An Overview — Networking Cost Performance Issues

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The purpose of this paper is to give managers a conceptual overview of several key issues in datacommunications networking. We will focus on several practical, useful guidelines. At the end we will address what is practical and sensible today for most applications. As managers, you cannot wait for the promises of 10 years or even 5 years from now. A basic principle we will stress is response time for the terminal user.

Response time will be stressed because the major function of an HP3000 is to serve a human being, a person using the computer through a computer terminal. As human beings, we demand fast response times. We take our cars instead of waiting for the bus. We take the plane because the train or car is too slow for long distances. We eat at fast food restaurants. We read newspapers because we can scan vast amounts of information, pages and pages, in just seconds. We are equally demanding of fast response and convenience from our computers.

Getting to some practical information we can use today, we will first look at 10 specific topics, and cover them in rapid fire order. The 10 items could be full blown topics in their own right. What we as managers want to get out of the 10 points, however, are the practical guidelines. The technical staff folks and the vendors all have their technical pitches, and we must distill out sensible solutions that work today.

The 10 points, then are:

1. Telephone line cost trends
2. Data communications hardware cost trends
3. Technology trends of datacommunications hardware
4. Local networking alternatives
5. Packet protocol caveats
6. Satellite communications caveats
7. Importance of fractional second response time
8. Bits per second versus speed
9. Point to point versus multipoint cost/performance considerations
10. One large, efficient network

We will look at each one of these 10 points and highlight the important points using a few charts, graphs and illustrations. After we get through the 10 points, we will have a better basis for quickly getting to some firm network approaches. While there are many choices, many of them correct, most fall within a narrow range of practical solutions. In the end, it is then the responsibility of the manager to choose a solution that works. There will be no right or wrong decisions, just some that fit better than others. The ones that fit the best will be those made by management that has a good idea of the direction in which it is going and the destination it wishes to reach, and then asks the right questions to get most directly to the destination.

POINT 1. *The trends in telephone company communications line costs.* The trend in costs is up. Costs for lines are increasing at about 16 percent annually. We have an example of Illinois local private line rates. In 1970, a local private line cost just $3.50 per month, went to $15.00 by 1975 and is now up to $35.00 per month. That is for a line that may just go across a street. Telephone company charges for toll calls have not gone up much at all in the same time frame. Take note, however, that the phone company is slowly but surely working to put even local calls on a usage charge basis. The local call usage charges are already in place in Chicago, New York, Washington and other cities, both in the United States and elsewhere in the world.

The upward price pressure is clearly on dedicated facilities. Today, many areas in the United States have not yet caught up to Illinois, but will. You can look upon the Illinois example as a benchmark for where rates will go throughout the United States. The telephone companies are going to the state public utility commissions and gradually raising these private line rates.

Guidelines we can draw from this are:

1. Economize on lines using statistical multiplexers
2. Economize on lines using split stream modems
3. Be aware that local dial up lines can become much more expensive
4. Satellite and private local facilities may not yet be less expensive than telephone company private lines.

POINT 2. *Datacommunications hardware trends.* Users have been spared the full impact of the rising phone line rates by the reduction in the prices of datacommunications hardware. You are all probably familiar with the constant reduction in the prices of CRT displays and printing terminals. The prices for modems and multilexers, two key datacomm ingredients for on line networks, have also seen prices come down. In 1970, a 9600 bits per second modem cost about $10,000, or "a buck a bit." Today, some 9600 bps modems can be purchased for as little as $3,000. The prices of 4800 bps modems have dropped from $5,000 in 1970 to half or less than half of that price. Statistical multiplexers, a product just about 3 years old now, has seen a 25% price reduction in its young product life.

Guidelines we can draw from the hardware trends are:

1. Expect these approximate hardware costs;
   - 0 to 300 bps dial up modems now cost $200 to $300 per unit,
   - 1200 bps full duplex dial up modems, $700 to $900 per unit,
   - 2400 bps synchronous 201 type modems, $700 to $1,200 per unit,
   - 4800 bps sync 208 type modems, $2,000 to $4,000 per unit,
   - 9600 bps sync 209 or V.29 modems, $3,000 to $6,000 per unit,
   - 4 channel statistical multiplexers, $1,500 per unit,
   - 8 channel statistical multiplexers, $2,400 per unit,
   - Short haul synchronous modems, $600 per unit,
   - Short haul asynchronous modems, $300 per unit,
2. Expect prices to come down, features to be added, or both.

POINT 3. *Technology trends*. The technology trends of datacommunications hardware have also been at work to spare the user the full impact of rising phone line rates. The statistical multiplexer just mentioned is a perfect example. The stat mux, as it is called, has improved the price performance of ASCII CRT's and printers by more than a factor of two. The stat mux makes more efficient use of the phone line, lets the async ASCII terminal run faster than it could before, and often at lower costs than some slower, less efficient methods.

Another technology improvement of just a few years ago that we already take for granted is the 1200 bps full duplex dial up modem, equivalent to the Bell model 212. The 212 has been around for just about a half dozen years. Look for 2400 bps full duplex dial up equipment, at an affordable price, in the very near future.

The technology in datacommunications is making more efficient use of existing facilities, facilities are getting faster and more reliable, we are getting more control over the equipment, and more features. Microprocessors are showing up in more datacommunications equipment every day. We can do more and more for less and less. Just look at how vendors are scrambling to stay profitable in the face of this trend by giving you more and more features for the same prices, or even lower prices. That is good news for all users.

