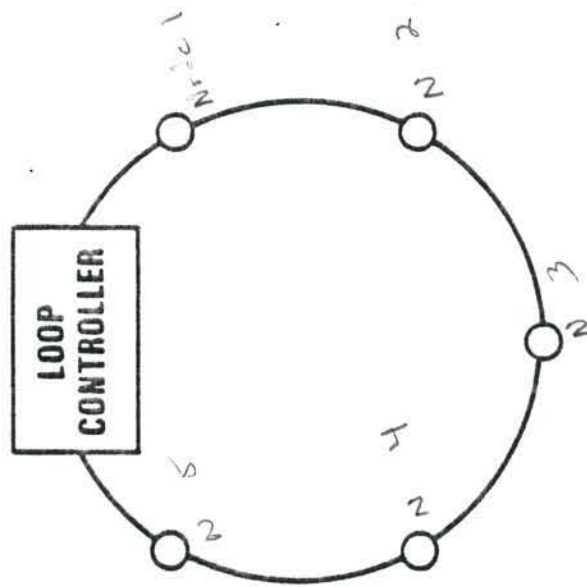


- Point to point via circuit switch or computer memory
- Hub switch can be host computer, office controller, or PBX
- Maximum number of nodes limited only by hub switch capacity

- if switch breaks, entire system dead.

S L R B
1 2 1 1
2 P 2 5

Loop Topology

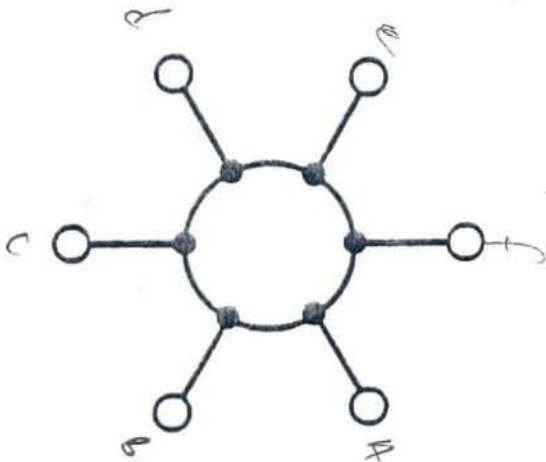


- All messages routed through loop controller
- IBM 8100, for example
- Fixed limit on maximum number of nodes, usually less than 32

- loop controller fails, entire system dies

Ring Topology

Popular
(Arcnet, Paurnc, VAX)



- Packet transmission around ring
- "Cambridge Ring", early example
- Generally 10 – 100 nodes

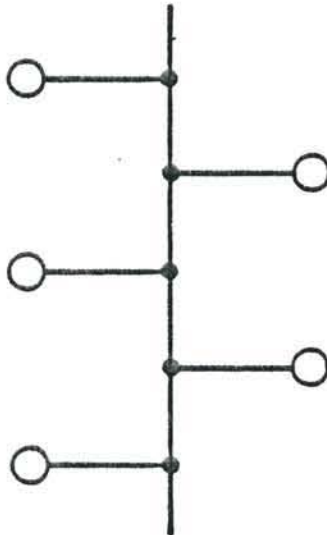
- each node has a mailbox

A sends to d

• B gets msg, examines, not for him so he sends on to c etc

Baseband Bus Topology

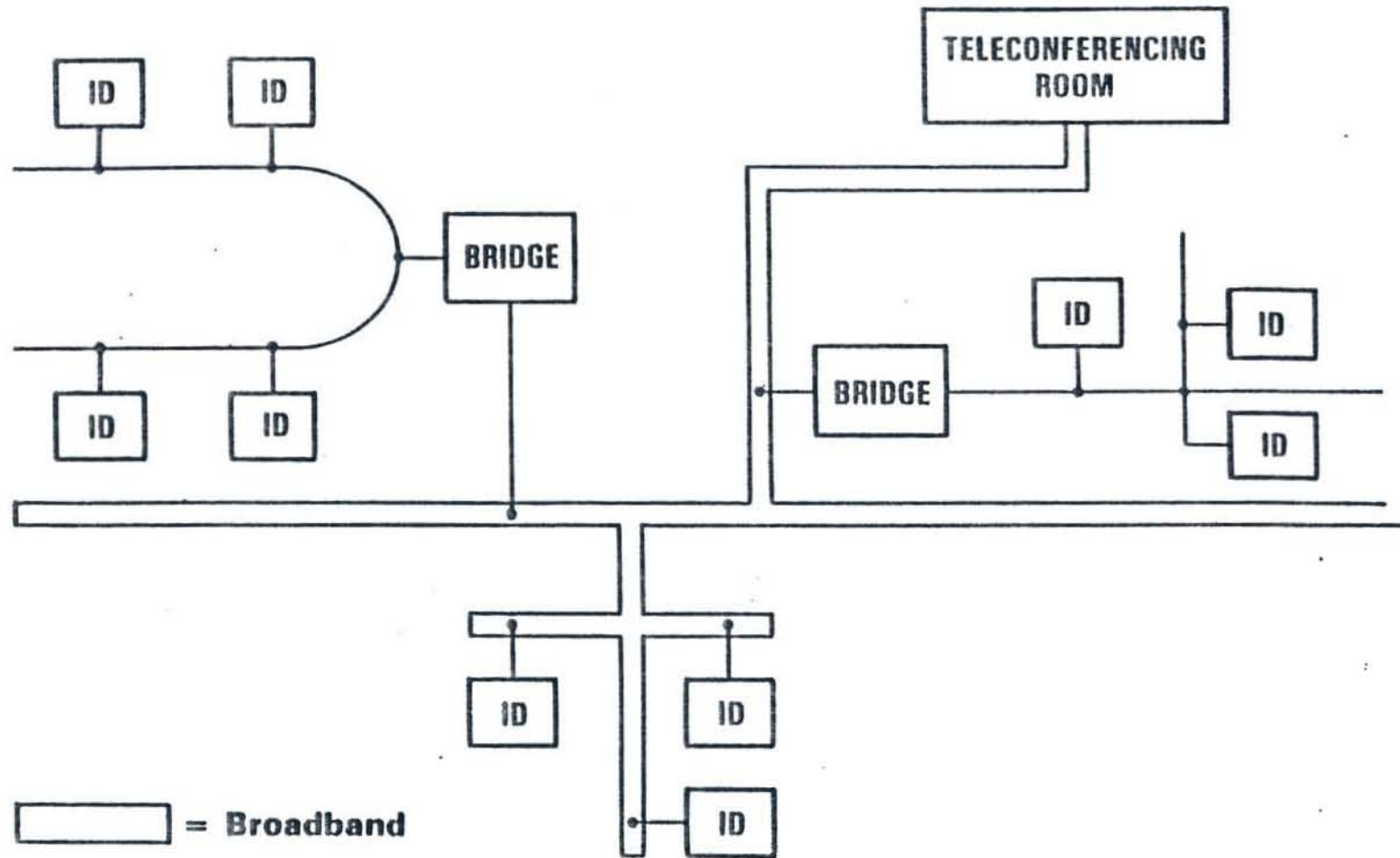
most common



- Broadcast
- ^{VAX} Ethernet, net/one ^{Ungerman}
- Can support several hundred nodes

Hybrid System

Bridged



[Thick Line] = Broadband

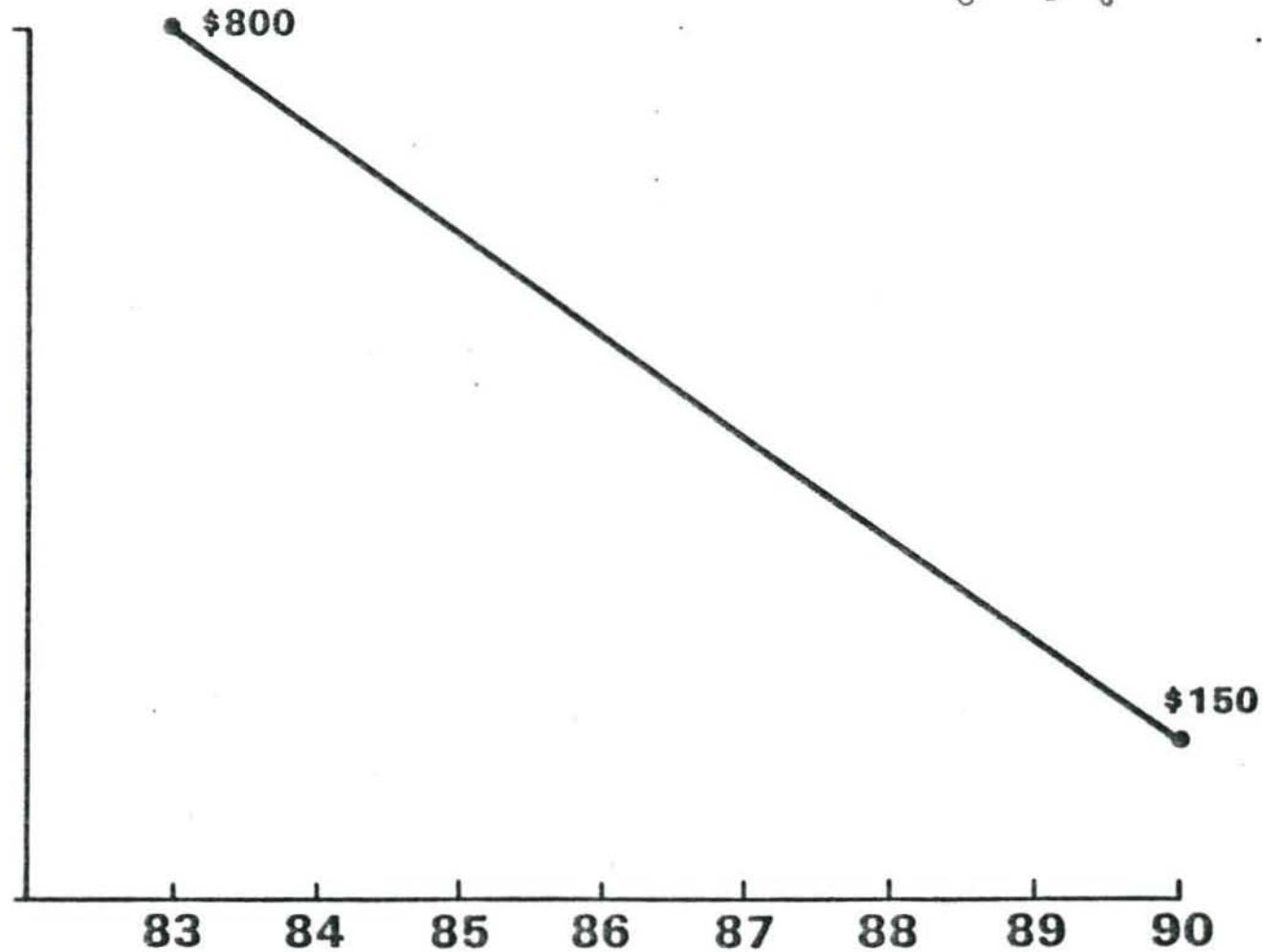
[Thin Line] = Baseband

[ID Box] = Interface Device

[Dot] = Physical Tap

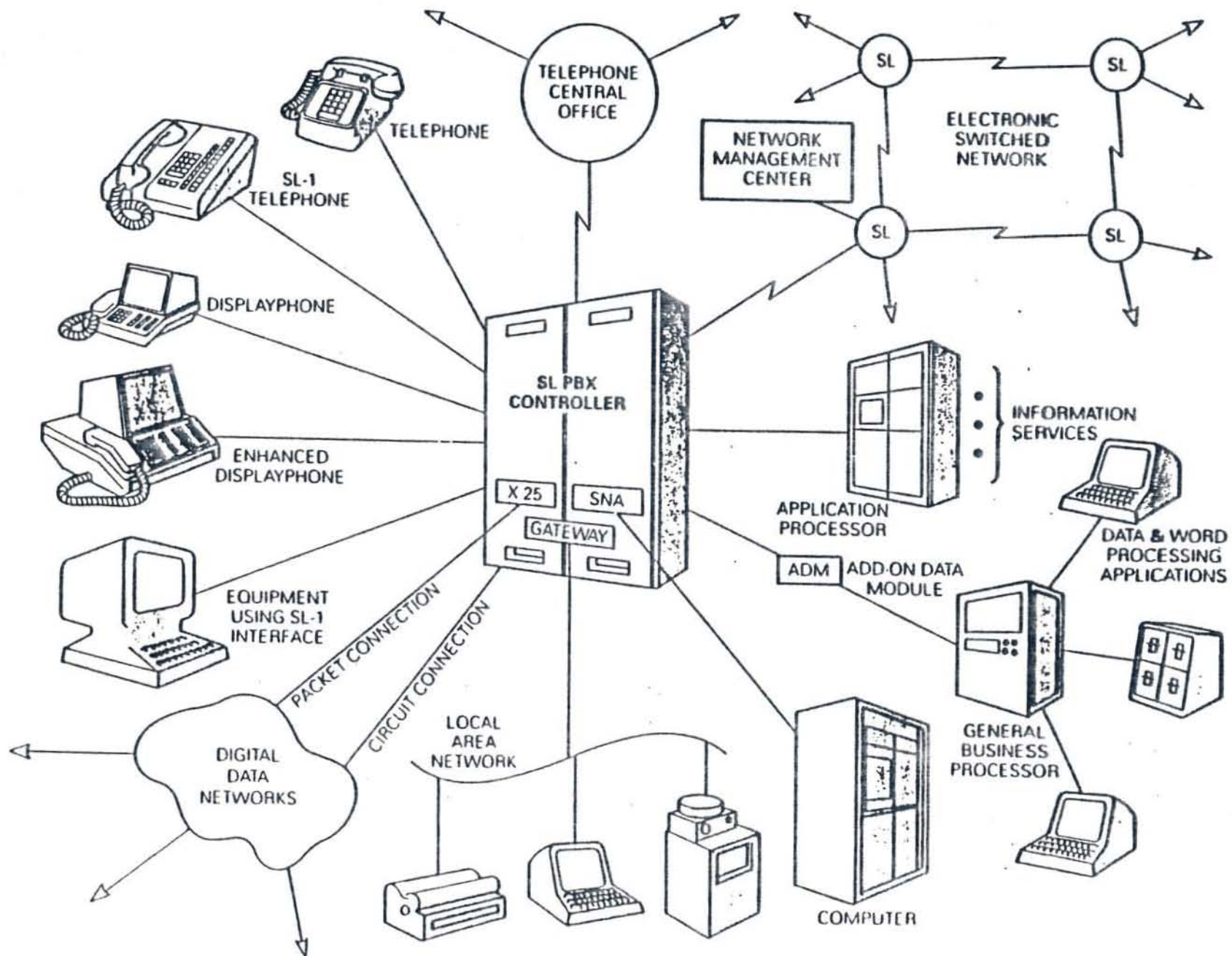
Local Area Network Work Station Port Attachment Cost

*Connection
Cost
only*

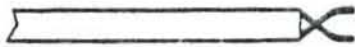


NORTHERN TELECOM'S

"OPEN WORLD"



EXAMPLES OF WIRE TYPES



TWISTED PAIR



COAXIAL CABLE

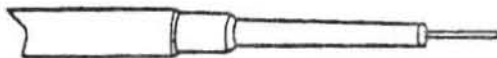
*Ethernet specifies
50 Ω
some have 75 Ω*



TWINAXIAL CABLE



SHIELDED MULTIPLE
TWISTED PAIRS

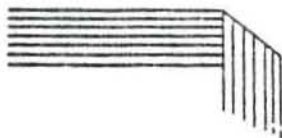


FIBER OPTIC
LINK

*point to point
6 μ m fiber (thin)*



MIXED
MEDIA



FLAT CARPET
CABLE (FCC)

BUILDING CODES AND STANDARDS

*considerations
for installing
cable*

- o UNIFORM BUILDING CODE - PRODUCED BY THE INTERNATIONAL CONFERENCE OF BUILDING OFFICIALS (ICBO); 5360 SOUTH WORKMAN MILL ROAD; WHITTIER, CALIFORNIA 90601

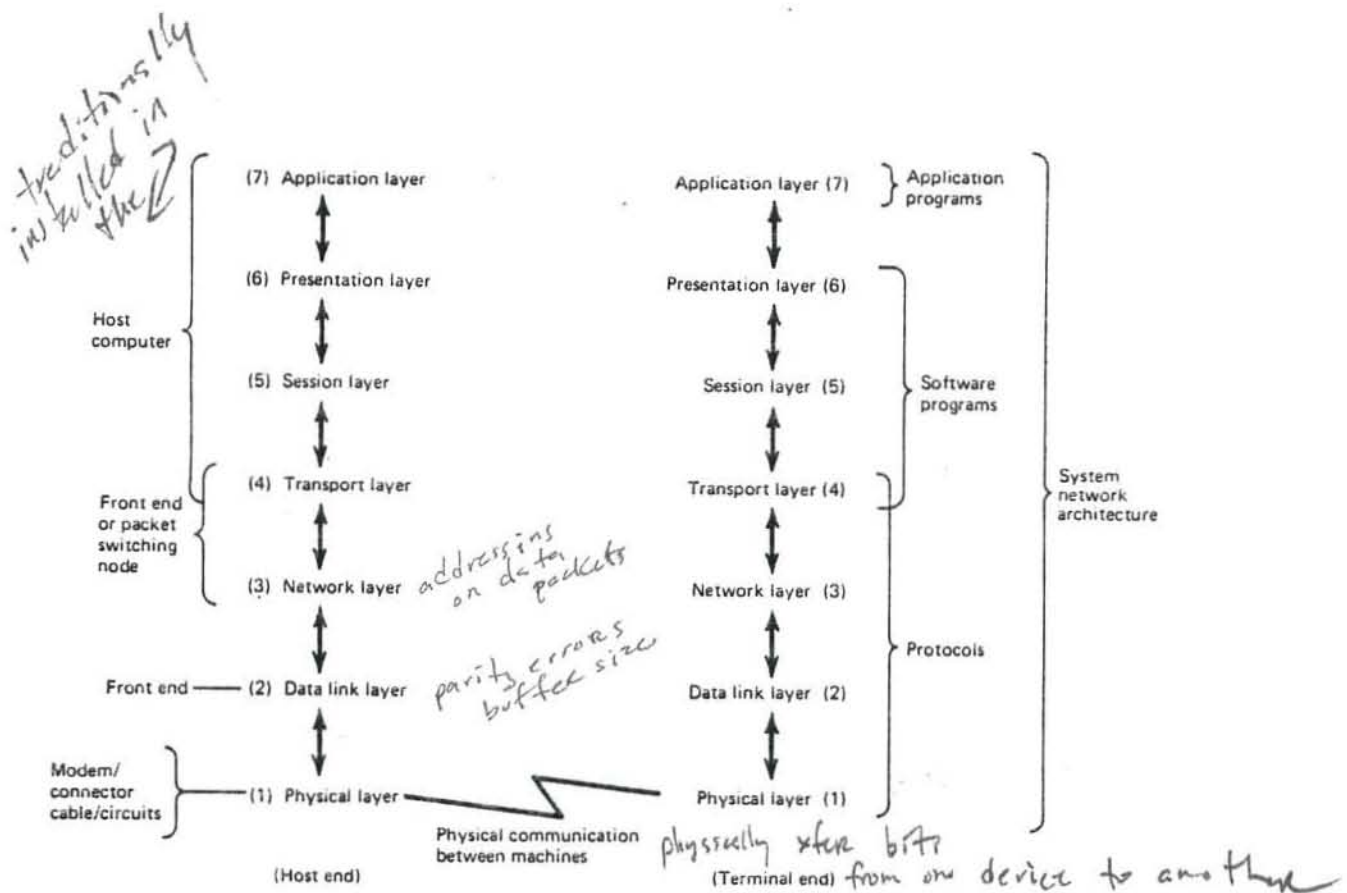
- o THE BOCA BASIC BUILDING CODE - PRODUCED BY THE BUILDING OFFICIALS AND CODE ADMINISTRATORS (BOCA) INTERNATIONAL, INC.; 17925 SOUTH HALSTED STREET; HOMewood, ILLINOIS 60430

- o STANDARD BUILDING CODE (SBC) - PRODUCED BY THE SOUTHERN BUILDING CODE CONGRESS INTERNATIONAL, INC.; 900 MONTCLAIR ROAD; BIRMINGHAM, ALABAMA 35213

- o THE NATIONAL BUILDING CODE (NBC) - PRODUCED BY THE AMERICAN INSURANCE ASSOCIATION; NEW YORK, NEW YORK



OSI 7-Layer Model



COPYRIGHT 1984 JOHN WILEY & SONS. Source: BUSINESS DATA COMMUNICATIONS: Basic Concepts, Security and Design (1984) by Jerry FitzGerald.

