THE DATA COMMUNICATIONS MARKET

MODEMS, MULTIPLEXERS AND COMMUNICATIONS PROCESSORS

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I - EXECUTIVE SUMMARY

Data communications revenues to the carriers were but $0.5 billion in 1970 and are forecasted to increase tenfold to over $5.0 billion in 1980. To make this growth possible, large numbers of data communication devices must be built and installed by the carriers as well as the users of the new data communication systems.

The Carterfone Decision of 1968 shattered the long-standing monopoly for the supply of terminal equipment for use on switched common carrier facilities and created at once a new "interconnect" industry which offers most favorable opportunities to independent equipment manufacturers. Hundreds of firms, large and small, responded to the challenge by entering the race to carve out a meaningful market share in the rapidly growing data communications equipment market and created more recently highly competitive conditions resulting in shakeouts in several market sectors.

Combined markets for modems, multiplexers and communications processors are expected to grow rapidly to almost $0.5 billion in a few years time, but each segment exhibits a unique growth pattern and presents specific challenges to competitors, few of whom have so far entered the market with a complete product line to meet all emerging opportunities, and many of whom do not have sufficient marketing organizations and service operations, as well as financial backing, to survive in this business.

Shipments of modems are expected to increase rapidly from nearly 200,000 per year today to over a million units annually by 1976. At the same time, a severe unit price erosion will prevent annual sales revenues from reaching more than about $70 million and will even later result in a reduction of this revenue rate in the face of continuing growth in unit shipments. Large Scale Integration and building in of modems into terminals and peripheral devices will reduce the use of that type of product to a component level, and permit only a few large volume manufacturers to exist as profit margins decrease drastically.

Multiplexer shipments will grow fivefold to reach a sales volume of $75 million per year in the year 1977, during peak demand from specialized common carriers, but subsequent saturation of the market and competition from programmable communications processors, which will offer the multiplexing function, will reduce that market to about $50 million in annual revenues during the second half of the seventies.

The communications processor market, which will double to about $350 million a year by 1976, is being predominantly supplied by computer and minicomputer manufacturers. Only 10% of that market segment is controlled by independent non-computer suppliers, and with the recent entry of IBM that company is expected to dominate this business in the near future, increasing its market share to as much as 50% of the total from only 17% at present.

A severe shakeout among the smaller producers of modems, multiplexers and communications processors is evidenced by rapidly falling prices in all market segments, but noticeably so in modems and communications processors. Partly this is a result of technological advances, but also it is due to very large numbers of competitors in a limited market which is unable to support all the entrants in this business.

The market will peak out in about 3 to 4 years, when numbers of units installed will continue to increase, but prices would have come down significantly to moderate this growth in terms of dollar volume. For more detailed discussion of each product area, please see the pertinent sections of this report.

The following table presents market forecasts through 1980 for modems, multiplexers, and communications processors.

TABLE I

MARKET PROJECTIONS FOR SALE OF MODEMS, MULTIPLEXERS AND COMMUNICATION PROCESSORS, 1970-1980

(Exclusive of sales by telephone companies)

($ in Millions)

Year	Multiplexers	Modems	Communication Processors	Total
1970	13.0	33.0	100.0	146.0
1971	17.5	36.0	170.0	223.5
1972	21.0	38.0	225.0	284.0
1973	24.0	43.0	260.0	327.0
1974	29.0	49.0	275.0	353.0
1975	38.0	60.0	300.0	398.0
1976	52.5	67.0	350.0	469.5
1977	75.0	58.0	335.0	468.0
1978	48.0	49.0	330.0	427.0
1979	49.0	42.0	320.0	411.0
1980	48.0	40.0	315.0	403.0

Source: Individual sections of this report.

II - DATA COMMUNICATIONS EXPLOSION

Summary

Almost 35% of all the general purpose computers in the United States today are operated on-line in communications oriented environments. This results in a growing population of terminals generating increasing amounts of data traffic.

Now that the batch processing computer systems are an old story and time-sharing systems have been firmly established, the computer user as well as new entrepreneurs are considering the possibility of increasing the efficiency of their systems even further by connecting with the vast and ubiquitous telephone network.

The marriage of computers and communications creates a need for new equipment without which the growth of on-line computing cannot take place.

This chapter discusses the ranges of growth of computers with terminals as a basis for the demand for multiplexers, modems and communications processors.

Ratios of terminals and population per terminal are also developed as parameters which indicate the limits of the projected growth in communications-based computer systems and terminals.