It is useful to look at the changes in technology over the years 1970, 1975, today, and what we may see in 1985.

1970

- Frequency division multiplexers (FDM)
- Time division multiplexers
- 103.113 type 300 bps modems
- 202 type 1200 bps modems
- 201 type 2000 to 2400 bps modems
- 208 type 4800 bps modems

1975

- Same as 1970 plus
- 212 type 300 to 1200 bps modems
- 209 type 9600 bps modems
- Short haul modems
- Coaxial cable modems
- First diagnostic tools

1980

- Same as 1975 plus
- Statistical multiplexers
- Integrated technical control systems
- Satellite
- Value Added Networks (VAN)

1985

- More software in datacomm products
- More features
- More cost effective local network products
- More cost effective fiber optics
- 2400 bps full duplex dial up modems

Guidelines drawn from technology trends:

1. Expect hardware to be very reliable, 20,000 to 50,000 hours Mean Time Between Failures (MTBF)
2. Look for simple to use features. For example, test functions that are useful but not too detailed if you or your staff do not use the functions daily. What good is it to know your bit error rate is 1 in 10 to the 6th, if you are not sure if that is good or bad.
3. As time goes on, look for more features for you money.

POINT 4. *Local networking*. Before we get to some of the details about local networking, take note that many local network products are still more promise than reality. Most installations today cannot yet take advantage of local networking technology because of the costs, or lack of interface compatibility.

Local networking alternatives include protocol options such as ethernet collision/detection, token passing methods, time division or frequency division. Links available include coaxial cable, twisted pair, infrared, microwave, and fiber optics. Hardware includes short haul modems, coaxial cable modems, ethernet type of interfaces, PABX's with data channel capability, and more hardware appears with increasing regularity. A good local networking overview article can be found in the December, 1981 issue of Datacommunications Magazine.

Guidelines concerning local networking:

1. For the HP3000, short haul modems are the most practical local network product.

2. Fiber optics are usually too expensive.
3. Ethernet type solutions are usually too expensive yet today.
4. Coaxial modems are often more expensive that short haul modems.
5. The short haul modem solution is practical today only within several miles of the computer. Beyond that, long haul modems are usually required.

POINT 5. *Packet Protocol Caveats:* Packet protocols that you hear about today include X.25, HDLC, SDLC, and many of the protocols found in the Value Added Network services such as Telenet and Tymnet. These protocols have a place, but are not going to be a complete solution. These protocols are:

- Designed mainly for message transfer, packets, electronic mail
- Too slow for full duplex operation
- Not suitable for the HP ENQ/ACK terminal to CPU handshake

As a practical guideline:

1. The packet protocols may have a place for mainframe to mainframe communications.
2. The packet protocols are rarely practical for terminal to mainframe communications.

POINT 6. *Satellite Communications Caveats.* The basic fact to consider abvout satellites is that they sit in a stationary orbit about 25,000 miles above the earth. It is that physical fact that contributes to the plus and minus features of satellites. First of all, satellite costs are not mileage sensitive. It matters not whether you go across the street or across the country, the cost is the same. Keep in mind that because it is not mileage sensitive, satellite is cost effective only on links of 500 miles or more.

A major consideration for satellite is local distribution of the data once you get it off of the satellite. From one major point to another major point, satellites can be cost effective, but not from many diverse points to many other diverse points.

Satellites are not very good for highly interactive data. Any transmission using satellite is bound by the speed of light, 186,000 miles per second. A round trip for data, via satellite, is 100,000 miles. Figure the round trip time to be almost 3/4 second.

Guidelines for satellite transmission:

1. Because of the round trip delay time, satellite is not suitable for the HP ENQ/ACK handshake or polled terminals (MTS).
2. You may wish to use satellite to connect mainframes, but not to connect terminals on line.

POINT 7. *Importance of fractional second response time.* At first glance, it may seem improbable that people need a 1/4 second response time or less to be efficient in interactive applications. It is in fact rather difficult to really grasp just how long 1/4 is.

To illustrate the importance of such small portions of time, consider the example of a radio call in show. We have all heard the person who calls in, and while listening to himself on a background radio, gets confused. The announcer says, "Please turn your radio down." Callers hear their own voices, fed back over the radio, but the delay disorients and confuses the caller.

To site another example, a user typing at a terminal will become very inefficient if the typed characters echoed back are delayed by just 1/4 second. The terminal user types ahead of the display rate of the characters and experiences what feels like a spongy keyboard. When a mistake is made at the keyboard, extra characters must be erased and retyped just to get back to the incorrect character.

When users are on line, say in a telephone order situation, it is important, if the person is to work at maximum efficiency, to get feedback for each keypress in 1/4 second or less. Typing at just 45 to 50 words per minute requires a key press every 1/4 second. When the keys do not get echoed back by the computer within that 1/4 second time window, the user slows down to match the echo time.

Keep in mind at this point that a high bits-per-second rate does not automatically mean fast response time. This fact can be easily illustrated by considering a 300 megabyte disk that we send by mail. If the post office delivers the disk in just 3 days, the transfer rate equals 9600 bits per second.