Networking Protocols Are Key To Future Unix Versions

AT&T and other vendors look to make Unix a networking standard

Unix as an operating system is reaching de facto standard status. However, due to the desires of AT&T and other vendors, communications implications and protocols are rapidly changing the operating system's very nature.

These vendors are attempting to make more of Unix and incorporate ISO networking specifications under a single Unix systems umbrella to ease communications between disparate machines. The various approaches touted by vendors are similar in certain respects and will no doubt find a confluence within a few years.

Such an integrated communications/operating systems umbrella could go a long way toward ridding Unix of some of its acknowledged shortcomings.

For example, Unix still lacks some of the connectivity and cooperative-processing features that Digital Equipment Corp. has incorporated into its VMS operating system. Unix also doesn't have a foothold in IBM's VM strongholds: applications requiring networking and connectivity.

In addition, Unix System V Release 2 and all earlier versions from AT&T Information Systems lack certain communications facilities:

- There are no interprocess communications between machines.
- No file systems are supported across CPU boundaries.
- No remote execution capabilities are provided.
- No support for industry-standard network protocols is offered.

These deficiencies have given companies other than AT&T an opportunity to correct Unix's shortcomings. The first round of improvements came from the University of California at Berkeley and resulted in the 4.2bsd operating system.

Prior to the development work at Berkeley, Unix had no communications capabilities. UC Berkeley introduced communications into the Unix kernel using the "sockets" concept as the network user interface (equivalent to the session layer of the ISO model). The kernel implements layers 1 through 5 of the ISO model; special utilities implement higher layers.

Every utility accessing the network has a

client process and a remote server process. 4.2bsd did not provide a mechanism by which new services could be incorporated into existing servers. Berkeley was also the first Unix developer to introduce high-speed data communications over high-speed links, providing TCP/IP protocols and Ethernet support.

AT&T-IS acknowledges that Unix has shortcomings. However, it expects that its evolving communication facilities can provide the foundation for new distributed applications that could redefine computing.

For instance, recent improvements to Unix System V comprise 4.2bsd features and other enhancements—while maintaining compatibility with AT&T-IS' Unix—by commercial software companies. In addition, workstation companies such as Sun Microsystems Inc. and Apollo Computer Inc. have employed 4.2bsd, as have several superminicomputer companies, including Pyramid Technology Corp. and Sequent Computer Systems Inc.

Because the design of the Unix operating system is sufficiently flexible, such communication facilities have been added as new requirements became apparent. Proof of its adaptability lies in the fact that many enhancements have already been made to the basic operating system kernel. Few operating systems could accommodate the improvements that Unix has taken on during the last five years and still retain their fundamental qualities and attributes.

If Unix's shortcomings can be overcome, AT&T may then have what it needs to make Unix the industry-standard network operating system. There are many reasons why this scenario may come to pass. For example:

Along with its widespread availability on many types of computers, Unix can arbitrate access by multiple users to multiple files and devices.

It currently features interprocess communications (IPC) for single CPUs and a file system that can span multiple mass-storage devices.

Unix also provides features for long-haul communications like the UseNet facility and for batch communications such as point-to-point electronic mail.

These attributes have attracted commercial vendors to support a variety of Unix networking proposals. They include Sun's Network File System (NFS), AT&T-IS' Remote File System (RFS) embedded in the upcoming Unix System V Release 3, VenturCom Inc.'s Distributed Systems Architecture (DSA), Sequent Computer Systems Inc.'s multiprocessor architecture, and General Motors Corp.'s Manufacturing Automation Protocol.

Sun extended 4.2bsd's communications capabilities with two features: Remote Procedure Calls (RPC) and External Data Representation (XDR). RPC and XDR allow users to define high-level services without introducing new servers and have been implemented at Johns Hopkins University Hospital.

PROPOSAL PROs AND CONS		
	PROs	CONs
4.2bsd	Widely used, readily available	Not transparent, No distributed file access
Sun	Transparent access to remote files, RPC and XDR facilities Available for 1 year	No remote device access, No record locking
System V.3	Transparent access to remote files and devices, Record locking, Support all major network protocols	New
VenturCom	Transparent access to remote files, devices and IPC, Record locking, Runs on 16-bit machines	New, No generalized RPC mechanisms
GM MAP	First to follow OSI protocols	New, Not transparent

Gig Graham is executive vice-president and co-founder of VenturCom Inc., a Cambridge, Mass.-based Unix software development and porting company. Tom Scott is manager of Unix internals at VenturCom.

By Gig Graham
and Tom Scott

where Unix-based client systems have been connected to IBM's VM-based 439 server systems via Ethernet.

Sun also introduced the Network File System (NFS), based internally on RPC and XDR, which made kernel enhancements to 4.2bsd, providing distributed access to files by distributing system calls. NFS uses stateless servers that do not permit record locking, remote device access, or distributed process synchronization. Sockets are used for interprocess communication.

AT&T's Streams network/user interface reflects a maturing in communications techniques that has evolved since 4.2bsd. Streams provides an open-ended approach to layered communications through the kernel-network interface. All major network protocols are implemented under the new AT&T release, including SNA, TCP/IP and XNS. This will effectively narrow the communications gap between IBM and AT&T.

The new release of System V will also incorporate the Remote File System (RFS), which provides transparent access to remote files and devices using stateful servers and extensive support for network administration. Distributed interprocess communication is not transparent, however, and IPC services used for more precise record locking and synchronization may not function in a distributed mode. System V.3 will include extensive support for network administration.

VenturCom's Distributed Systems Architecture (DSA) is embodied in its Venix operating system, a Unix System V derivative, and consists of a distributed file system (DFS), distributed interprocess communications (DIPC) and distributed execution (DEXEC). State servers provide distributed file, device and interprocess communications access. DSA is very close to AT&T's RFS in capability. In addition, VenturCom has developed the DSA to work within the constraints of a 16-bit architecture, namely the Intel Corp. processors used in IBM Personal Computers.

With DSA, Unix is currently the server operating system, but VenturCom proposes to im-

plement a server under DEC's VMS. The company's objective of distributed transaction processing is less heterogeneous than Sun's approach, but provides a greater degree of transactional processing.

Currently layered over 4.2bsd sockets, DSA can also use AT&T's Streams technology.

Sequent provides a true distributed operating system, allowing for load balancing and additive MIPS—the ability to add more processors and thereby achieve a higher MIPS rating. To achieve this, Sequent has dramatically modified the Unix kernel internals.

Sequent's approach is integral to its fault-tolerant architecture and therefore limited to that system. However, as standards for both operating systems and networks evolve, the kernel internals approach will increasingly be the foundation for development.

Because of the sockets-like procedures of MAP, several hardware vendors have followed GM's lead and have implemented the MAP under 4.2bsd. The basic benefit of MAP is that it allows for heterogeneous machines and operating systems communicating over a network. It places much more emphasis on time-critical network interactions, and less on user interaction.

All of these approaches are based to a large extent on the International Standards Organization networking model. The model breaks the networking problem down into seven different layers or issues that must be addressed, beginning with the physical hardware and data-link layers; the network, transport, and session layers, which relate to the basic communications supported by the operating system kernel; and the presentation and application layers, which include kernel enhancements and utilities for distributed services.

The ISO architecture presents a good outline for evaluating commercially offered products. To evaluate a network, both resources and services must first be described.

A resource is an object such as a file, device, message, or semaphore. A service manipulates a resource. For example, resources such as files are manipulated by services such as file I/O. In networking, resources are not actually distributed, because they have physical locations on the network. Instead, access to resources is extended, via distributed services to many new users and processes.

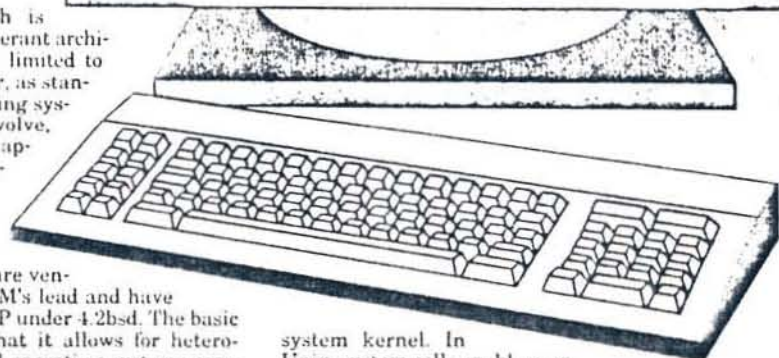
A network operating system must have certain fundamental characteristics. It must have general multiuser capabilities, since networking is by nature multiuser. Multiuser operating systems have already solved the problems of organizing groups of users, managing devices, and establishing permission and protection of resources from unauthorized access.

A network operating system must also reside on many machines rather than a single computer architecture. The ideal system must effectively eliminate machine boundaries. These boundaries are overcome by having the services that manipulate a single CPU's resources be transparently extended to manipulate those of a group.

These services may be described as either low level or high level. Low-level services are the system calls provided by the operating-

REVIEW OF NETWORKING PROPOSALS

ISO Layer	4.2bsd	Sun	System V.3	VenturCom	GM MAP
7. Application	Special utilities, no rep. layer, FTP, TELNET, new applications using Sockets.	Any application using NFS, applications using Sockets.	Any application using NFS, applications using Streams, Complies with V.3, includes new utilities.	Any application using DFS or DIPC, Complies with V.3, includes new utilities.	Partially defined.
6. Presentation	Library routines for byte ordering.	External data representations.	Various Stream modules.	Library routines similar to XDR.	Not yet defined.
5. Session	Seventeen new system calls implementing Sockets.	Remote Procedure Calls layered on top of Sockets, etc.	Three new system calls implementing Streams.	Based internally on Sockets, later Streams.	Based on Sockets.
4. Transport & 3. Network	TCP/IP do	TCP/IP	Protocol modules for SNA, TCP/IP, XNS, etc.	TCP/IP and IBM PC Net.	Proposed.
2. Data Link & 1. Physical	Ethernet (802.3)	Ethernet (802.3)	SNA, Ethernet, Token Ring, etc.	Ethernet (802.3) & IBM PC Net.	Token bus net (802.4)



system kernel. In Unix, system calls enable user processes to manipulate the resources.

High-level services are the utilities running under the operating system, and are built on top of the basic kernel services. Unix utilities enable users to execute shell commands, copy files, and line-print files.

A network operating system must also work with other operating systems. While Unix may become the best network operating system, it need not be the only operating system on the network.

A variety of operating systems should share resources. This sharing may not be bidirectional, so there must be a distinction between a client operating system (residing on a workstation or PC) and a server operating system (residing on the host mini-computer or mainframe).

(Owing to the inherent complexity introduced by more than one operating system, the only client operating system discussed is Unix. PC DOS is not considered on the assumption that PC DOS applications will run as a task under Unix using Unix to provide the network services.)

Because Unix is a multiuser operating system that is available on many different types of hardware, it holds some of the qualities needed in a networking operating system. However, vendors have had to make tradeoffs on their Unix versions that effectively let dissimilar operating systems work together on a network.

Deciding what services to distribute on a network will affect the applicability and marketability of network operating systems. Vendors may concentrate upon distributing either high-level services, such as terminal emulation and file transfer, or low-level services like those defined by the system call interface.

Three different approaches are currently being used for network access.

(Continued on Page P18)

Unix Networking Terminology

AT&T Streams — The network/user interface provided by System V; equivalent to the Session layer of the ISO model, with additional capabilities for Presentation.

Berkeley Sockets — The network/user interface provided by Berkeley Standard Distribution 4.2; equivalent to the Session layer of the ISO model. §02.5

Client operating system — The operating system under which a specific client process operates.

Client processes — Processes that use services provided by other, usually remote, processes.

Distributed File System — Kernel enhancements to Unix V.2, provided by VenturCom, enabling applications to transparently access remote files and devices.

External Data Representation — Protocols defined and implemented by Sun Microsystems for the exchange of data in a machine-independent fashion.

(Continued on Page P18)

Making Unix A Standard For Networking

(Continued from Page P9)
At one end of the spectrum the utilities distribution scheme is very similar to the batch-processing method of executing a remote command. The system-call scheme does not require new utilities, but depends on the operating system, which executes a system call to manipulate remote resources. At the other end of the spectrum, the kernel internals approach is much closer to true interactive processing.

Historically, special utilities have been employed to distribute high-level services. Recently, vendors have modified the operating system kernel to distribute low-level services provided by the system calls.

High-level (utilities) distribution of services has the dis-

advantage of introducing new utilities (such as Arpanet's TelNet) or library functions that do not allow applications to transparently use the underlying networking. But since this approach is a step removed from the system call interface, it can easily gloss over the differences in underlying operating systems. However, it forces applications to adopt a convention that is not native to any one type of operating system.

Furthermore, the utilities scheme operates at a machine-to-machine level, calling for the operator to physically recognize which machine the utility must run on. This method is not transparent to applications programs and, therefore, perpetuates the struggle with machine boundaries and requires new utilities to activate network processes. Remote utilities require remote servers, which could have a tendency to proliferate and become unwieldy to manage. Since operating system services are bypassed, new security features must be added.

The utilities scheme is the least interactive of the approaches, and as a result, transaction processing is difficult. But this approach has historically been important

the development of network operating systems and is currently used when it is not possible or desirable to modify the client and server operating system.

Unlike the high-level distribution of services, the system call scheme can be made transparent to the applications. Binary code compatibility is maintained so existing utilities can use the network without recompilation. Since the existing utilities define the high-level services running on a computer, these services become distributed as well. The applications make system calls to manipulate resources, which, because of modifications to the client operating system, can reside locally or on a remote machine.

Using this method, transaction processing is possible and the operating system maintains security. More recent network operating systems use this approach, but they differ in the extent to which resources are distributed.

The kernel internals scheme provides the most elegant method, and is increasingly used in fault-tolerant computers to maintain parallel processing. This method, referred to as a "distributed operating

system" rather than a network operating system, has all the advantages of the system call scheme, and it also allows for dynamic load balancing and new processors to be added to improve performance.

However, the benefits of these distributed operating systems cannot be easily extended to heterogeneous operating systems and computers. Porting them to new environments is impractical, and no standards exist on these systems to reflect a consensus about implementations.

The history of computing has been characterized by general-purpose machines offering general-purpose solutions.

However, during the last several years, the popularity of PCs has fostered a new level of specialization in computer solutions.

The next era of computing will take place as larger centralized computing environments are merged with these innovative offerings on personal computer workstations. This will occur as machine boundaries are removed and applications are no longer tied to a single computer. And Unix may provide the key to unlocking those boundaries.

Networking Terminology

(Continued from Page P9)

Heterogenous machine types — Machines based on different CPUs and/or architectures.

Heterogenous OS types — Operating systems that differ in the services provided to user processes.

Homogeneous machine types — Machines that are very similar in architecture.

Interprocess communication — A facility provided by an operating system allowing processes to exchange messages and to synchronize.

Network File System — Kernel enhancements to 4.2bsd, provided by Sun Microsystems, enabling applications to transparently access remote files.

OSI Model — The Reference Model of Open Systems Interconnection, developed by the International Standards Organization for describing protocols used to connect systems together.

Processes — The run-time entity provided by an operating system to execute an applications program.

Remote File System — Kernel enhancements provided in AT&T release V.3, enabling applications to transparently access remote files and devices.

Remote Procedure Call — Protocols defined and implemented by Sun Microsystems that permit procedures to be directed to special serving processes on remote machines for execution.