Increasing Use of Computers with Terminals

After a decade of spectacular growth, the computer industry slowed down and its hardware sectors exhibit more the characteristics of a maturing "replacement" market. Some sectors, however, continue or are beginning to show above average growth as new uses of computers are being introduced and popularized on a large scale throughout the nation.

One of the fastest growing segments is the remote computing area, where the use of computers is dependent on efficient data communications facilities and equipment.

Suppliers of data terminals, modems, multiplexers and minicomputers as data concentrators and pre-processors are benefitting directly from this growth, selling the necessary hardware to those who serve the ultimate user by offering time-sharing, remote batch processing, information services and various reservation services.

Market and technology trends become apparent when communications capabilities of the latest and most popular computers are examined. During the 1960's IBM 1401, the most widely used computer, had virtually no communications capability. The medium sized IBM System 360 computers which replaced the 1401's and represent the bulk of computer installations today, have a very limited communications capability and require special IBM "front end" equipment such as IBM 2701, 2702, 2703, etc. to perform in communications environment. The present IBM 370 series, however, is well equipped in communications hardware as well as software. This means that for the first time, data communications concepts are being made available to the huge "middle market" of commercial EDP users.

Source of Data Communications Growth

At present, estimates put the percentage of computers operating on-line with data terminals at about 35% of all computer installations and it is expected that by 1980 at least 70% of all the installations will operate in on-line modes.

Based on the present number of terminals in use, from one application to another, an average of about 24 terminals are attached to each on-line computer. The concept of "average number of terminals per computer" is a handy statistical tool. It should be recognized that this number varies substantially from one installation to another; certain specific systems with brief inquiry periods may actually have hundreds of terminals connected and controlled through communications processors or "front ends."

During the next few years we expect the average number of terminals per computer will increase to about 36, which will result in over 4 million data terminals in use by 1980.

Although computer systems have limited numbers of lines for communications, there may be a much larger population of terminals connected to the system because not all the devices are in use at the same time. In addition, interactive terminals may be connected via the dial-up network to many different computer systems at the users' option, depending on availability of computer resources at a particular location. Large time-sharing networks already employ communications processors and message switching systems to take advantage of all the computing facilities throughout their operating region.

Additional impetus in use of remote terminals is expected during the mid-seventies when independent communications common carriers such as MCI Communications Corporation and Datran will have their facilities available for use by the terminal user.

An increasing number of computers being installed in the next decade features "communications capability" and has remote, on-line terminals. Our estimates show that while the number of general purpose computers will increase threefold by 1980, it will be accompanied by a tenfold increase in data terminals during the same time period.

Yearly growth rates of computer installations are estimated at 10-15%, while those with communications capability will grow at rates between 16-36%. Data Terminals growth rates at the same time will be between 25-40% and the average number of terminals per system will increase significantly.

TABLE II

COMPUTERS IN USE WITH TERMINALS
(1970-1980)

Year	General Purpose Computers in Use	% in Use With Terminals	No. in Use With Terminals	Average Terminals Per System	No. of Terminals In Use
1970	49,000	25%	12,250	23	280,000
1971	53,000	31%	16,700	23	384,000
1972	61,500	37%	22,750	24	545,000
1973	70,100	43%	30,100	24	720,000
1974	80,600	48%	38,700	25	960,000
1975	92,700	54%	50,000	25	1,250,000
1976	105,700	59%	62,400	26	1,620,000
1977	119,400	63%	75,700	28	2,120,000
1978	133,700	66%	88,000	30	2,650,000
1979	148,400	68%	100,000	33	3,300,000
1980	163,300	70%	114,000	36	4,100,000

Source: Interconnect Market Study, 1972, Frost & Sullivan.

TABLE III

RELATION BETWEEN POPULATION AND TERMINALS, 1970-1980

Year	No. of Terminals	Millions (U.S. only) Growth of Population	No. of People Per Terminal
1970	280,000	200	725
1971	384,000	203	503
1972	545,000	206	308
1973	720,000	209	290
1974	960,000	212	220
1975	1,250,000	215	172
1976	1,620,000	218	135
1977	2,120,000	221	105
1978	2,650,000	224	85
1979	3,300,000	227	70
1980	4,100,000	230	56

The above table relates the growth in the number of terminals to the growth of population. It is generally believed today that the limit for terminals will occur when it reaches a ratio of about 50-75 people per terminal.

III - DATA COMMUNICATIONS AS A MARKET

Summary

Data communications revenues, while growing at 35-50% annually, account for only 3% of the total communications revenues of the common carriers and by 1980 are expected to increase to at least 10% of the total.