Guidelines for considering response time:

1. Response time over the communications link should be measured in milliseconds for interactive use. If the user operating a local terminal sees no delay, then the remote terminal user should see no delay, either.
2. For batch work, for file transfers and electronic mail, response time is less important than the bits-per-second transfer rate.

POINT 8. *Bits per second versus speed.* It may seem contradictory at first, but 9600 bits per second may not be as fast as 2400 bits per second. The difference is response time difference.

A Bell 2400 bps modem, model 201 allows for much faster polling in an MTS environment than does a 9600 bps modem, model 209. The difference in response time is accounted for in the Request To Send/Clear To Send delay functions of these modems. In a multipoint polled (MTS) environment, the RTS/CTS delay allows the modem at the central computer site to "tune" itself to the incoming signals from modems at any one of several remote sites.

The 2400 bps modem has an RTS/CTS delay of only 7 milliseconds, while the 9600 bps modem has a delay of 147 milliseconds. Given a typical poll of 12 characters and a 3 character response (a total of 15 characters), the

2400 bps modems allow for 3 times as many polls per second. For short message traffic, the lower speed modem may be a good bit faster.

Guidelines regards bits-per-second versus speed:

1. In a polled (MTS) environment, 2400 or 4800 bps is often the best you can do for your money.
2. File transfers to an RJE station or mainframe to mainframe can benefit from the 9600 bps modems, since there is usually no concern about the RTS/CTS delay.
3. Using statistical multiplexers and asynchronous terminals, the typical best speed is 2400 bps for the terminals, and 4800 bps for the composite modem link, for up to 8 terminals. 9600 bps may be called for if printers are heavily used.

POINT 9. *Point to point versus multipoint (MTS).* In an HP3000 environment, point to point usually means using asynchronous CRT's and printers. Multipoint is the MTS environment. What we want to do here is look at the differences from the datacomm point of view.

We have a case study to look at comparing MTS with point to point using statistical multiplexers. The user is in Dundee, Michigan. The test involved 2 CRT's and 1 printer, running on 4800 bps Bell 208 modems. The specific test was to evaluate how the user saw response time, and to measure actual output volumes.

The results were clearly in favor of the statistical multiplexer method of operation, even when terminals were slowed from 4800 under MTS to 2400 bps async. Measured output was more than double for the async mode of operation. The users at terminals saw noticeable reduction in response time when the printer was running, but not when using the asynchronous mode and statistical multiplexers.

It should be noted, too, that the async terminal operation is usually easier to set up, easier to diagnose, easier to maintain.

Guidelines on point to point versus multipoint:

1. In most cases on an HP3000, point to point asynchronous operation proves to be the most cost and performance effective.
2. You may wish to consider MTS (polled terminals) if you do very little printing along with CRT displays at remote sites and your response time can reduced by a few seconds. The printer is the major consideration.

POINT 10. *One large efficient network.* The network we will examine here is the United States switched phone network, the one we use when dialing local or long distance calls. The US phone network, managed primarily by AT&T, is well developed, efficient, and employs the princples of good networking.

Examining the routing of a phone call from Champaign, Illinois to San Antonio provides a good look at the structure of the network. A typical call is routed:

1. From the local telephone station, over a station loop to the central or end office.
2. The end office connects to a toll office via a toll connecting trunk.
3. The toll office, say in Champaign, connects to another toll office via an intertoll trunk. There are several classes of toll offices in the network hierarchy.
4. To avoid going through the entire chain of toll office command, the call may be routed from one lower level office to another, close to the destination. The lower level offices are connected via high useage trunks (HUT's).
5. The toll office close to or actually in San Antonio connects the call to the end office in the city, which rings the local phone.
6. The call is completed when you pick up the phone.

This entire process is referred to as circuit switching, since the call connection uses actual, physical circuits. Packet switching, on the other hand, does not make a connection via actual circuits, but packages up the data and routes the databased on destination addresses included in the packages.

Suggested guidelines based on the phone network:

1. Think of your HP3000 as though it is a PABX on location in a business. Its purpose is to connect terminals to files and terminals to terminals.
2. Terminals will almost always be connected to the HP3000 the way phones are connected to a PABX or central office, with one port per terminal, just as there is one physical line per phone number or extension.
3. Access through the HP3000 should be as standard and simple as possible.

At this point, we will look at a specific network on an HP3000. The user here is Johnson and Staley of Nashville, Tenessee. This network takes all this information and illustrates the kind of datacommunications most practical for 90% of all HP3000's.

The Johnson and Staley application is on line order entry and inventory maintenence for a distributer of school supplies.

The Johnson and Staley application embodies our 10 points in the following ways:

1. The line configuration is designed to keep the phone line costs to a minimum.
2. The links between the multiplexers are 4800 bps, about the best in price for the bits-per-second rate needed. Five years ago Johnson and Staley would probably have decided that the modem and multiplexer costs were to high to go on line.
3. The DDS, bandsplitting of DDS, and the stat mux's are all late 1970's technology.
4. Local networking is not applicable here.

5. Satellite links are not cost or performance effective here.
6. Packet networks are not cost or performance effective here.
7. The on line order entry activity required very fast response times.
8. A link of 9600 bps per terminal grouping would not improve performance in this application. The volume of data is small for this application. The need is for instant access to the inventory and order records.
9. Line cost savings that might otherwise be available only thru multidrop networking are acheived by bandsplitting.
10. Terminals are connected on a per port basis to the HP3000, much like extensions to a switchboard.