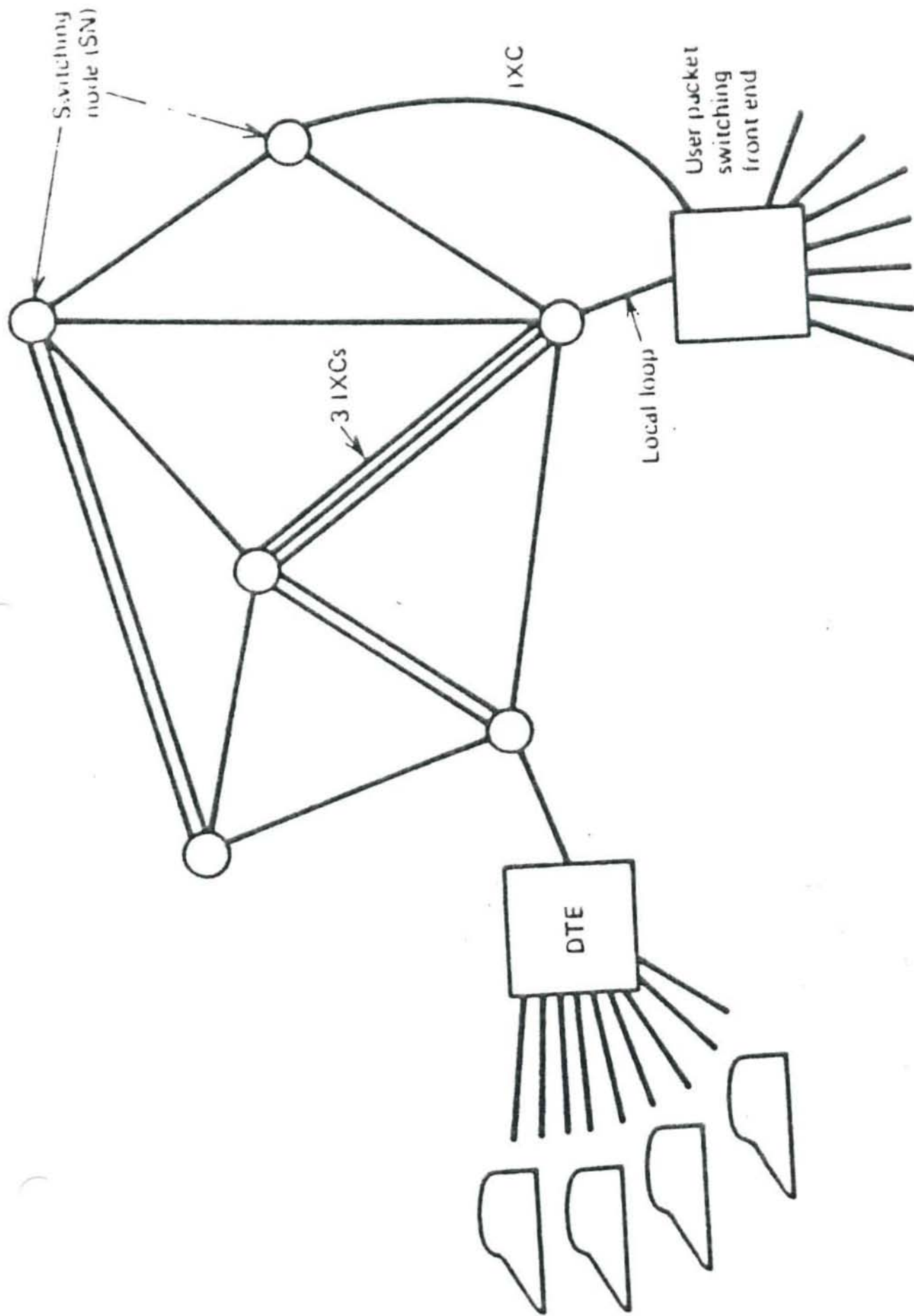
Server processes — Processes that provide services through the network to client processes.

Server operating system — The operating system under which a specific server process operates.

State servers — A type of server that maintains information about its client between requests from its client.

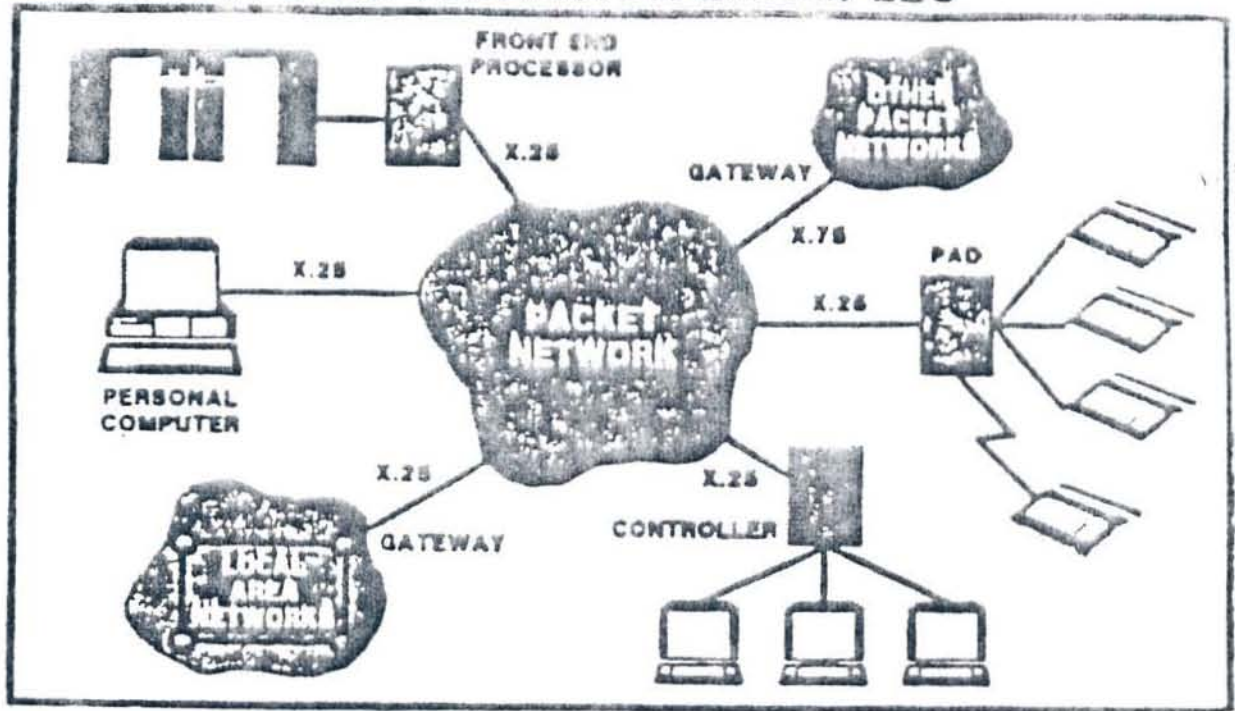
Stateless servers — A type of server that operates without any state information. Requests from clients are independent of each other.

System V Interface Definition — The basic operating system interface on which Unix application software can always depend.

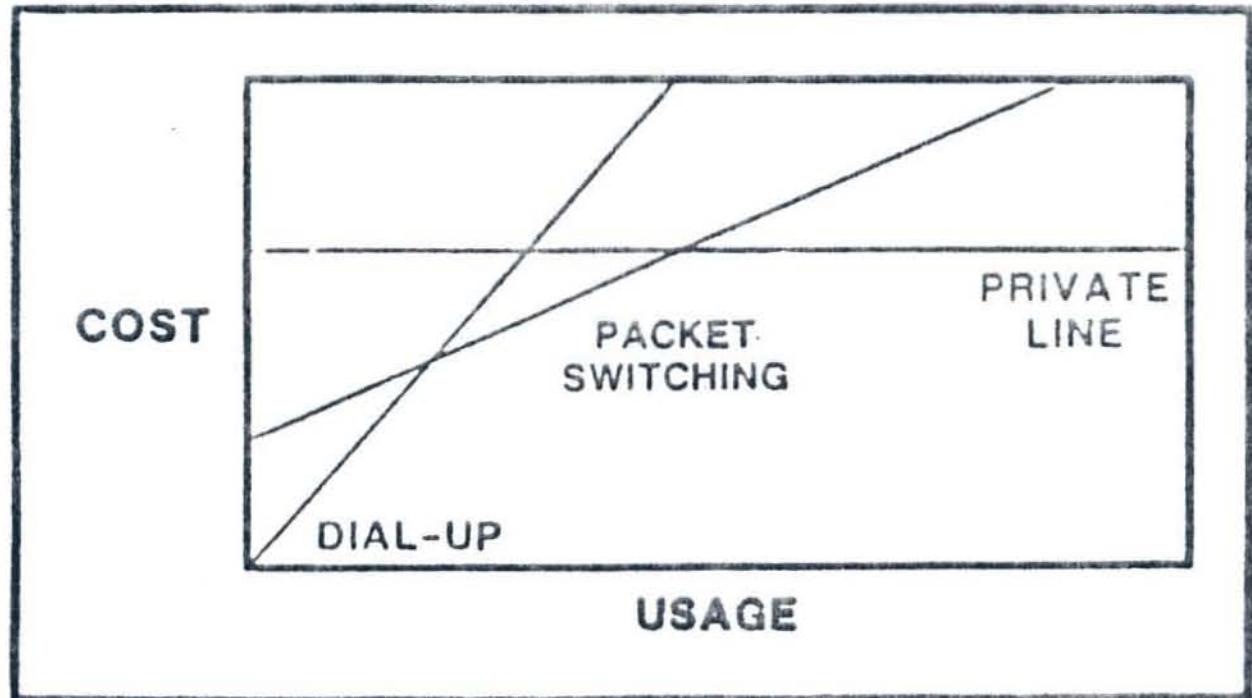


DTE (data terminal equipment)
This encompasses the user
machine, computer, front end,
or terminal.

NETWORK CONFIGURATION EXAMPLES



DESIGN CONSIDERATIONS



ADVANTAGES OF X.25 NETWORKS

- COST EFFECTIVE FOR LOW TO INTERMEDIATE TRAFFIC VOLUMES
- BILLING IS INDEPENDENT OF DISTANCE ; VARIATION ALSO BY REMOTENESS DENSITY
- SINGLE PHYSICAL LINK CAN SUPPORT MANY LOGICAL CONNECTIONS
- DIFFERENT TERMINALS AND COMPUTERS MAY BE INTERCONNECTED
- NETWORK PROVIDES VALUE ADDED SERVICES (ERROR RECOVERY ON LINE 'HIT')

MUX'G/DMUX'G AND ROUTING

FLOW CONTROL

ERROR CONTROL

NETWORK MAINTENANCE

MESSAGE ACCOUNTING

- INTERNATIONAL SERVICE THROUGH GATEWAYS

PACKET SWITCHING CONCEPTS

DATA AND CONTROL INFORMATION ARE PACKETIZED

VIRTUAL CIRCUIT BETWEEN 2 DTEs:

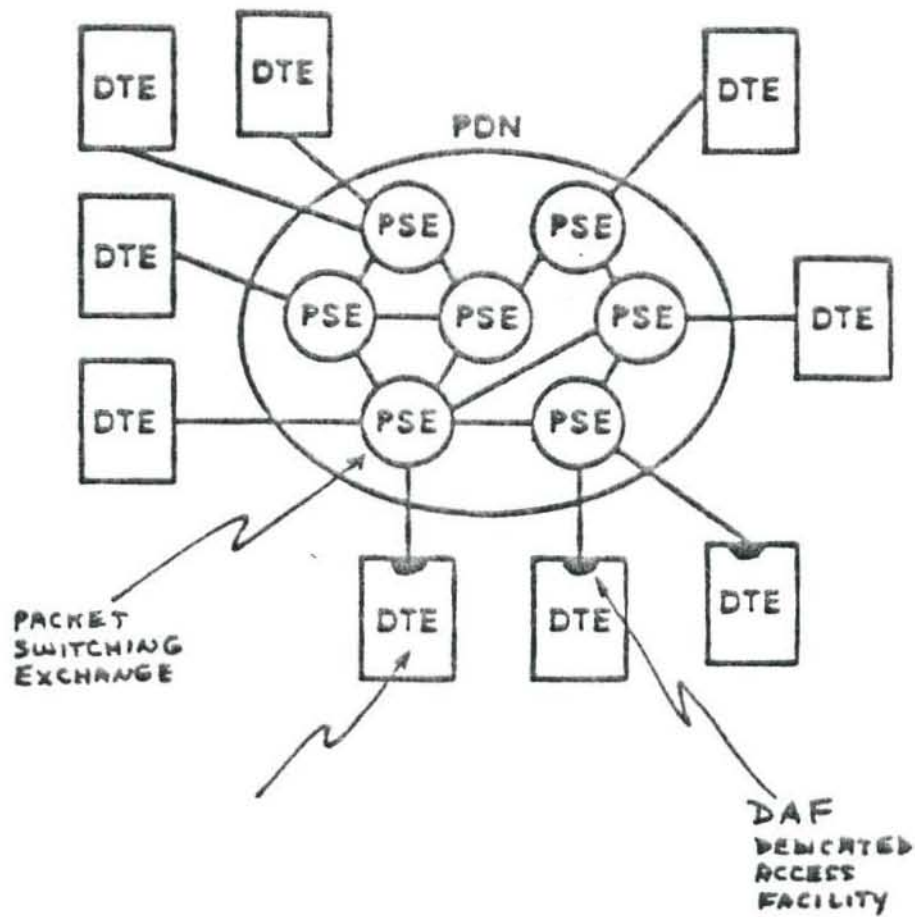
- VIRTUAL CALL \cong LOGICAL PATH FROM SRC TO DESTINATION
- PERMANENT VIRTUAL CALL

STATISTICAL MULTIPLEXING USED TO SHARE LINES

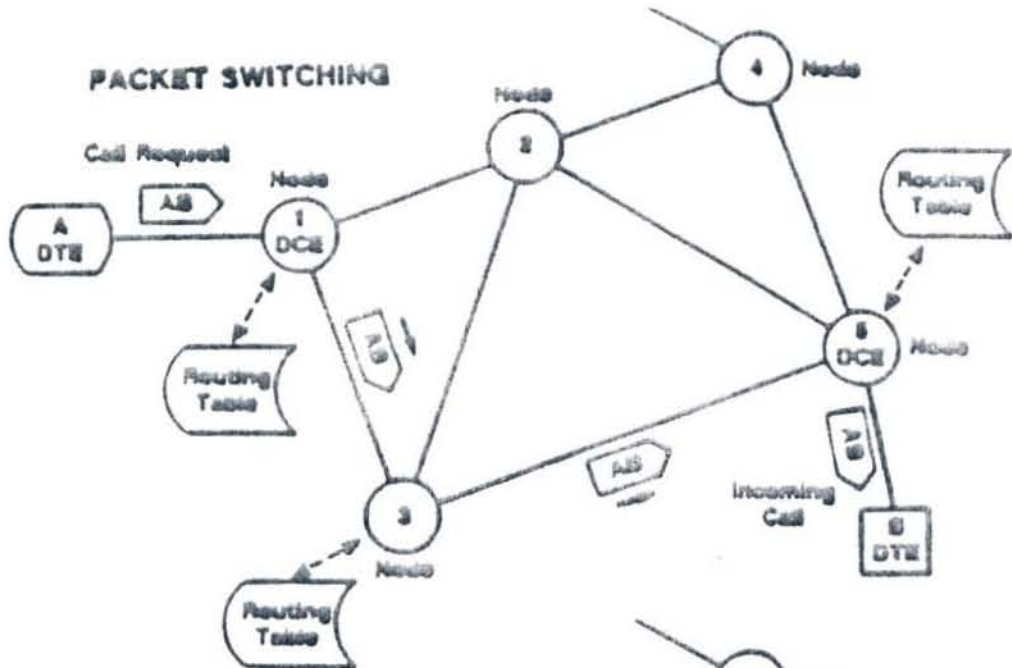
DYNAMIC ALLOCATION OF BANDWIDTH

- LINKS ASSIGNED WHEN DATA TRANSFER OCCURS
- PATHS BETWEEN END POINTS MAY VARY

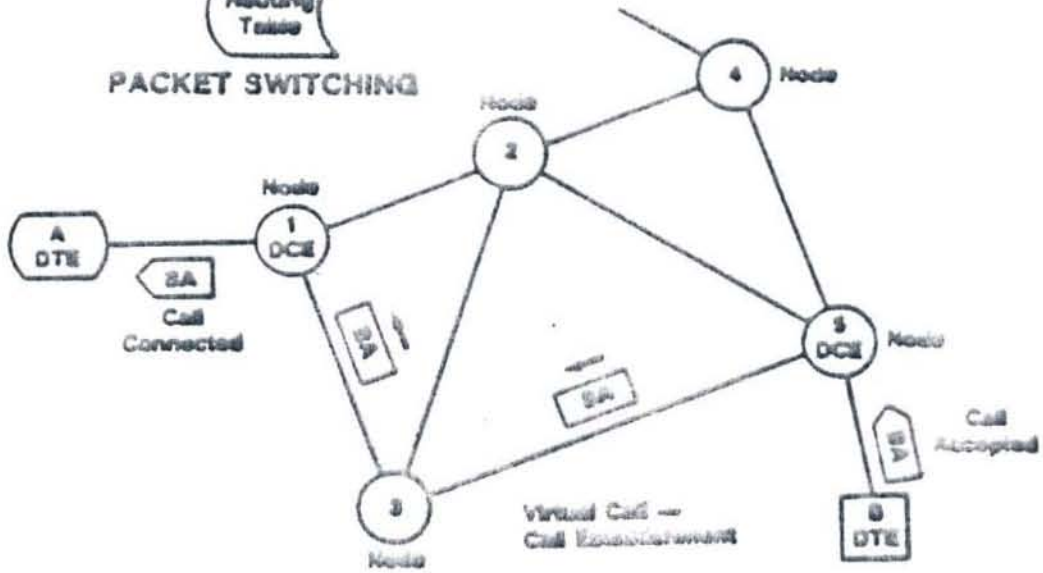
TYPICAL PDN



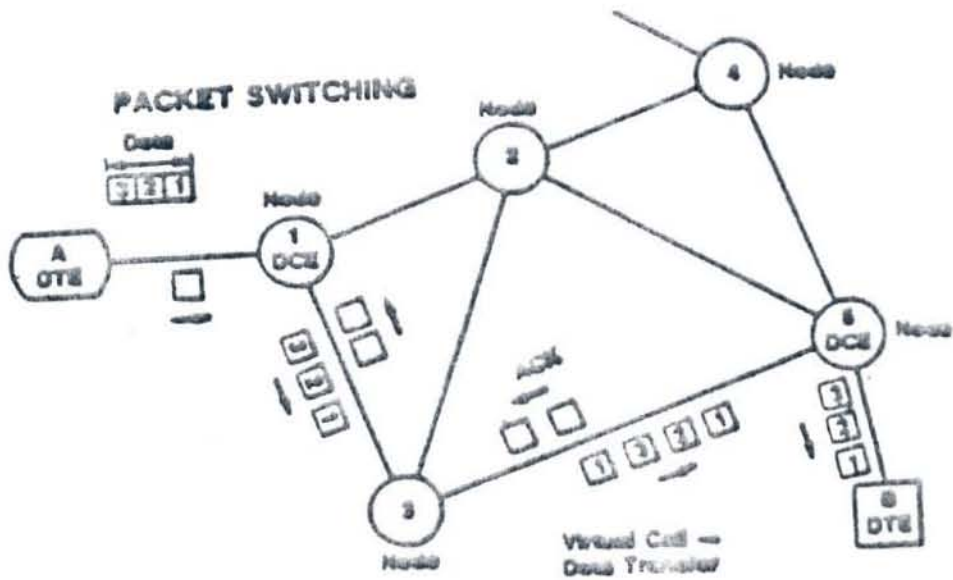
PACKET SWITCHING



PACKET SWITCHING



PACKET SWITCHING



X.25 PROTOCOL

DTE/DCE Electrical Interface

(X.21 bit)

- X.21 or RS 232C compatible
- Independent of other levels

DTE/DCE Frame Level Interface

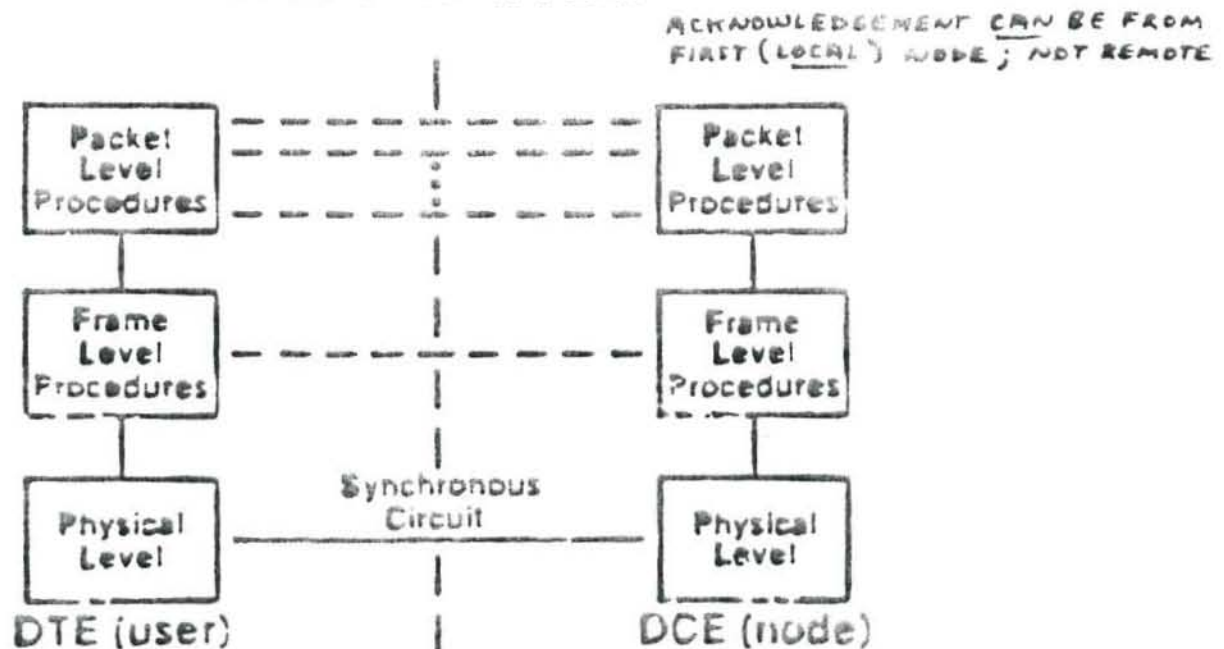
- Link access procedures – LAPB is new/preferred
- Does not know about virtual calls

DTE/DCE Packet Level Procedures

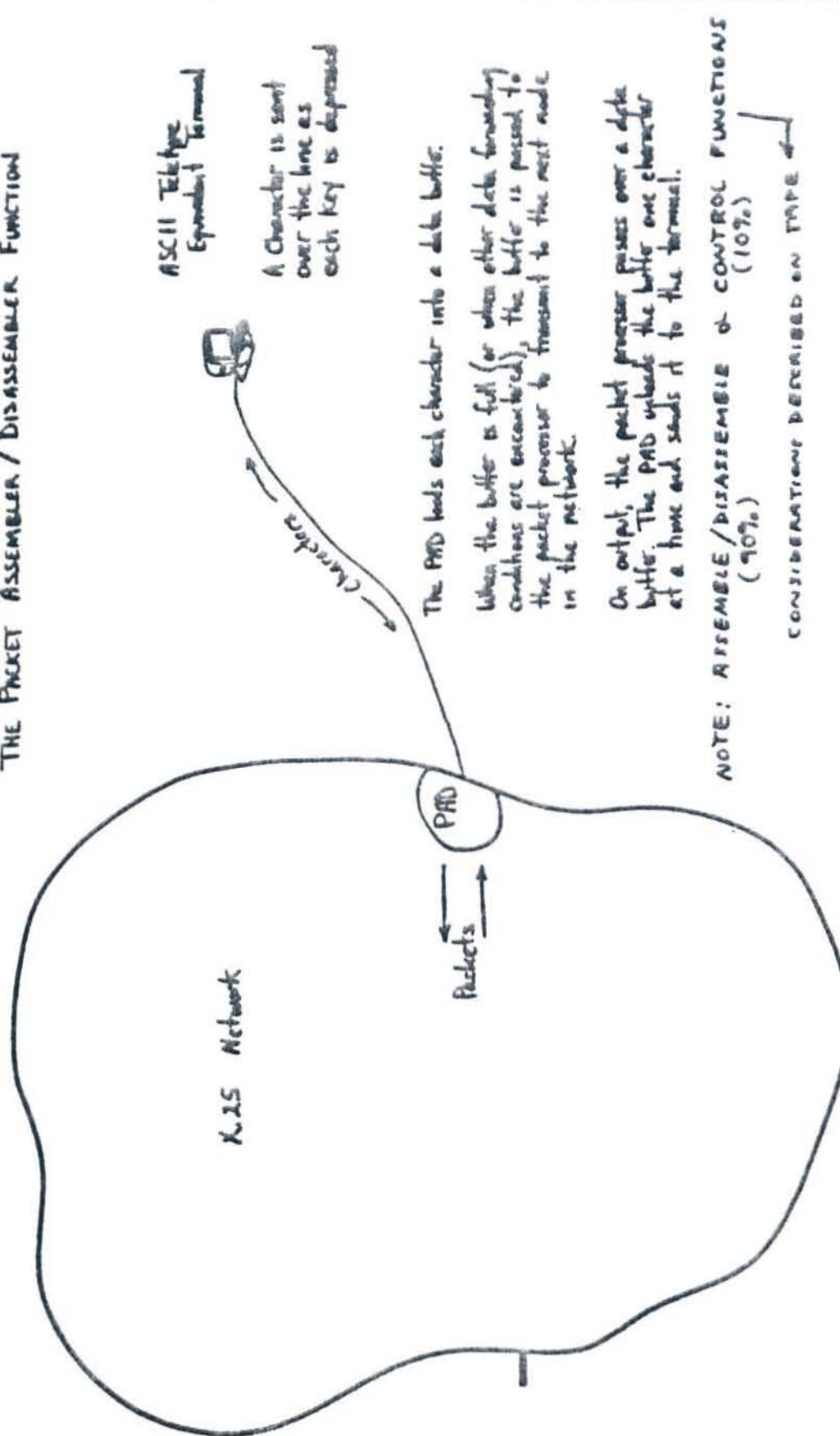
FORMATS PACKETS; FLOW CTRL; SETUP VIRTUAL CALLS

- Virtual call procedures
(Set-up, Maintain, Flow control, Clear)
- May be end-to-end (DTE/DTE)
 ↳ BUT NOT ALWAYS

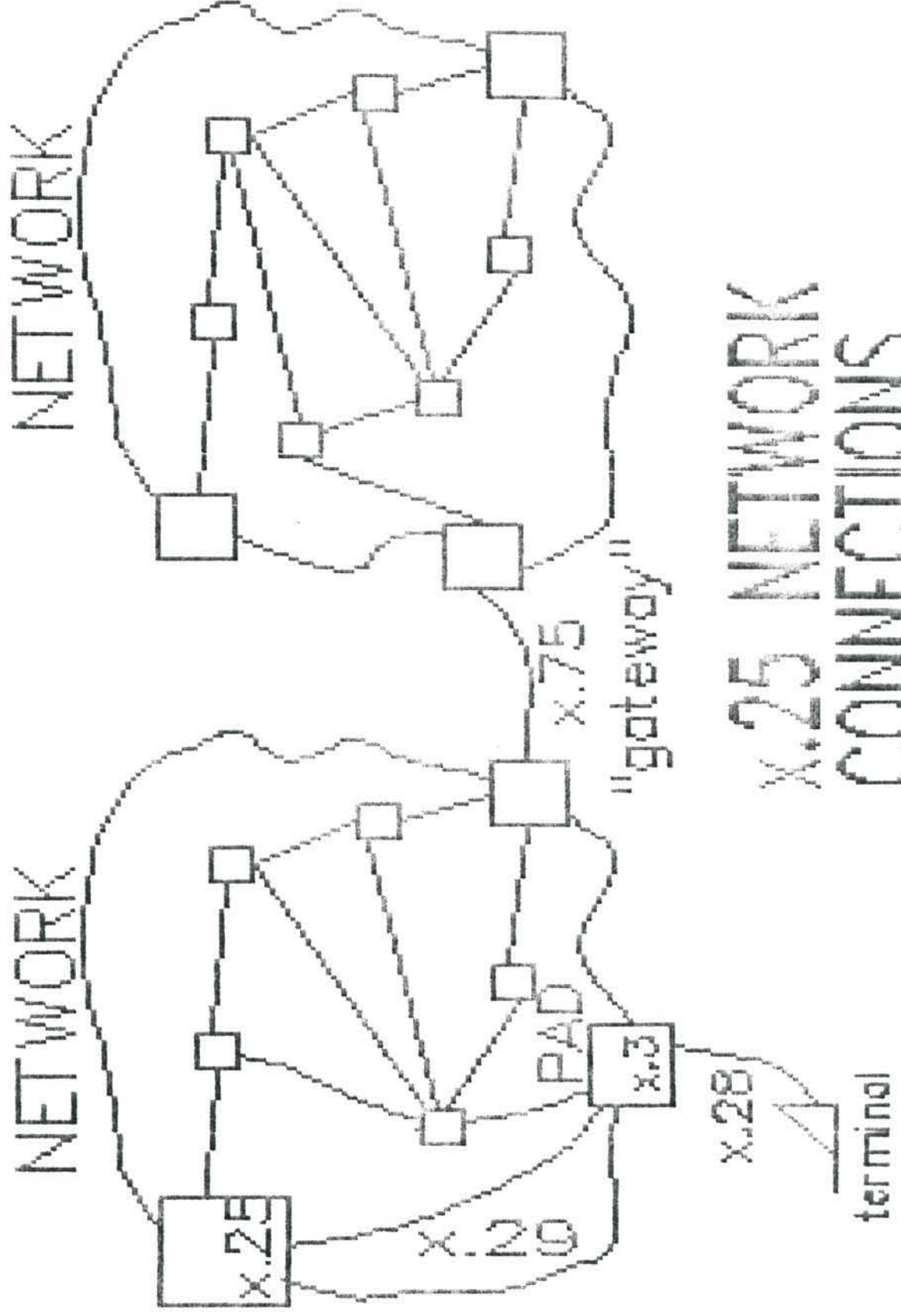
X.25 INTERFACE



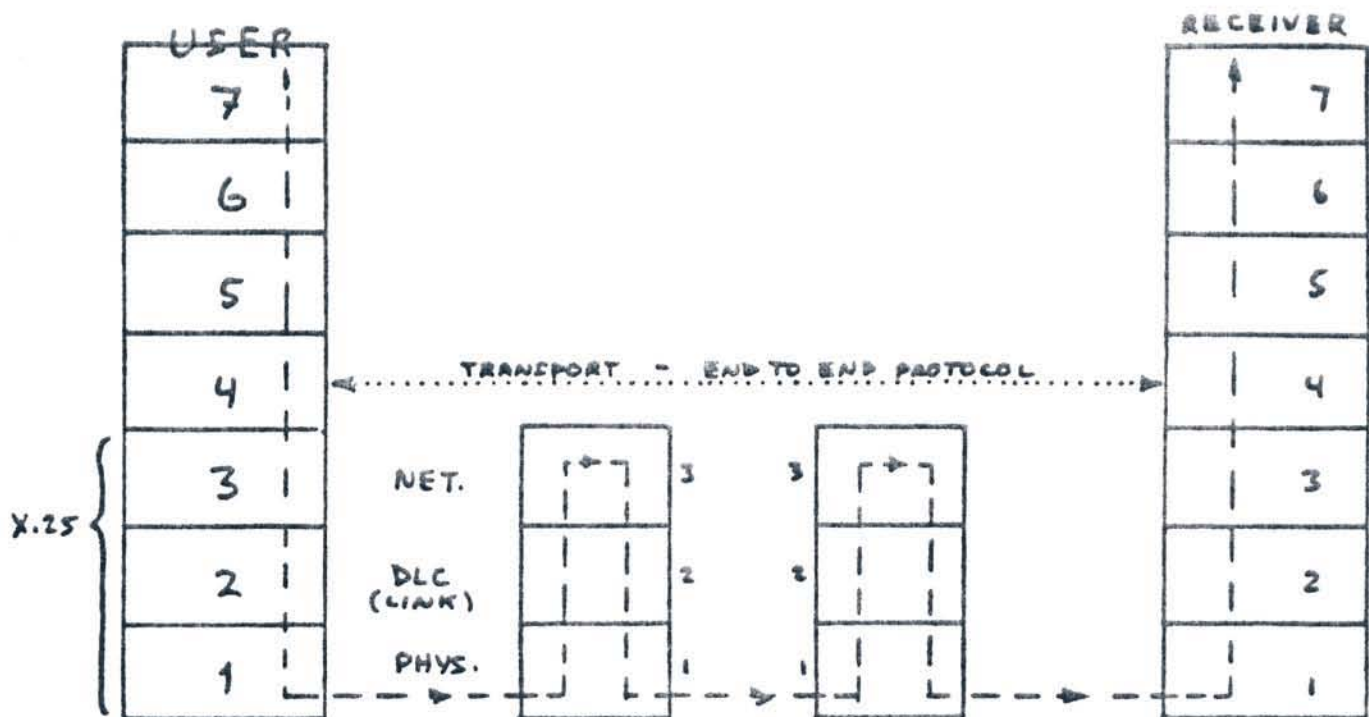
THE PACKET ASSEMBLER / DISASSEMBLER FUNCTION



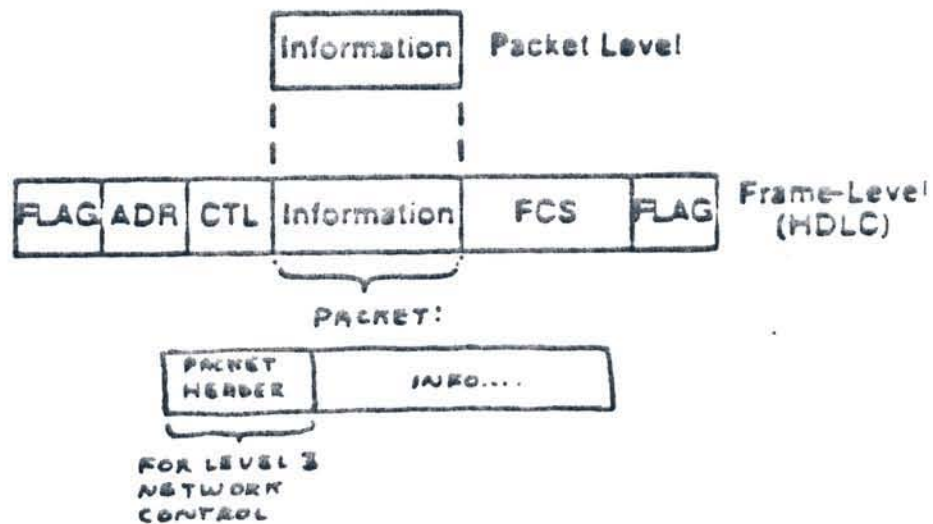
PAD (PACKET ASSEMBLER/DISASSEMBLER) FUNCTION



X.25 NETWORK CONNECTIONS



FRAMING FORMAT



HDLC FRAMING



FLAG = X 7E

FCS = 16 bits for error detection

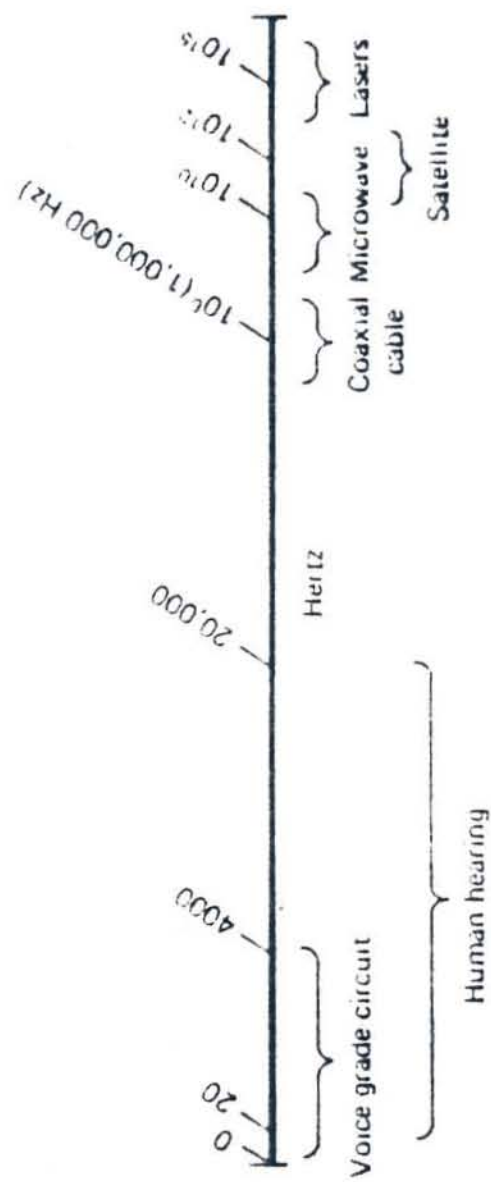


FIGURE 3-16 Frequency spectrum.

NBC was paying AT&T \$30 million a year to carry its network signals. Now, at a cost of \$300 million-plus, NBC is cutting loose from AT&T once and for all. Bad arithmetic? Hardly. More like a revolution.

Here comes Ku-band

By Martin Mayer

NETWORK TELEVISION in the U.S. has been tied to the operating facilities and technologies of Ma Bell since the coaxial cable first spanned the country in 1951. Next Jan. 1 or

thereabouts, the National Broadcasting Co. will take a scissors and bravely cut that umbilical cord, thanks to a bold, new satellite-based communications system that will replace AT&T's wires and microwaves.