SUMMARY OF HOW 90% OF ALL HP3000'S COMMUNICATE

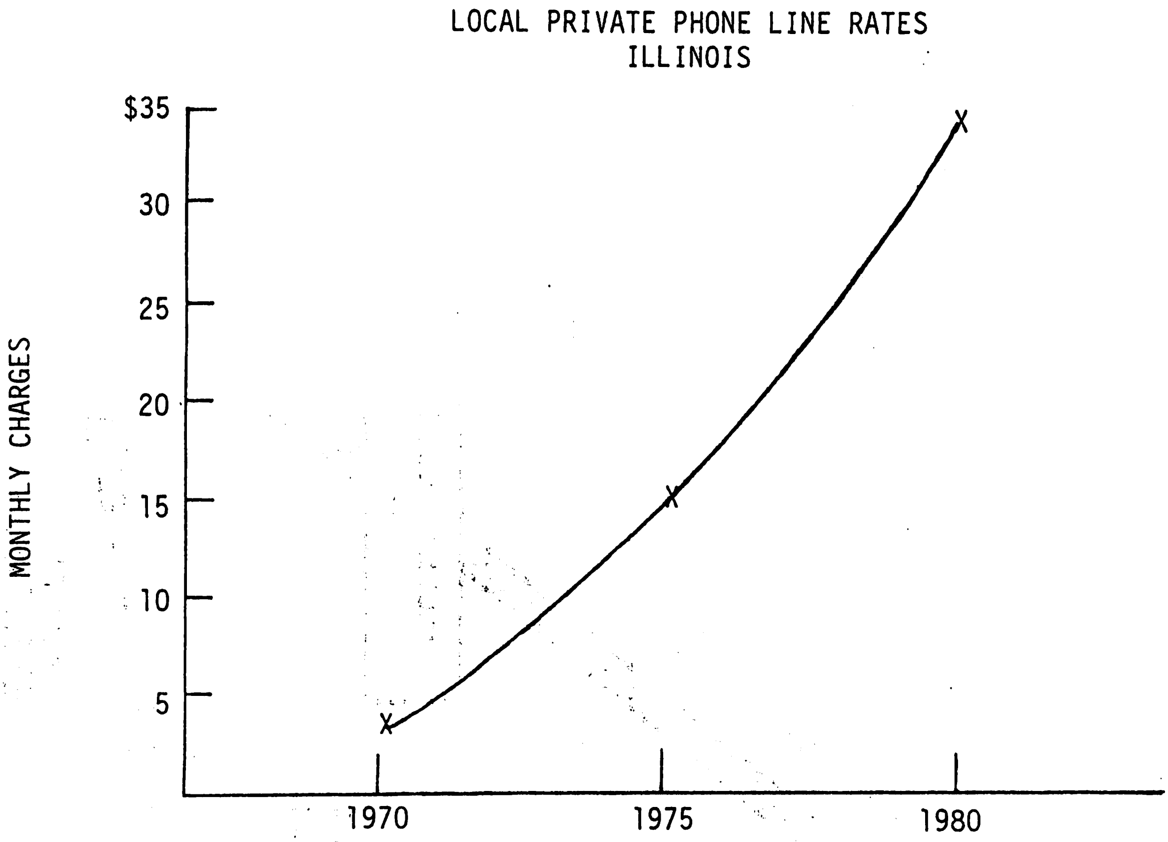
HP3000 to HP3000 or larger mainframe:

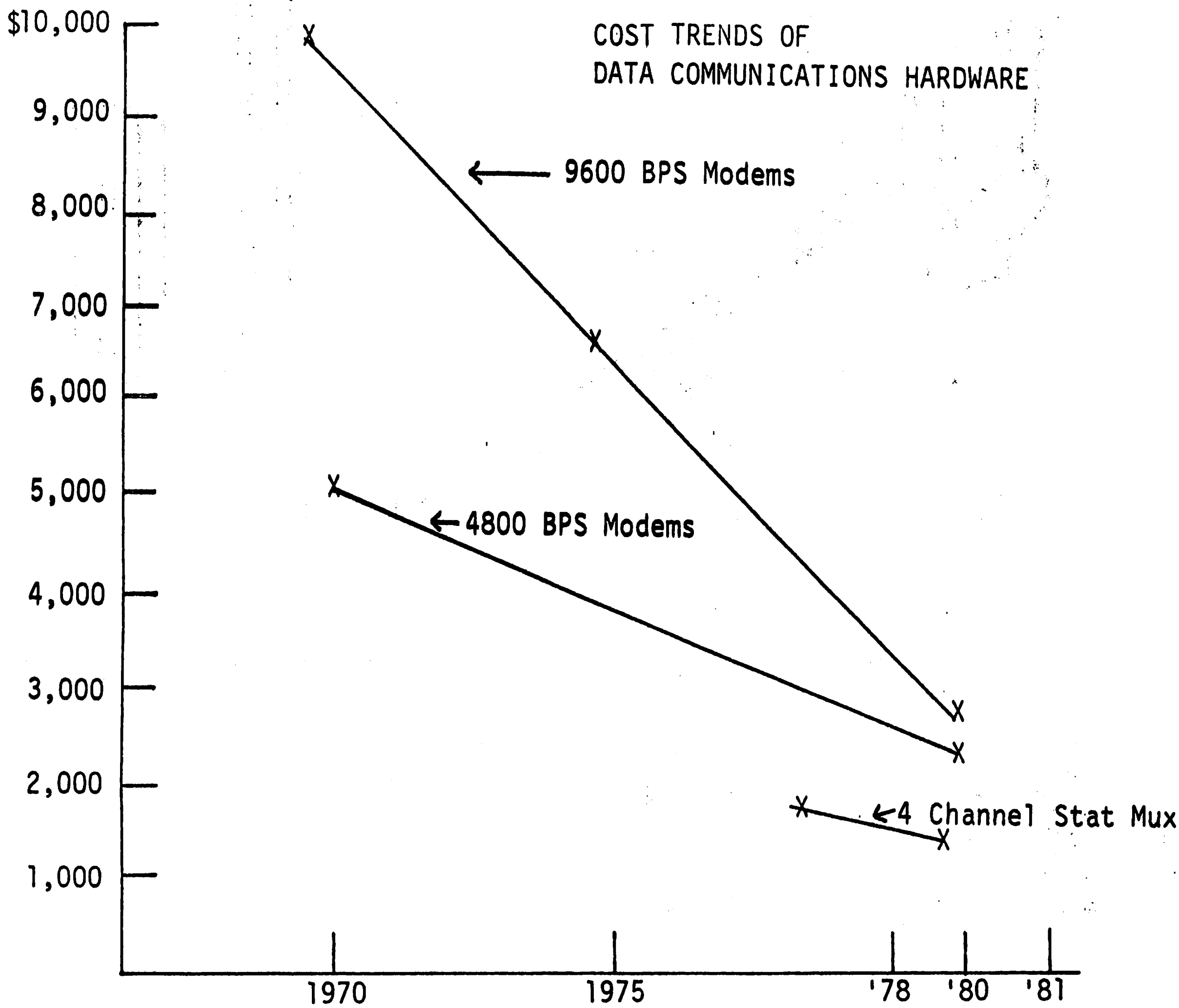
- Synchronous facilities
- Private line
- 2400, 4800 or 9600 BPS
- Digital Data Service (DDS)
- Very few satellite links

HP3000 to terminals:

- Hardwired or within 100 miles of the mainframe
- Asynchronous, with dial up, single modems or stat mux's
- Speeds of 1200 or 2400 BPS

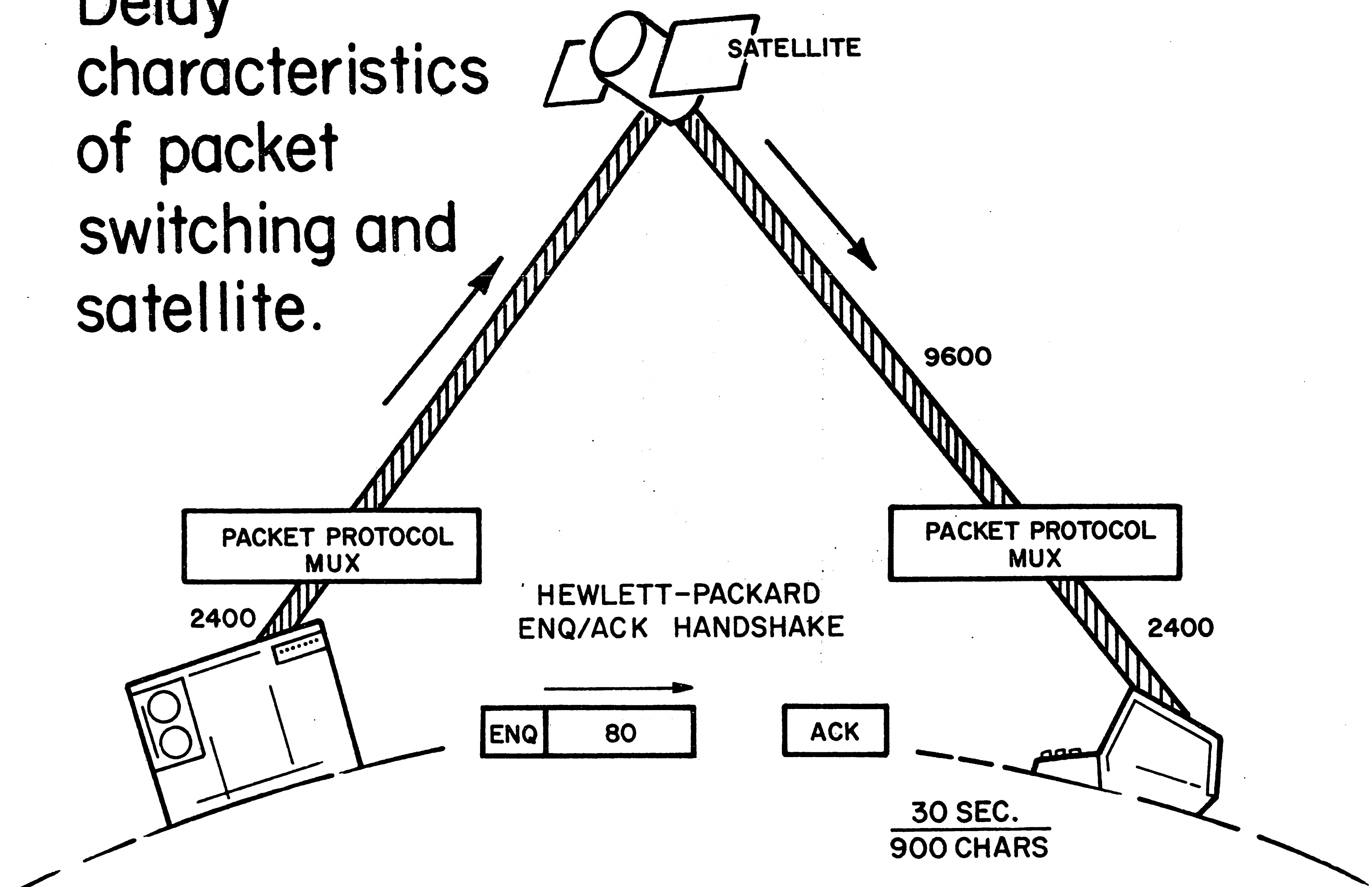
In conclusion, for all the choices and possible confusion surrounding HP3000's in a data communications environment, 90% of all systems have the same configurations, with minor variations.