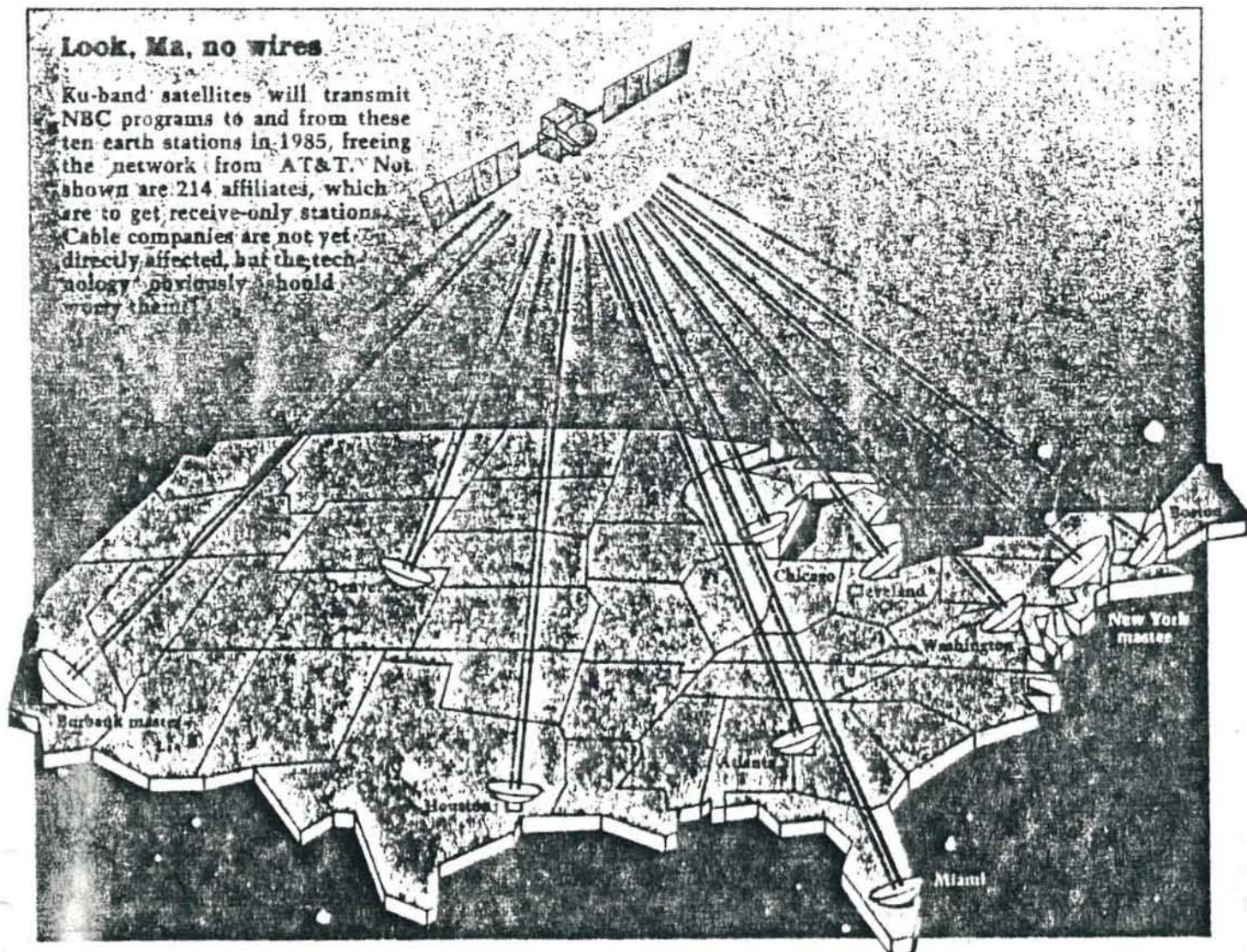
The new system is the product of a

\$400 million venture coupling the NBC network, Comsat, Harris Corp. and RCA. It rests on the first large-scale commercial use of the super-high frequency "Ku" band of the radio spectrum (12 billion to 14 billion cycles per second, or "megahertz"). Radio waves that high in the spectrum are so short they can be absorbed by raindrops. Conventional wisdom has long argued that the resulting "rain fades" would make those frequencies useless for television or other high-speed data-transmission purposes requiring essentially perfect accuracy virtually all the time.

But Comsat, the prime contractor for the satellite system, has ignored the conventional wisdom and has confidently guaranteed NBC what the engineers call "four nines"—99.99% reliability. In more than three months of experimental operation this year, involving 22 of the network's 214 stations, the system has exceeded specifications. In part of the country NBC has already declared independence from AT&T. The network discon-

Look, Ma, no wires

Ku-band satellites will transmit NBC programs to and from these ten earth stations in 1985, freeing the network from AT&T. Not shown are 214 affiliates, which are to get receive-only stations. Cable companies are not yet directly affected, but the technology obviously should worry them.



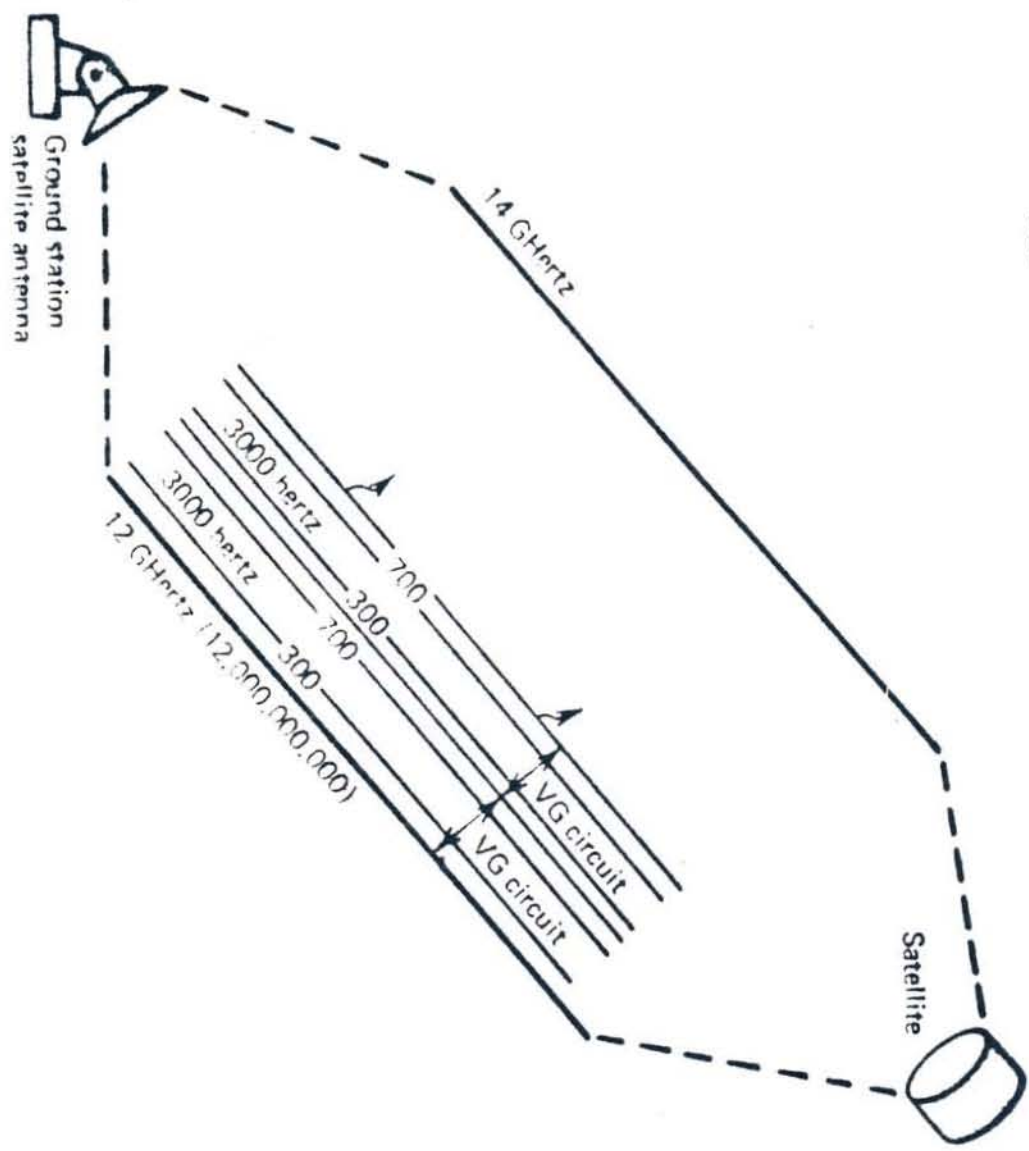
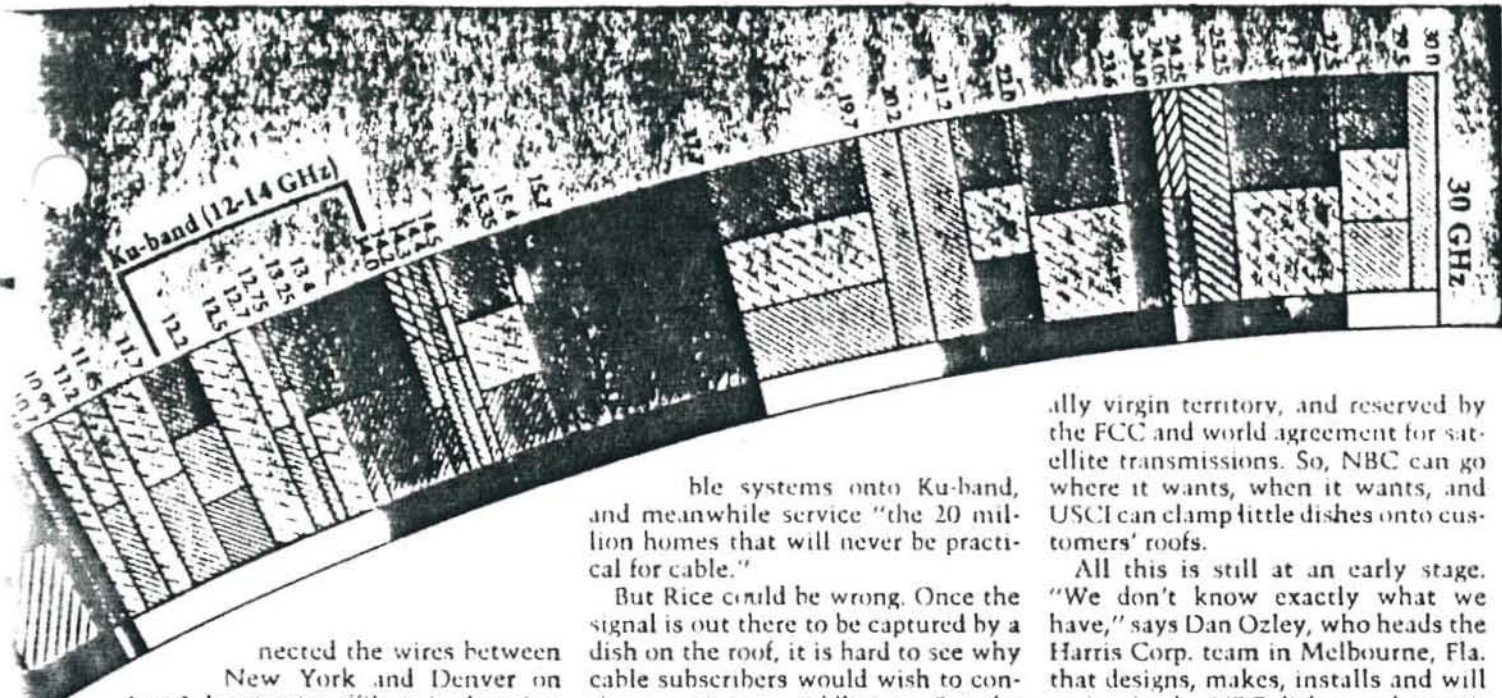


FIGURE 3-18 Guardbands.



nected the wires between New York and Denver on Apr. 2, leaving its affiliate in that city, and affiliates in other cities in the Mountain States that have been fed through Denver, entirely dependent on the satellite.

The stakes are high in Ku-band transmission by satellite. Even now, billions of dollars are being spent wiring cities for cable television, at a cost of perhaps \$700 per home. But because the waves in the Ku-band are so short (*see chart*) they can be caught and concentrated by a much smaller antenna dish, the sort of thing a householder can put on his roof, providing a choice of pay channels and special programs without cable. The pioneer service in direct-to-home satellite television—United Satellite Communications, Inc., a venture bankrolled by Prudential Insurance—will sell and install a dish between 30 inches and 4 feet in diameter (depending on the location) and supply all the associated electronics (including a hand-held controller to let you pick one of five channels beamed from the heavens) at a price of \$395.

RCA is building three highly powered Ku-band satellites, to be launched in the second half of this decade. Together they will offer 48 transponders for annual rental at \$3.8 million each; NBC will take four, moving its signals to a new bird, and all the others are still available. "We see television eating most of it up," says Harold Rice, vice president for video/audio services at RCA American Communications. He argues that existing pay-TV services like Home Box Office will be among his best customers, because they can switch their existing transmissions to the ca-

ble systems onto Ku-band, and meanwhile service "the 20 million homes that will never be practical for cable."

But Rice could be wrong. Once the signal is out there to be captured by a dish on the roof, it is hard to see why cable subscribers would wish to continue paying a middleman. For the cable entrepreneurs, those satellite launches have the look of someone writing a message in the sky.

AT&T seems to have guessed wrong on the feasibility of Ku-band—it refused an invitation to bid on the NBC project before the deal was made with Comsat. Now it faces not only the loss of revenues from television interconnections but also heightened competition for data transmission services. That's because the unused sidebands around a television signal on a Ku channel offer the equivalent of hundreds of data-quality microwave channels. "We can transmit anything from credit card information to a retail store to entertainment to a home," says USCI President Nathaniel Kwit. "It's a unique opportunity to take advantage of bandwidth. You ask me, 'What are you going to do with the opportunity?' My answer is, I don't know yet."

There is, of course, nothing new about the use of satellites to carry television signals. Pay cable TV and services like the Cable News Network and C-SPAN (for Cable Satellite Public Affairs Network) are feasible only through satellite distribution of their signals. Entrepreneurs around the country own and rent out trucks with dishes that can shoot television signals up to satellites for broadcast coverage of live events. But all this activity occurs in the frequency band of 4 to 6 gigahertz (called the "C-band"), which is also used by terrestrial microwave, an awesome clutter of telephone calls, data transmission and television channels.

The Ku-band, by contrast, is virtu-

ally virgin territory, and reserved by the FCC and world agreement for satellite transmissions. So, NBC can go where it wants, when it wants, and USCI can clamp little dishes onto customers' roofs.

All this is still at an early stage. "We don't know exactly what we have," says Dan Ozley, who heads the Harris Corp. team in Melbourne, Fla. that designs, makes, installs and will maintain the NBC dishes and associated electronics at the network's 214 affiliated stations. To date, only 22 stations have been recipients of Ku-band test feeds. Last month Harris went into overdrive on an installation schedule that calls for completing, testing and placing into operation a new ground station for an affiliate somewhere in the U.S. every working day for the rest of this year.

At the beginning, the new system will not save money for NBC or its affiliates. Michael Sherlock, the network's executive vice president for operations and technical services, reports that satellite distribution next year will cost NBC "considerably more" than the \$30 million the network paid AT&T last year in line charges. But the Comsat contract gives NBC an established price through 1995, and long before the decade's end the new system should be a bargain. After all, in its filings for the new long-lines rates following the breakup of the Bell System, AT&T asked the FCC to approve a 43% increase in charges for distributing television signals. Both NBC and its affiliates see an iceberg below that tip.

Most important to NBC is the newly capacious and flexible communications system the Ku-band satellite offers. As against the one channel on an AT&T loop, the satellite provides four channels: The network can feed not only what is to go on the air now over the affiliate's broadcast frequency, but also material to be stored for subsequent use on local news shows, etc. Different regions can pick up different signals, according to need. On football Sundays or baseball Satur-

Traffic control

In 1920 radio station KDKA in Pittsburgh broadcast the presidential election returns—Warren Harding trounced James Cox—on a frequency of 830 kilohertz, 830,000 cycles per second. Ten presidents after that first commercial broadcast, the spectrum of usable radio waves has expanded to the gigahertz range—1 billion cycles per second—and beyond.

That super-high-frequency range (3 GHz to 30 GHz)—including the so-called Ku-band—is charted across these pages. It is, of course, only a fraction of all bands, but it's just about the highest portion of the radio spectrum used commercially. This year NBC began using a slice of the Ku-band, between 12 GHz and 14 GHz, to transmit television programming to its affiliated stations. Until now this band was considered too risky by reliability-obsessed TV executives. The problem: The microwaves in this range are so short they can be absorbed by mere raindrops and even fog.

Comsat, which is NBC's prime contractor, and Harris Corp., its subcontractor, plan to solve this "rain fade" by using greater power and larger receiving dishes. NBC was forced up to Ku because clutter elsewhere, notably

in the C-band, limits the availability of licenses and jeopardizes network-quality service.

All the bands of the arc look filled, a colorful deception. Allocation to a particular use by the FCC does not necessarily mean heavy traffic. But the much-used C-band is bustling, filled with transcontinental telephone links plus space-to-earth and earth-to-space transmissions for most U.S. commercial satellites. Contrast this with the Ku-band, allocated to satellite transmissions and—until now—lightly used.

For all the FCC's precision in allocating the spectrum, incidentally, there is no agreement at the agency on how to pronounce the word *gigahertz*.

Some staffers say "gig-a hertz" and others say "pe-a hertz." Says a tactful bureaucrat,

"Both are correct."—Maria Fisher.

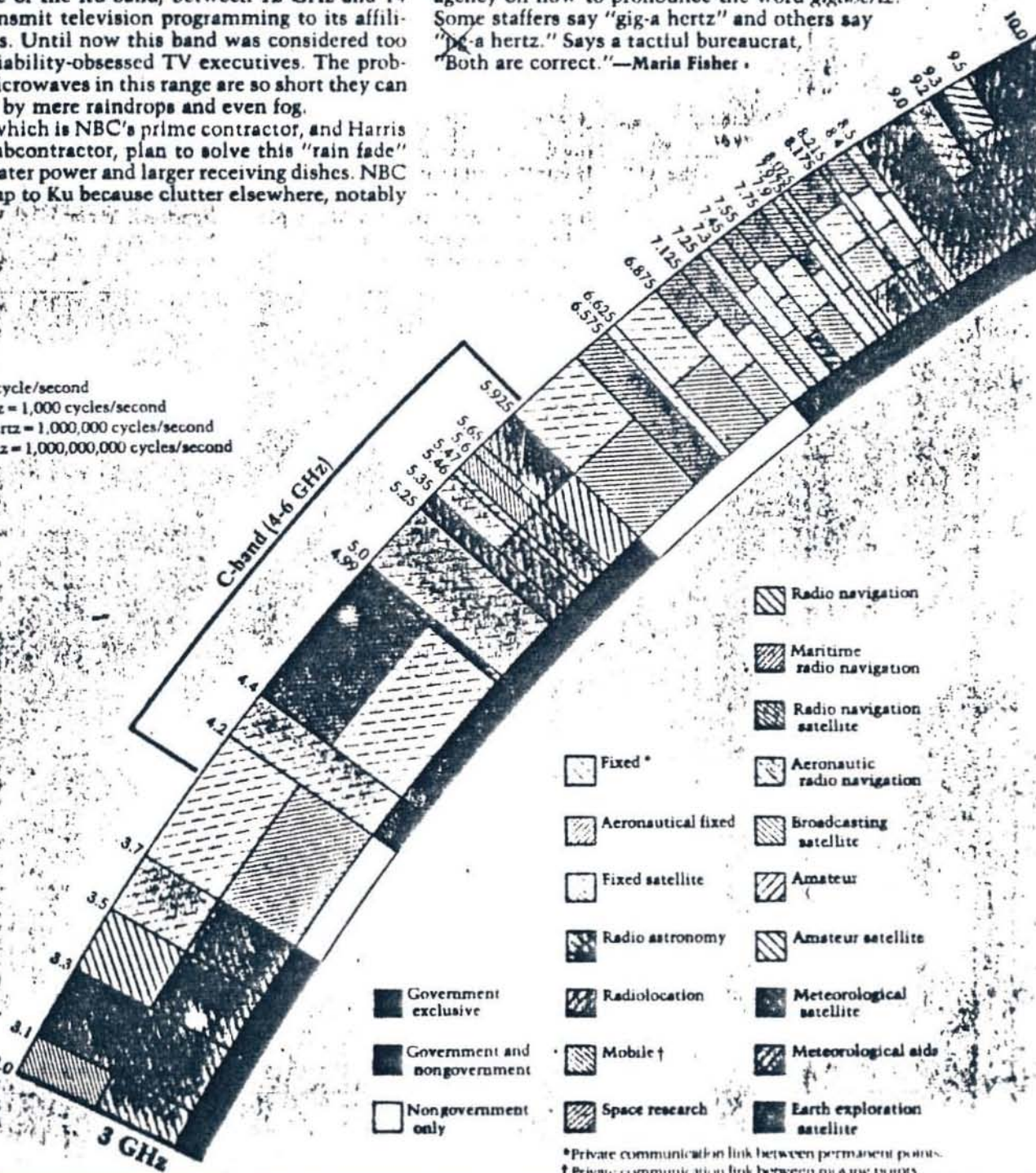
Equivalents:

Hz = 1 hertz = 1 cycle/second

KHz = 1 kilohertz = 1,000 cycles/second

MHz = 1 megahertz = 1,000,000 cycles/second

GHz = 1 gigahertz = 1,000,000,000 cycles/second



When a computer and its users interact at a pace that ensures that neither has to wait on the other, productivity soars, the cost of the work done on the computer tumbles, employees get more satisfaction from their work, and its quality tends to improve. Few online computer systems are this well balanced; few executives are aware that such a balance is economically and technically feasible.

In fact, at one time it was thought that a relatively slow response, up to two seconds, was acceptable because the person was thinking about the next task. Research on rapid response time now indicates that this earlier theory is not borne out by the facts: productivity increases in more than direct proportion to a decrease in response time. This brief describes some of this research and the implications for increasing productivity and cutting costs that are among the chief challenges of business today.

The Economic Value of Rapid Response Time

Lead for 2/19



Walter J. Doherty, Manager of Systems Performance and Technology Transfer for the Computing Systems Department at IBM's Thomas J. Watson Research Center.



Arvind J. Thadhani, Advisory Engineer at IBM's General Products Division headquarters, San Jose, California.

Background

A transaction consists of a user command from a terminal and the system's reply. It is the fundamental unit of work for online system users. It can be divided into two time sequences (Figure 1):

User Response Time. This is the time span between the moment a user receives a complete reply to one command and enters the next command. People often refer to this as think time.

System Response Time. This is the time span between the moment the user enters a command and the moment a complete response is displayed on the terminal. System response time can be further divided into:

- Computer response time, the time the computer actually spends processing and servicing the user's command
- Communication time, the transit time for a command to go to the computer and the time for the reply to come back

When online systems first began to spread throughout the business world, psychologists such as Robert B. Miller, then of IBM's Poughkeepsie laboratory, argued that two seconds was the longest a person should wait for a response from the computer. This interval became a challenge that designers and managers of

online systems strove to meet. With those early online systems, this was not easy, but people comforted themselves with the thought that the user was thinking out the next step in the transaction stream while waiting for the computer to reply. Implicit was the belief that users were thinking as rapidly as they could, uninfluenced by how long the system took to respond.

Today's online systems, easily performing many millions of instructions per second with memories far larger than the largest available with the most powerful of IBM's System/360 machines, can now respond to hundreds of users in less than two seconds each. Walter J. Doherty, of IBM's Thomas J. Watson Research Center, was one of the first to see the significance of this rapid improvement in system capability.

He and Richard P. Kelisky, Director of Computing Systems for IBM's Research Division, wrote about their observations in 1979, "...each second of system response degradation leads to a similar degradation added to the user's time for the following [command]. This phenomenon seems to be related to an individual's attention span. The traditional model of a person thinking after each system

response appears to be inaccurate. Instead, people seem to have a sequence of actions in mind, contained in a short-term mental memory buffer. Increases in SRT [system response time] seem to disrupt the thought processes, and this may result in having to rethink the sequence of actions to be continued."

In a pioneering article, inspired by Doherty's work, Arvind J. Thadhani, of IBM's San Jose Laboratory, suggests that the number of transactions a programmer completes in an hour increases noticeably as system response time falls, and rises dramatically once system response time falls below one second. To illustrate (Figure 2), with system response of three seconds, Thadhani found that a programmer executes about 180 transactions per hour. But, bring system response time down to 0.3 seconds and the number of transactions the programmer can execute in an hour jumps to 371, an increase of 106 percent. Put another way, a reduction of 2.7 seconds in system response saves 10.3 seconds of the user's time (Figure 3). This seemingly insignificant time saving is the springboard for sizable increases in productivity.

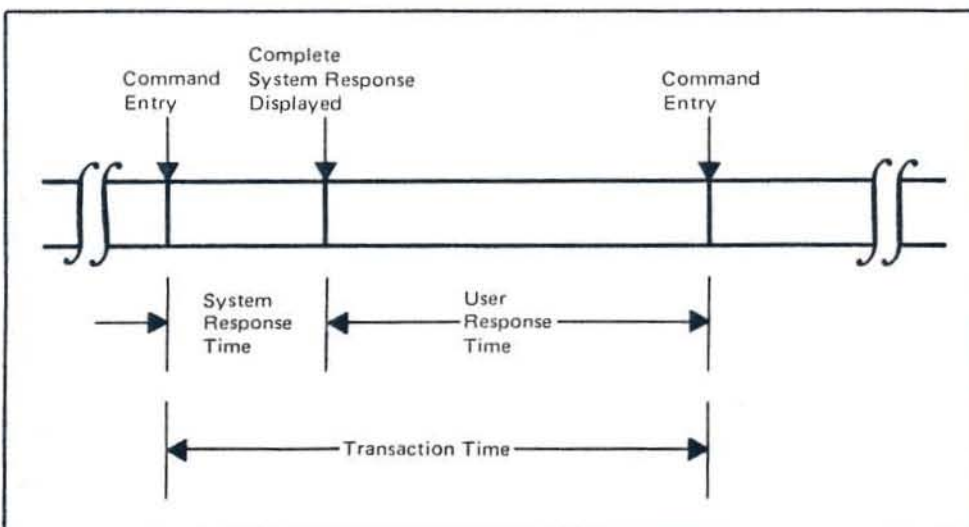


Figure 1. Elements of an Online Transaction

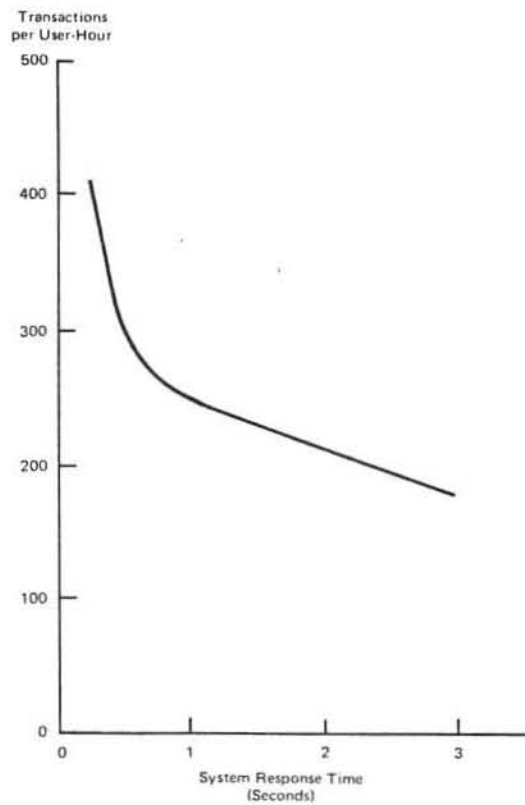


Figure 2. Relationship Between System Response Time and the Number of Transactions a User Can Complete in an Hour

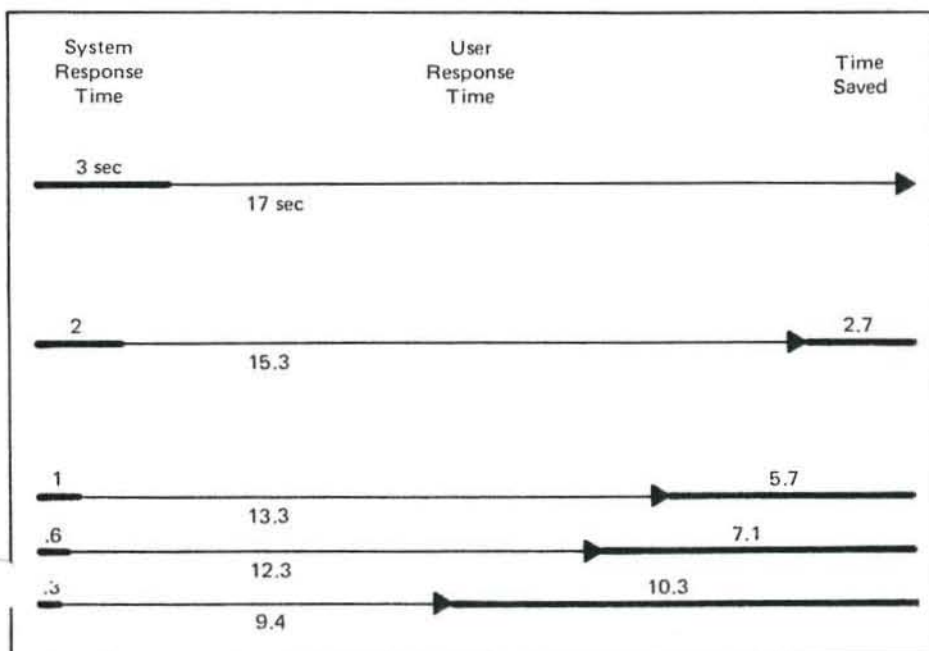


Figure 3. User Time Saved as System Response Time Improves

Benefits

The potential benefits for an organization in providing improved and ultimately subsecond response time for online computing include substantial cost savings, improved individual productivity, shortened project schedules, and a better quality of work. These benefits are inherent in the computing situation; they do not depend on the type of work being done, as will be demonstrated by the diversity of the environments in which they have been demonstrated. Let us look at these benefits in more detail.

Substantial Cost Savings

Saving a few seconds of a person's time here and there may seem to be of little matter, but these seconds accumulate rapidly and build quickly to represent large dollar amounts, large enough to more than justify the cost of installing a larger processor if one is needed to provide more rapid system response. The National Institutes of Health (NIH) provides an outstanding illustration.

In 1979 their installed system was designed to offer 300 simultaneous users word processing, programming, computing, and remote job entry capabilities, with the response to 80 percent of the transactions being processed in .5 seconds or less. Terminal work sessions, called tasks throughout this brief, averaged 95,000 per month. At its design level, the system had functioned to the satisfaction of its users, but increasing demand was threatening its ability to continue providing an acceptable level of service (Figure 4). The number of simultaneous users had grown to almost 400 and was projected to be 500 in 18 months. With 390 users, the computer response time had deteriorated to an average of 4 seconds and the time to complete an average task had increased 50%, from 32 minutes to 48 minutes (Figure 5). To solve this problem, Joseph D. Naughton, Chief of the NIH Computer Center, proposed to upgrade the processor. He had observed that system deterioration was causing the NIH's users to spend an additional 22,500 hours at their terminals each month, yet they were accomplishing the same number of tasks. The system and user cost for this time were estimated at \$900,000 monthly (Figure 6), 15 times the incremental cost of a new processor capable of providing subsecond response

time to 500 simultaneous users. For the National Institutes of Health, the cost of upgrading their processor was more than justified by the savings in user time and the restoration of their low task costs.

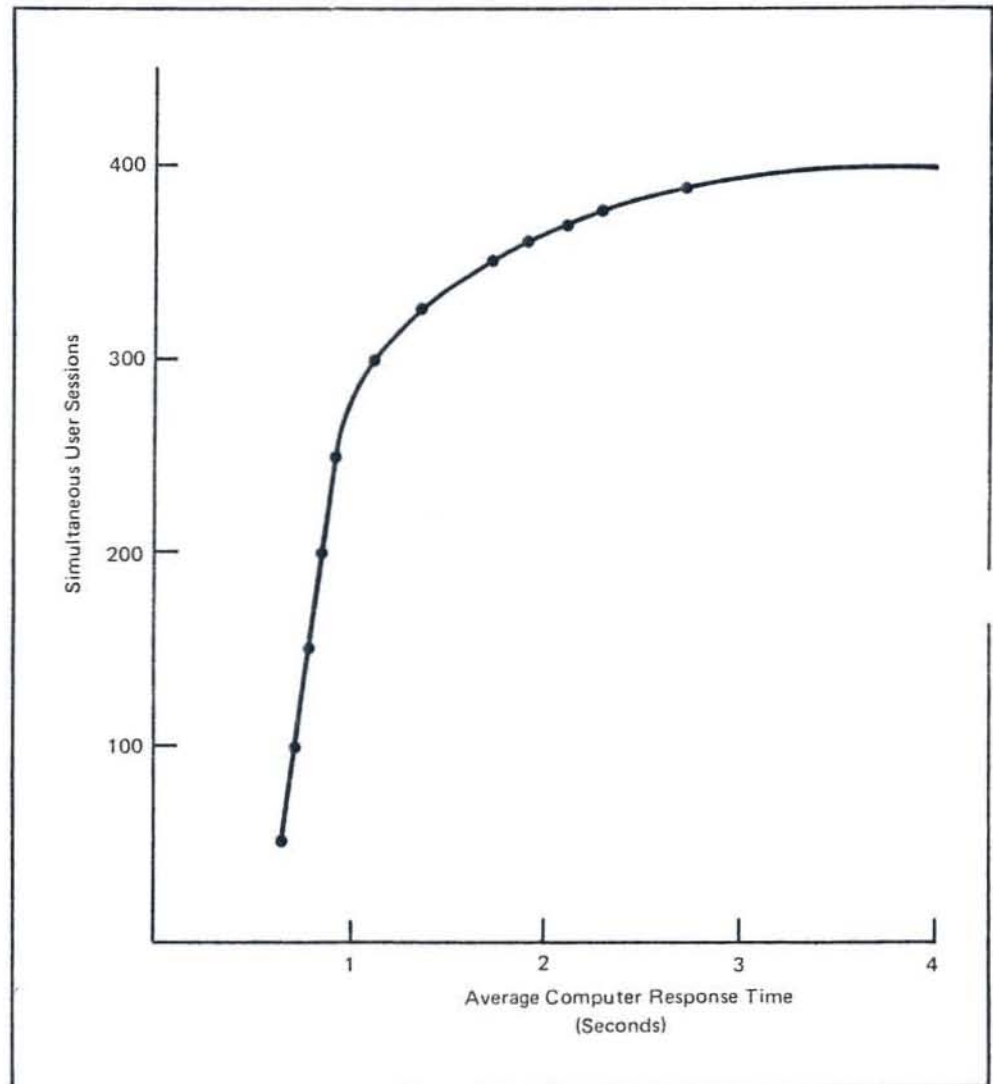


Figure 4. Response Time Deterioration with Increasing System Usage at the National Institutes of Health Computer Utility

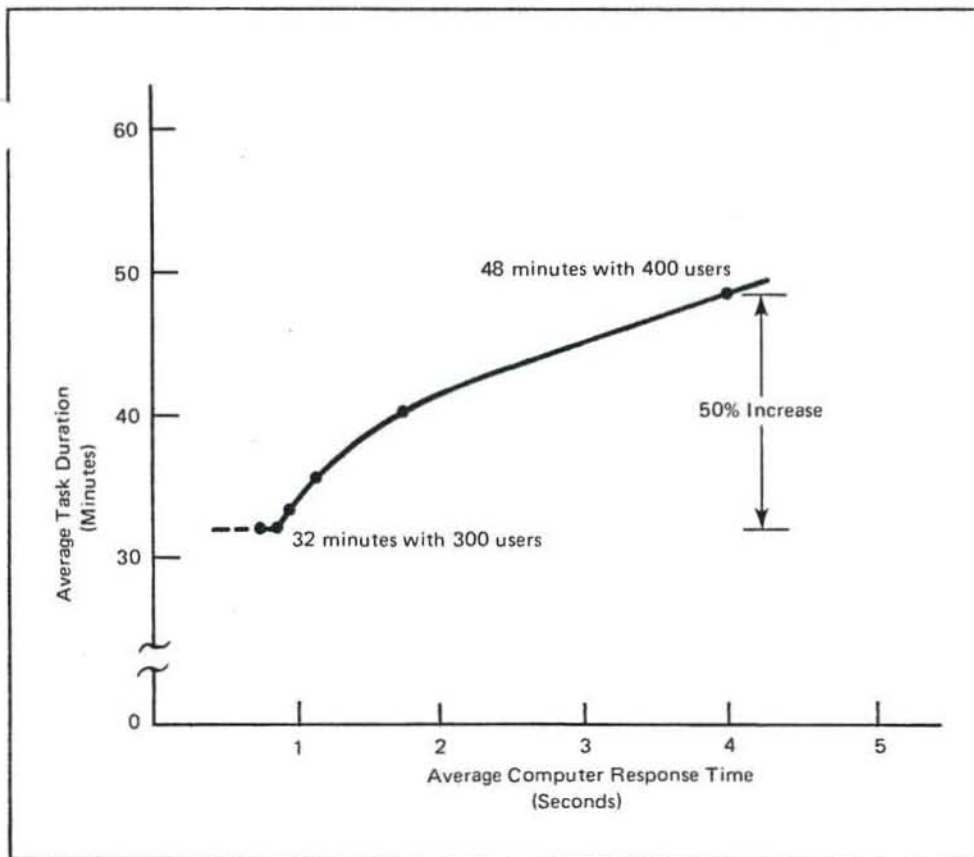


Figure 5. Growth of Task Duration with Response Time Deterioration at the National Institutes of Health Computer Utility

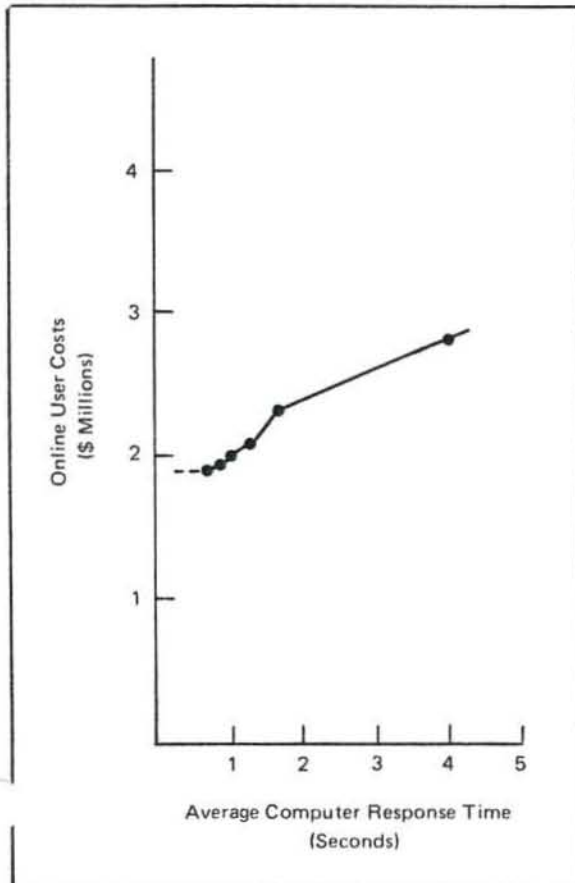


Figure 6. Increased Monthly Costs with Response Time Deterioration at the National Institutes of Health Computer Utility

Improved Individual Productivity

Improved individual productivity is perhaps the most significant benefit to be obtained from rapid response time. After the publication of Thadhani's findings, a number of IBM projects sprang up to confirm his and Doherty's work and determine what effect improved and subsecond response would have on individual productivity. One such study involved the System Products Division (SPD). Among other online applications, SPD laboratories provide high-function graphics to assist their engineers in the physical design of boards, cards and chips, all components in today's computers. The engineers use display terminals specifically designed for the high transaction rates necessary to manipulate graphic images.