LOCAL PRIVATE PHONE LINE RATES
ILLINOIS
MONTHLY CHARGES
$35
30
25
20
15
10
5
1970
1975
1980


COST TRENDS OF
DATA COMMUNICATIONS HARDWARE
$10,000
9,000
8,000
7,000
6,000
5,000
4,000
3,000
2,000
1,000
9600 BPS Modems
4800 BPS Modems
4 Channel Stat Mux
1970
1975
'78
'80
'81

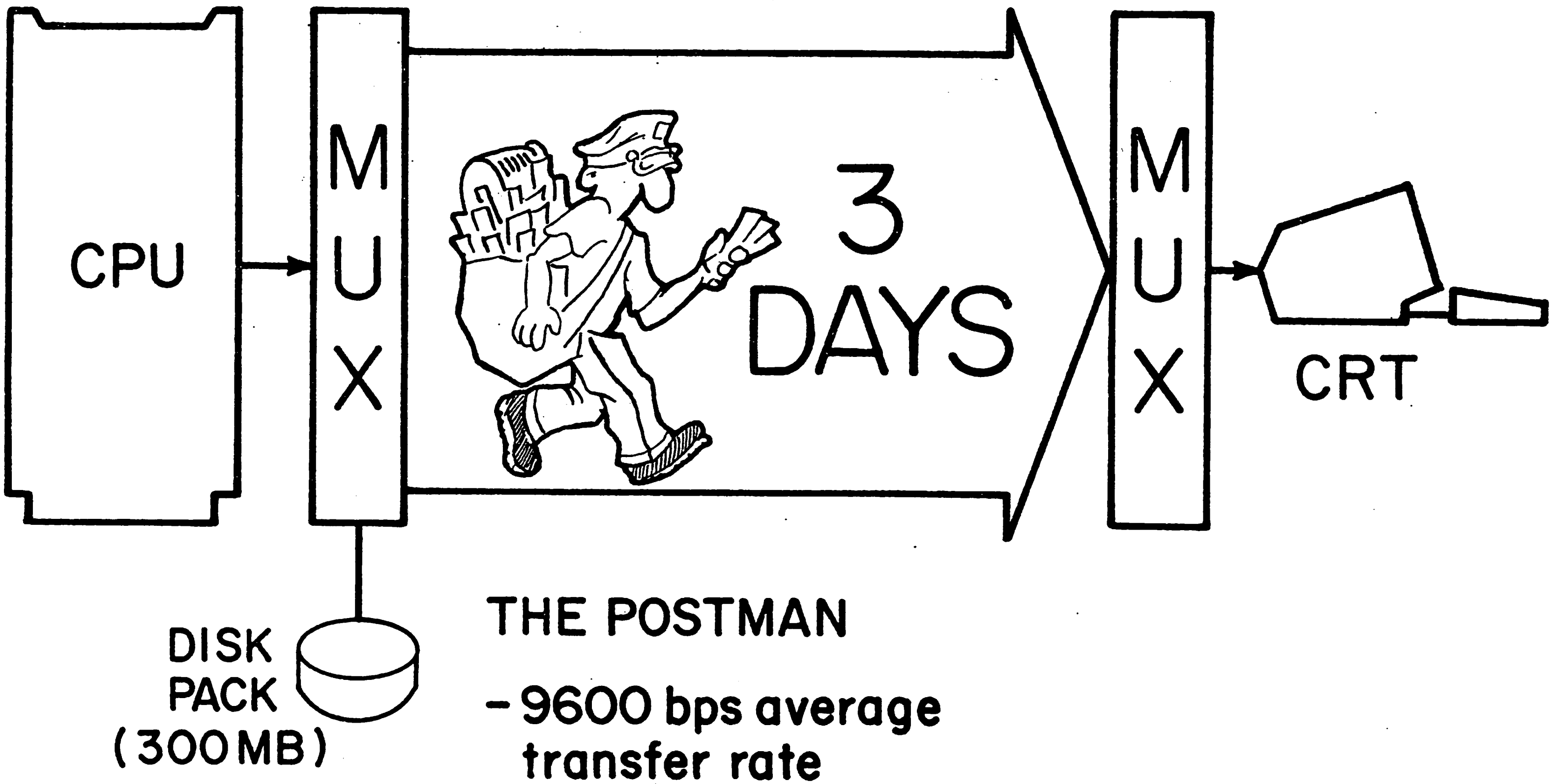
C.C.I. 81

Delay characteristics of packet switching and satellite.