The SPD study measured 75 work sessions of 15 engineers at graphic display terminals as they performed various physical design tasks. Their transaction rate data confirmed Thadhani's curve, (Figure 7). Indeed, it showed considerably more. All users benefited from subsecond response time. In addition, an average, experienced engineer working with subsecond response was as productive as an expert with slower response. A novice's performance became as good as the experienced professional and the productivity of the expert was dramatically enhanced.

SPD conducted an additional series of tests at different laboratories to see whether the actual elapsed time to do a particular task would decrease with subsecond response time and increased transaction rates. For these tests, a group of engineers were acquainted with a card wiring task and then asked to perform it under conditions that made system response time the dominant variable. SPD correlated the elapsed time each engineer needed to wire the card with the system response time being provided during the session.

The findings from the four laboratories all showed significant reductions in the time to perform the card wiring task (Figure 8). In laboratory A, task time was reduced by 4.5 minutes for every 0.1 second reduction in system response time. Card wiring time went from 82 minutes to 66 minutes, an improvement of 20%, as response time decreased from .6 seconds to .25 seconds. In laboratory D, task time was reduced 3.6 minutes for every 0.1 second improvement in system response time. Correspondingly, card wiring time went from 36 to 23.5 minutes

for a productivity gain of 35 percent when system response time was brought down from 0.6 second to 0.25 seconds.

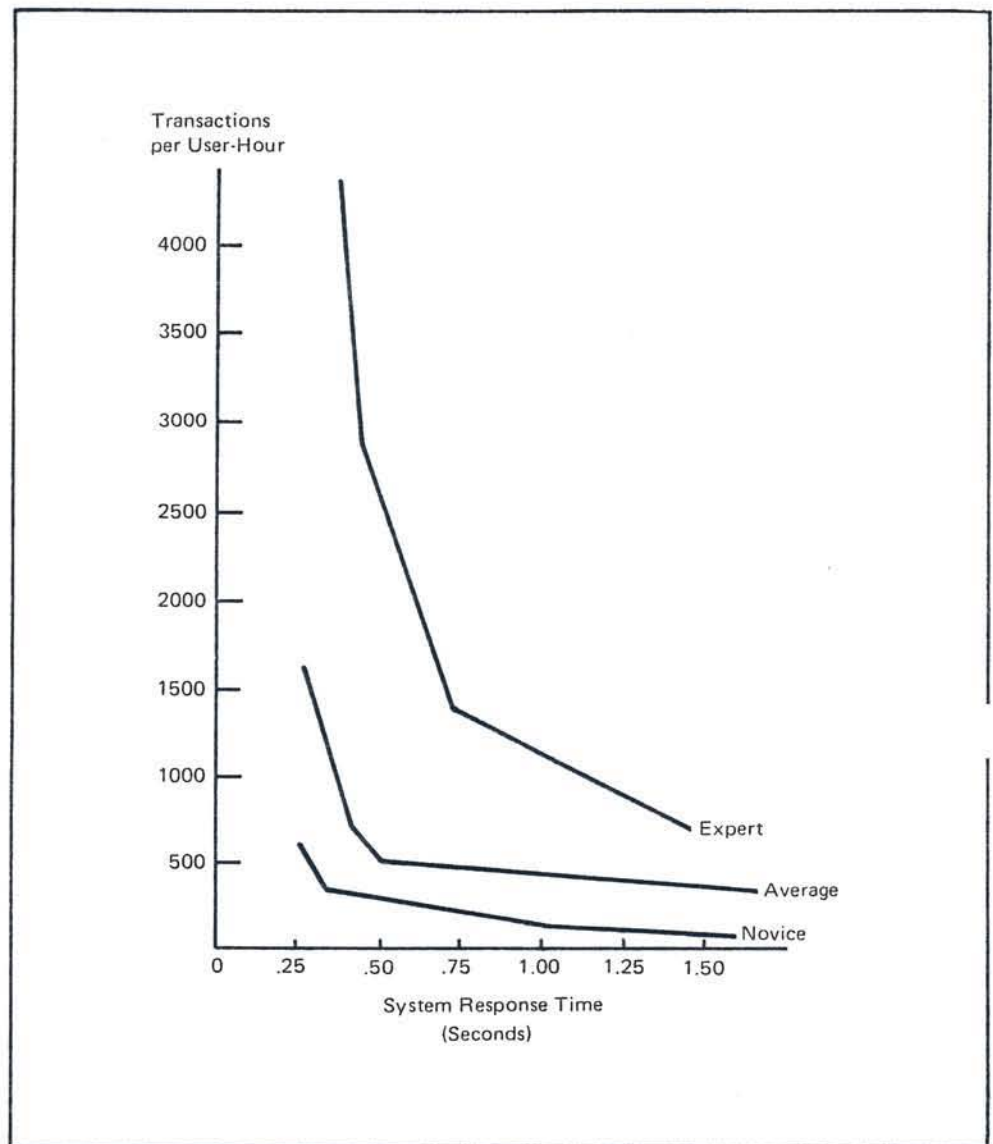


Figure 7. High Function Graphics, Transaction Rate versus System Response Time

Shortened Project Schedules

Management at IBM's program development facility in Portsmouth, England, saw the potential in Doherty's and Thadhani's work. In order to make their own test, they provided each programmer in an upcoming project with individual terminals and subsecond system response. The people in this facility measure, as a matter of accepted practice, the output of individual programmers and programming groups and have, over the years, developed rather accurate techniques for estimating the time and resources that a project requires. Therefore, any substantial deviation from one of their estimates can be considered a true variance and valid comparisons of group performance are possible.

Most of the facility's terminals operate over a communication network using comparatively low-speed data communications, rather than through high-speed lines that are connected directly to the system. Each terminal in the test project was connected to the system by high-speed local communication lines. This change brought system response time for the project team down from the 2.3 seconds that was common throughout the facility to 0.84 seconds.

Based on the expected number of function points in the program, a measure that considers both the size and complexity of the program, it was estimated that the project would require 30.8 months of programmer time, spread over 19 weeks. It was actually completed four weeks early and required only 18.7 months of programmer time, 39 percent less than expected.

The team's productivity was also compared with their performance on a similar project six months earlier, using function points as the basis for the comparison. With subsecond system response, the average programmer produced 14.4 function points per month, 58 percent more output than the 9.1 function points per month the average programmer had produced on the earlier project.

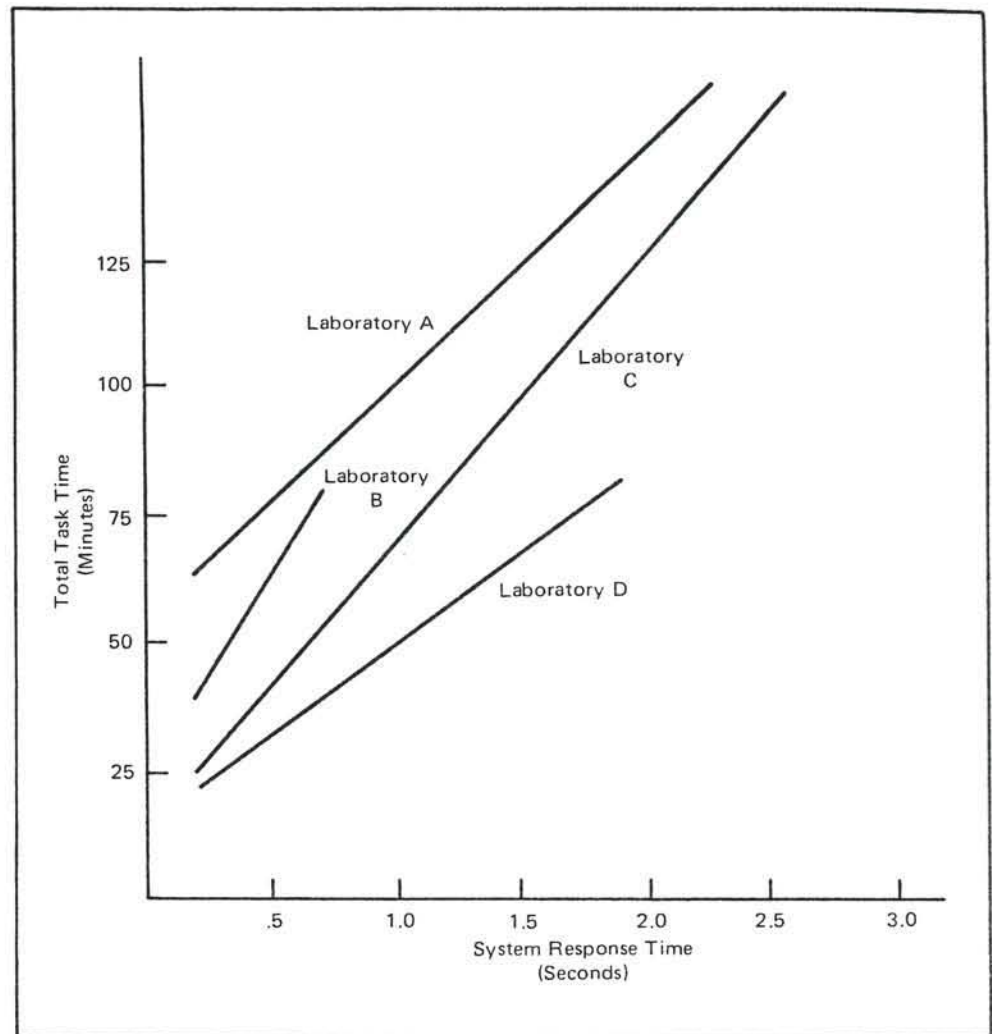


Figure 8. Effect of Improved System Response Time on Total Task Time, as Determined in Card Wiring Experiments at Four IBM Laboratories

Improved Quality

Given a level of service that was much better than they were accustomed to receiving, the programmers on this project explored a wider range of problem solutions than they would normally pursue and increased the scope of their online work. Their professional enthusiasm was justified by subsequent reports from quality assurance. Tests there uncovered only 3.0 trouble reports per hundred function points, compared to 6.9 trouble reports per hundred function points for the team's earlier project.

Broad Applicability

The studies described up to this point involved scientists, engineers, and programmers. A test conducted with administrative professionals indicates that the same benefits can be realized with subsecond response time in data base applications. Component forecasters at IBM's Poughkeepsie facility make frequent reference to an online data base when estimating requirements for electronic parts. The work involves the maintenance of part inventories, bills of materials, and timetables of production and delivery, all tasks similar to those handled by production planners in many organizations.

Five component forecasters were provided subsecond response time for a half-day experiment during which their transaction rate productivity was measured. In their normal working environment they had a system response time of five or more seconds and an average individual productivity rate of 99 transactions per hour. During the test they worked at an average of 336 transactions per hour, a productivity increase of 339%.

Effect on Other Computing

Response time improvements do not lessen the demand for processing; they speed up the performance of tasks by compressing computing into a shorter time span. It follows that as more of these tasks can be performed in the course of a normal business day, the computer will have to handle a significantly increased amount of online work, both batch and transaction processing, if the momentum generated by the faster response is not to be lost.

An example will illustrate. Assume the online entry, batch compilation, and debugging of a program requires the execution of 100 million instructions. Further assume that this is accomplished in one day by an online programmer working with several-second response time and two-hour batch turnaround time. To increase productivity, provide this programmer with subsecond response and a batch turnaround time of one hour. Completion of the program may now be reduced to four hours. Execution of 100 million instructions will now be done in half the time.

Data from the National Institutes of Health and IBM's Portsmouth study support this conclusion. At NIH there was an average of 90 transactions and two batch submissions per work session. This did not vary, even though work session length varied with the computer response time. At Portsmouth, processing time as measured by the amount consumed per function point was approximately constant. Hence, daily processor time consumed by the programmers with subsecond response time went up because each was producing more output.

Thus, to realize the full productivity benefits of improved system response time, the computing center must also be prepared to increase all levels of service. This may be done by expanding the size of the system or by distributing part of the online workload to smaller local systems. The specifics of the solution depend on the organization's total computing environment.

Cost/Benefit Illustration

To bring the potential benefits of rapid system response into perspective, consider an illustration. Based on the data Thadhani published (Figure 2), the average user can complete 180 transactions per hour at three second response time (Figure 9). For simplicity, then, assume a task that involves 180 transactions and takes an hour to complete. Any one user can complete eight such tasks in a day. Further, assume the burdened value of the user's time is \$35 per hour. These numbers will be held constant for the purposes of this illustration.

As system response time improves, the time required to complete a task drops from the original 60 minutes to only 29.1 minutes. Since the average user completes eight such tasks in a day, the maximum amount of time that can be saved is 247.2 minutes, or 4.1 hours. In a month of 21 work days, the value of these saved minutes is \$3,028.

The number of simultaneous users an online system supports varies from organization to organization as does the amount of improvement in response time which is needed. But, in all cases in this illustration (Figure 10), the financial incentive for bringing system response time from three seconds into the subsecond range is substantial, ranging from \$150,000 per month when only 50 people use a system at any one time to \$908,000 when 300 people use the system simultaneously.

Conclusion

Rapid system response time, ultimately reaching subsecond values and implemented with adequate system support, offers the promise of substantial improvements in user productivity. IBM and others have verified this and demonstrated that lower unit job costs can result. Other organizations may want to pursue studies similar to those mentioned in this brief and go on to implement subsecond system response for their own online systems.

System Response Time (Seconds)	Transactions per Hour*	Task Time (Minutes)	Time Saved per Task (Minutes)	Time Saved per Day (Minutes)
3.0	180	60.0	—	—
2.0	208	51.9	8.1	64.8
1.0	252	42.9	17.1	136.8
0.6	279	37.7	22.3	178.4
0.3	371	29.1	30.9	247.2

*Based on Thadhani's data (Figure 3)

Figure 9. Computation of the Time a User Saves in a Day as System Response Time Improved from 3.0 Seconds to 0.3 Seconds

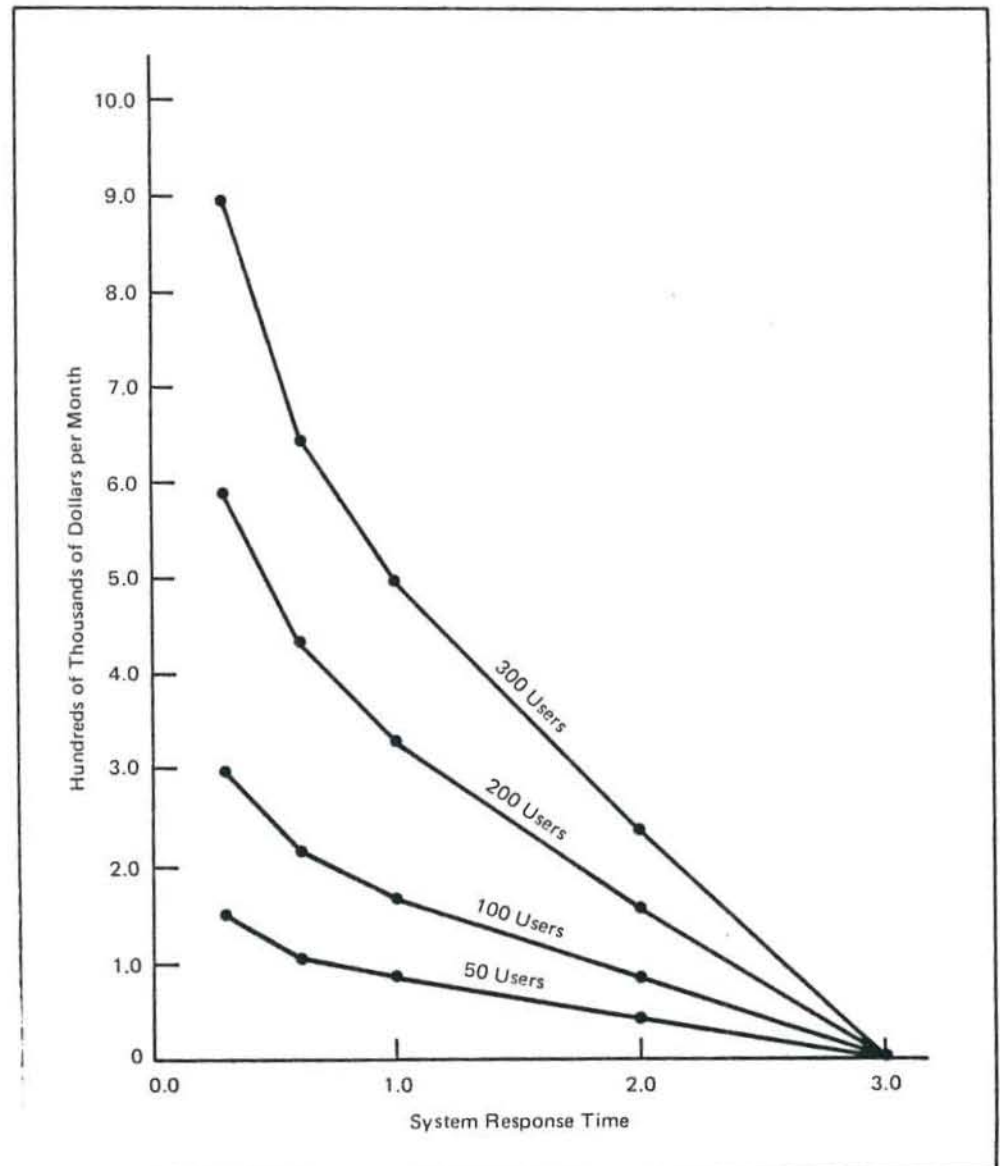


Figure 10. Potential Monthly Savings from Rapid System Response for Systems with Varying Numbers of Simultaneous Users

THE "370" FAMILY

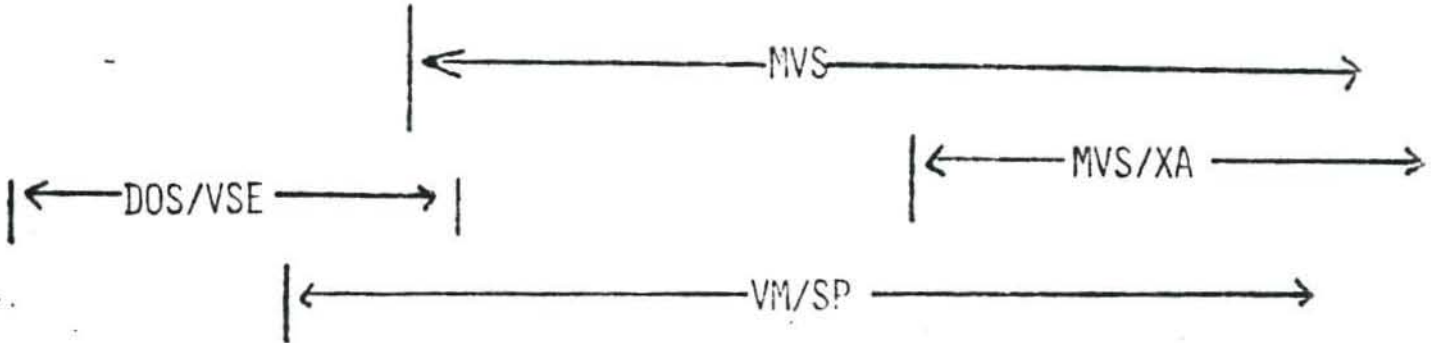
1 MIP

15 MIP

6 MEG

32 MEG

4321 4331 4341 3031 3033 3083 3082 3081 3084



NON 370 COMPATIBLE MACHINES

- SERIES /1
16 BIT MINI
(IBM PDP-11)
- 8100
DISTRIBUTED PROCESSOR
- IBM PERSONAL COMPUTER

MAJOR PERIPHERAL FAMILIES

TERMINALS 3270

3278-II	1,920 CHARACTER CRT (3277 OLD MODEL)
3279	COLOR CAPABILITY
3178	LOW COST 3278
3290	10,000 CHARACTER PLASMA DISPLAY

ALL ATTACH TO 3274 CLUSTER CONTROLLER

FRONT ENDS

3705	
3725	RECENTLY ANNOUNCED 2.5 TIME THRUPUT OF 3705 TWICE THE PRICE PERFORMANCE MAX 230 Kbps LINE SPEED

SOFTWARE FOR BOTH IS NCP (NETWORK CONTROL PROGRAM)

OPERATING SYSTEMS

MVS (MULTIPLE VIRTUAL STORAGE)

LARGE SYSTEM O.S.

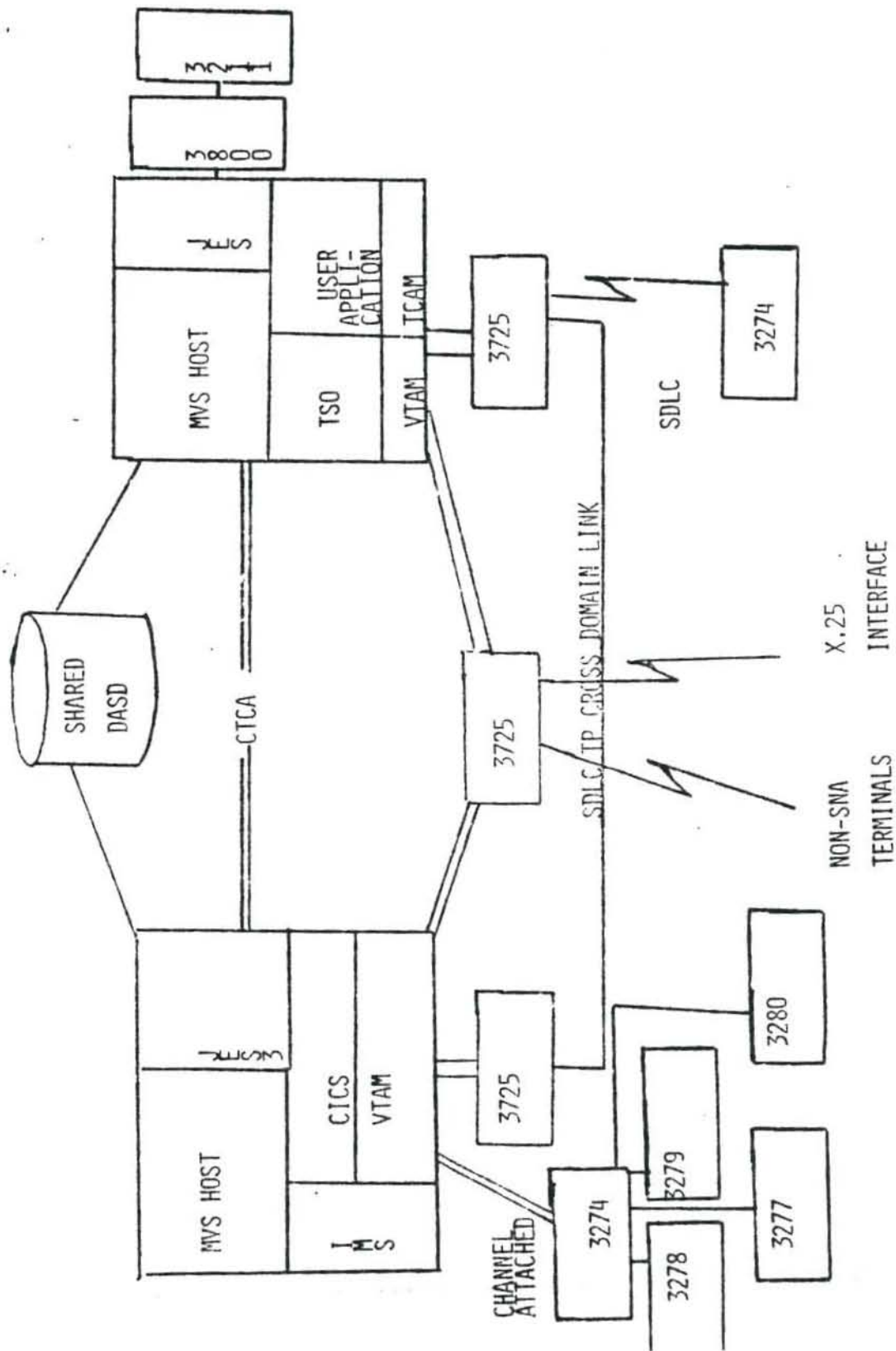
DATA BASE/ DATA COMMUNICATIONS APPLICATIONS

SUBSYSTEMS

- JES (JOB ENTRY SUBSYSTEM)
JES2 (REWRITTEN HASP)
JES3 (REWRITTEN ASP)

FOR LARGE LOOSELY COUPLED MULTIPROCESSOR CONFIGURATIONS

- NETWORKING
SNA (SYSTEMS NETWORK ARCHITECTURE)
ACCESS METHODS (VTAM, TCAM)
- DATABASE/ DATA COMM
IMS (INFORMATION MANAGEMENT SYSTEM)
CICS (CUSTOMER INFO. CONTROL SYSTEM)
- TIMESHARING
TSO (TIME SHARING OPTION)



TYPICAL IBM MULT-HOST CONFIGURATION - JES3 RPLX - SNA I/F

1. Front end communication processors can perform the following functions:
 - a. Communication line control.
 - b. Protocol/code conversion.
 - c. Message queuing/buffering.
 - d. Error control.
 - ☒ e. All of the above.
2. A line splitter and/or an intelligent port selector is a:
 - a. Terminal.
 - b. Modem.
 - ☒ c. Line adapter.
 - d. Protocol converter.
 - e. None of the above.
3. Modems perform the following functions:
 - a. Analog to digital conversion.
 - b. Loopback testing.
 - c. Modulation.
 - d. Diagnostic checking.
 - ☒ e. All of the above.
4. Multiplexers are used to:
 - ☒ a. Reduce circuit costs.
 - b. Increase transmission speed.
 - c. Increase transmission throughput.
 - d. None of the above.
 - ☒ e. All of the above.
5. Concentrators can be similar to or a sub-set of:
 - a. Multiplexers.
 - b. Biplaxers.
 - c. Neither a nor b.
 - ☒ d. Both a and b.
 - e. None of the above.
6. Hardware encryption involves the use of:
 - a. Protocol converters.
 - b. PBX/CBX.
 - c. Concentrator.
 - d. All of the above.
 - ☒ e. None of the above.

- T 7. The terms data communications, telecommunications, and teleprocessing are used interchangeably by many writers in the field of data communications.
- F 8. Connector cables interconnect, or go between telephone company central (switching) offices.
- F 9. Single application networks simultaneously process the data from many business applications on an international scale, on a multiorganization basis.
- F 10. Special common carriers design custom telecommunications circuits to be implemented in terminals.
- F 11. Videotex involves the two-way transmission between the telephone set in your home and many other organizations outside of your home.
12. A line-sharing device may be used to:
- a. Connect the local loop to the telephone company central office.
 - b. Connect the front end communication processor to the host computer.
 - ☒ c. Connect several terminals to a modem.
 - d. All of the above.
 - e. None of the above.
- F 13. The host computer is considered to be the same as a remote concentrator.
- T 14. A front end communication processor is the primary interface between the central data processing system (host computer) and the data communication network.
- F 15. The basic function of a modem is to prevent errors during data communication.
- F 16. Frequency division multiplexing is the same thing as time division multiplexing.
17. The host computer in your business system is considered to be the:
- a. Remote concentrator.
 - b. Protocol converter.
 - ☒ c. Central computer.
 - d. Remote switch.
 - e. None of the above.

category of terminal:

- a. Remote job entry terminal.
- b. Video terminal.
- ☒ c. Transaction terminal.
- d. Intelligent terminal.
- e. Teleprinter terminal.

19. Which one of the following is not a piece of data communication hardware:

- a. Multiplexer.
- b. Modem.
- c. Terminal.
- ☒ d. Protocol.
- e. Protocol converter.

F 20. ASCII is a five-level code.

F 21. The bit positioning numbering system is identical between EBCDIC and ASCII.

F 22. An eight-level code has 128²⁸ different combinations.

☒ T 23. OK Open-wire pairs, wire cables, and coaxial cables are the same type of transmission media.

☒ 24. Optical fibers are the primary circuit in cellular radio.

T 25. The usable bandwidth of a voice grade circuit is 3,000 Hertz.

F 26. DPSK and PSK are identical modulation techniques.

T 27. Pulse code modulation can be used to convert an analog voice signal to a digital stream of pulses for digital transmission.

F 28. Bits and baud are always identical.

☒ T 29. Polling and selecting perform precisely identical tasks, which is to see if the terminal has a message ready to transmit to the central site.

☒ F 30. Echo suppressors are not required in a dial-up data communication connection.

31 Baseband signaling involves:

- a. Frequency modulation.
- ☒ b. Direct electrical voltages. ^{dc?}
- c. Phase modulation.
- d. Amplitude modulation.
- e. None of the above.

32 The most common code of data communications is:

- ☒ a. ASCII.
- ☒ b. EBCDIC.
- c. BCD.

- F 37.** A signal that is transmitted from its source machine in direct electrical voltages is called baseband signaling.
- F 38.** Asynchronous transmission is a form of block transmission where an entire block is transmitted at one time.
- T 39.** Connector cables are used to interconnect a terminal and a modem.
- F 40.** An RS449 connector cable has a maximum cable length of 50 feet.
- T 41.** The "clear-to-send" signal is sent out by the modem.
- F 42.** Digital modems are more expensive than analog modems.
- T 43.** A station terminal is sometimes called a terminal block or voice jack.
- T 44.** The terms amplifiers and attenuation relate to each other in a cause-effect relationship.
- F 45.** Two-wire/four-wire circuits and full duplex/half duplex are identical concepts.
- T 46.** A T-1 carrier is used for digital transmission.
- 47.** The front end processor performs functions such as message logging, error detection, protocol conversion, and so on.
- I/T 48.** Satellite circuits have a greater delay time than microwave circuits.
- 49.** Which mode of transmission will result in the greatest throughput:
- a. Asynchronous.
 - (b) Synchronous**
 - c. Both are the same
 - d. A combination of the two.
- 50.** Which of the following are connector cables:
- (a) RS232C.**
 - b. RS449.
 - c. X.21.
 - (d) All of the above.**
 - e. None of the above.
- OK →**
- 51.** A terminal box or voice jack is an:
- a. Amplifier.
 - (b) Station terminal.**
 - c. Local loop.
 - d. Digital modem.
 - e. Switch

47. If you are able to transmit in both directions, but utilize only one direction at a time, your circuit would be:
- a. Full duplex.
 - ☒ b. Half duplex.
 - c. Simplex.
 - d. Complex.
 - e. None of the above.
48. Front end communication processors usually imply the use of a technique called:
- ☒ a. Central control.
 - b. Interrupt.
 - c. Multiplexing.
 - d. Hardware encryption.
 - e. Multidrop circuits.

Fill-in

49. Local Loop is the circuit that would interconnect the terminal at your business location to the telephone company central office.
50. data termination Systems (DTS) is one of the technologies that may overcome the bottleneck of interconnecting your terminal to the telephone company central office.
51. A dial up network provides the public with a network that they can share (lease). Examples of companies in this business are: Telenet, Tymnet, Sprint, and MCI.
52. Interexchange channels are the circuits that interconnect the telephone company central offices in different cities.
53. A channel might be a copper wire interconnecting two terminals.
54. A microprocessor is the Central Processing Unit (CPU) in a micro-computer.
55. Image documents can be transmitted using a Facsimile device.
- For what does PBX stand? Private Branch Exchange
56. Intelligent terminals are ones that have a built-in microprocessor chip with the capability of being programmed and executing stored programs.
57. Hardware encryption involves a lockable box that is placed between your terminal and the modem, and between the front end communication processor and the modem.

58. A protocol converter allows a terminal that uses one protocol to talk to another host computer that uses a different protocol.
- The primary use for a converter is to combine circuits.
59. Multiplexing done by the telephone company for voice calls is pure multiplexing (not statistical), and it is totally transparent to the caller. In other words, there is no delay of your voice.
60. A mathematical model describes the entities of a system and their attributes are represented by mathematical variables.
61. Simulation is a technique to duplicate the behavior of the communication system or network.
62. Response time is viewed as an elapsed time incurred. It usually is viewed as the time between when the terminal operator types the send key and the return on the first character to the terminal.
63. A voice grade twisted pair is the most common communication circuit in use today.
64. 1 MHz (Megahertz) = 1 million cycles per second.
65. One piece of hardware that you might find between the host computer and the front end communication processor is the data channel.
66. Error detection and message logging are two key functions performed by the front end communication processor.
67. The telephone company central office is where your Local Loop terminates.
68. attenuation is the weakening in strength of a signal as it passes down a wire.
69. amplifiers are used to increase the strength of a signal at various fixed points on the circuit path.
70. The digital side of a digital-to-analog modem is the side that is connected to the terminal.
71. Data signaling/synchronization is where the terminal and the modem exchange signals prior to the transmission of a message.
72. An RS232C is a connector cable.
73. Character-by-character transmission is called asynchronous transmission.

74. Describe what "downline network control" means.

The removal of data communication control functions from the host computer to other devices outside the host; such as the F.E.P., intelligent controllers, modems, etc. Free's host for application processing.

75. How many unique combinations are there in a 5-, 6-, 7- or 8-bit code?

$$2^5 = 32 \quad 2^8 = 256$$

$$2^6 = 64$$

$$2^7 = 128$$

76. Using the ASCII code structure, what is the exact 8-bit configuration of the line control code "NAK" for an even parity system.

~~1101 0011~~ 0001 0101

77. What is the most significant disadvantage of using a multiplexer? A possible increase in response time. Delay

78. How many pins/wires are in the RS232C interface plug? 25

79. How many pins/wires are in the RS449 interface plug? 37 Do you know how many pins are in the reverse, or secondary channel plug that might accompany an RS449? Yes, 9

80. Can you draw a picture of the frequencies in order to represent full duplex transmission on a two-wire circuit? (ON BACK OF THIS PAGE)

81. If you had transmission where you could transmit in both directions simultaneously, what would you call this? full duplex

82. Muckrakers Anonymous Publishing Co. has a 2,400 bps dial-up line using a BSC protocol. The remote terminals are set for full duplex operation, and operate in the Mid-West. The best choice of the remote modems listed below is:

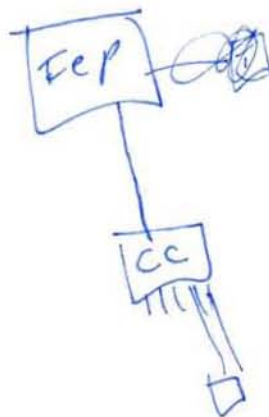
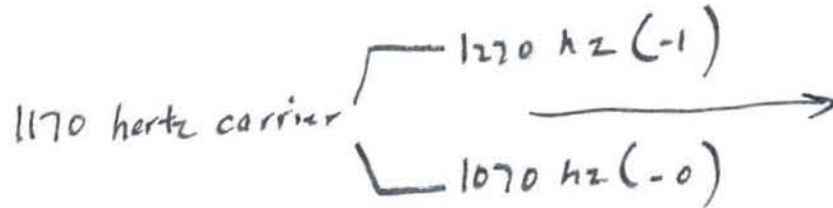
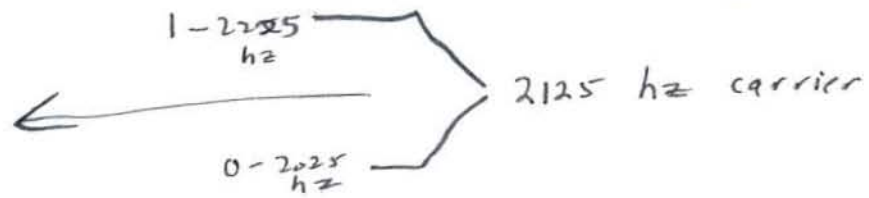
- a. Synchronous modem, 2,400 bps Bell 201 type
- b. Asynchronous modem, 2,400 bps with Full Duplex capability on dial-up line
- c. Multispeed modem 2,400/4,800 bps with split channel feature and CCITT interface.
- (d) Synchronous modem, 2,400 bps with Full Duplex capability on dial-up.

83. When supporting synchronous batch terminals operating at speeds of 2400BPS the best type of multiplexer to use is:

- a. STAT MUX
- b. Character Interleaved TDM
- c. Bit Interleaved TDM
- (d) FDM MIX

Pdx two-wire

80.



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