11 — 38 — 7

The Postman delivers 9600 bps.



THE POSTMAN

- 9600 bps average transfer rate
- Good for large volume several day delivery

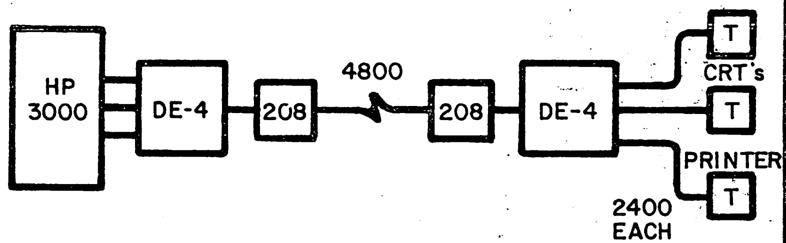
C.C.I. 81

BENCHMARKED 12-79

2 network alternatives

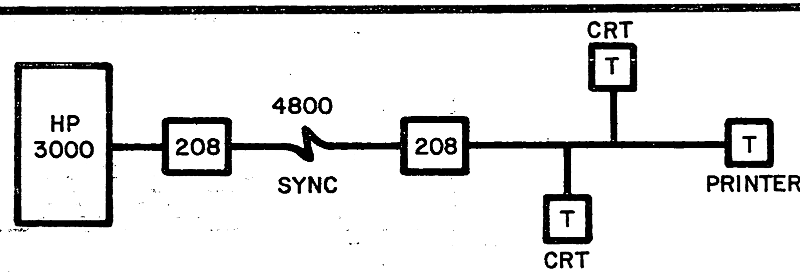
Asynchronous stat muxed terminals

POINT TO POINT



Polled

MULTIDROP/MULTIPOINT



TESTED AT DUNDEE CEMENT, DUNDEE, MICHIGAN

Total one way output...

listing only —

280 CPS Average

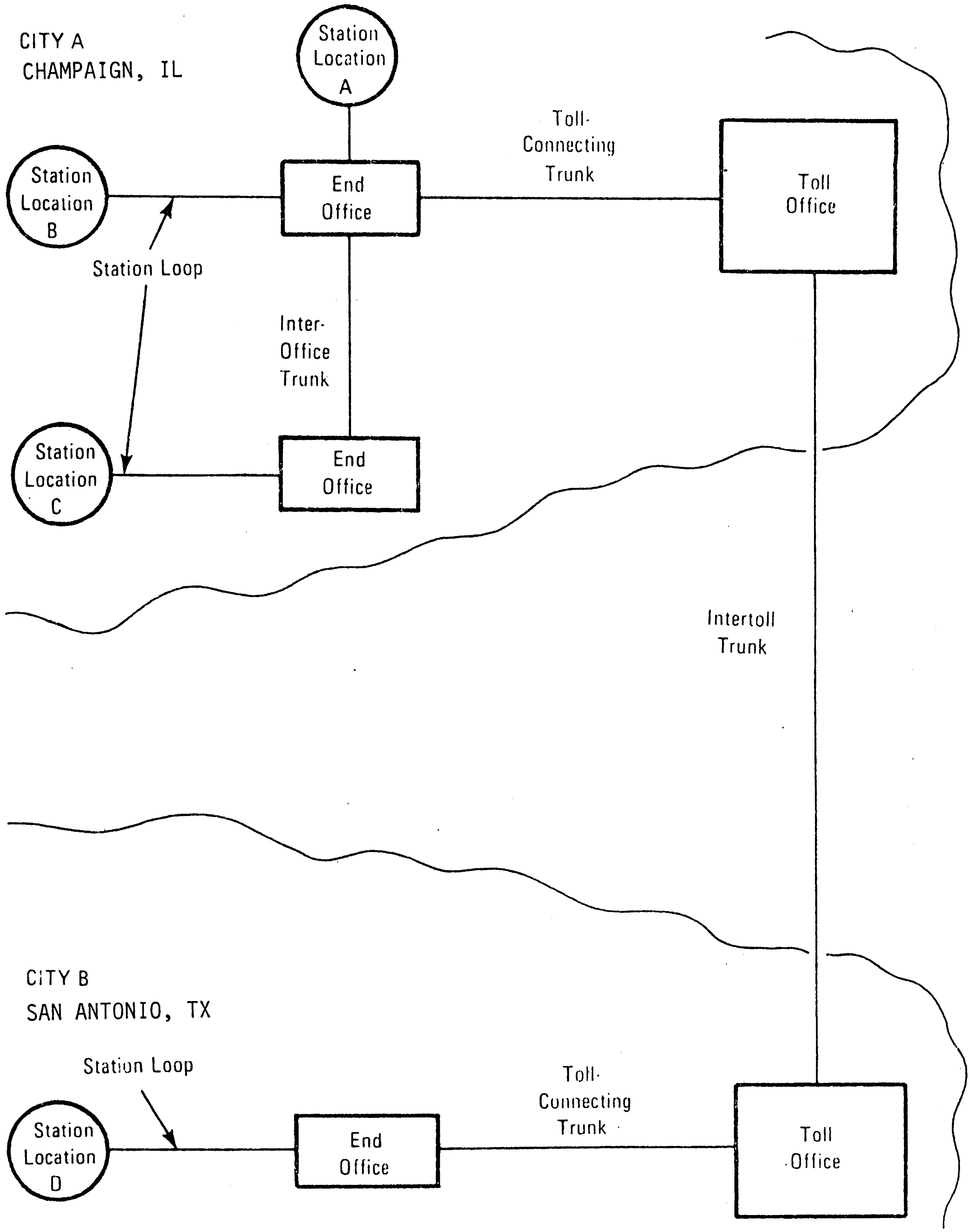
Same modems, terminals, data output – ASYNC Interactive

Total one way output...

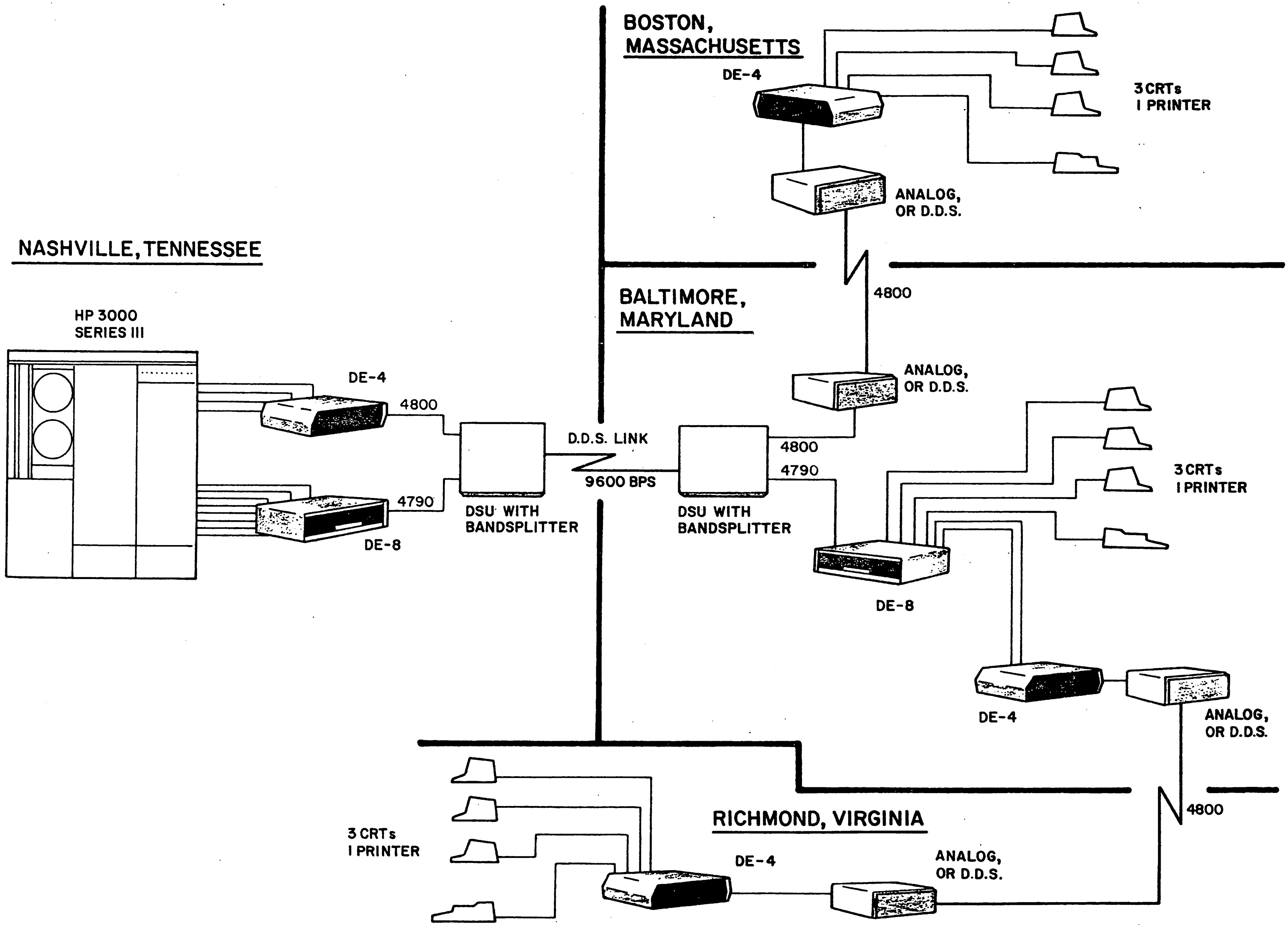
listing only —

115 CPS Average

Same modems, terminals, data output – SYNCHRONOUS Polled



Typical Routing for Connections


BOSTON, MASSACHUSETTS
DE-4
3 CRTs
1 PRINTER
ANALOG, OR D.D.S.
4800
NASHVILLE, TENNESSEE
BALTIMORE, MARYLAND
HP 3000 SERIES III
DE-4
4800
ANALOG, OR D.D.S.
D.D.S. LINK
9600 BPS
4800
4790
3 CRTs
1 PRINTER
4790
DSU WITH BANDSPLITTER
DSU WITH BANDSPLITTER
DE-8
DE-8
DE-4
ANALOG, OR D.D.S.
4800
RICHMOND, VIRGINIA
3 CRTs
1 PRINTER
DE-4
ANALOG, OR D.D.S.