In order to appreciate fully the data communications markets, it is necessary to divorce the actual communications revenues of the common carriers who provide the transmission facilities from the sales volume of the manufacturers producing data communications equipment. Too often in the past those were not put in proper perspective, causing confusion and misunderstanding.

This chapter presents total communications revenues, indicates the percentage of data communications relative to that total, and discusses the need for special data communications equipment which must be sold to generate those revenues.

We concentrate on projections of data equipment used in transmitting data on the common carrier networks such as modems, multiplexers, and communications processors. This study does not discuss user data communication devices which originate or receive data such as terminals, data collection stations, voice response units, computer data banks or peripherals.

The chapter also discusses major data traffic growth areas which require such data communication equipment to generate the data traffic volume.

Growth of Communications

Modern data communications dates back to the mid-1950's and Bell introduced its Data-Phone service as long ago as 1958. At that time, according to the telephone company, the service was greeted with a particular lack of interest on the part of the computer user preoccupied with optimization of batch-oriented computer systems.

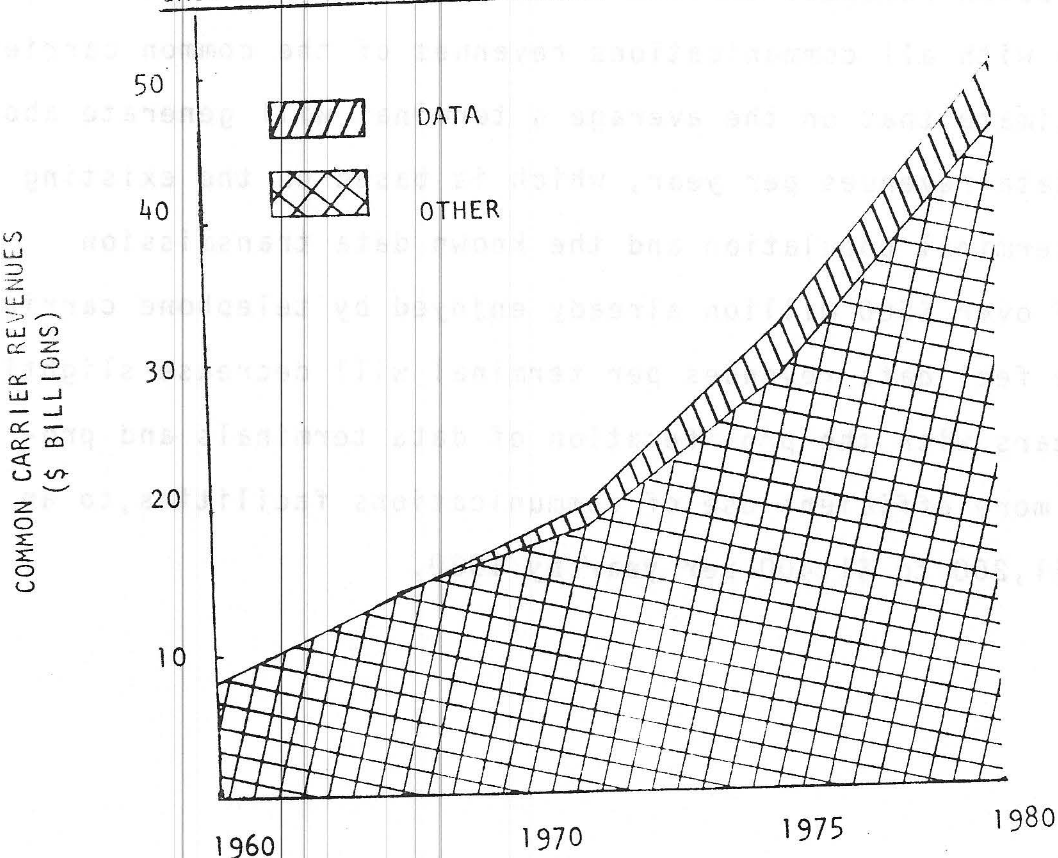
With the advent of second- and third-generation machines, users realized the economies and flexibilities that were possible in operation of computers with communications capabilities. Government and military agencies were the first large-scale users of data communications,and by 1970 the sub-industry matured to the point when it became the fastest growing segment of the communications business.

By 1970, data communications revenues of the common carriers accounted for more than $500 million and were reported growing at 35-50% annually and are expected to increase tenfold to at least $5 billion by 1980.

But keeping things in perspective, it must be realized that total communications revenues of the common carriers are expected to reach $50 billion in 1980, doubling from the present level of about $25 billion. Thus data communications, while growing faster than all other segments of the communications business, accounts for only 3% of all transmission time and a similar percentage of total transmission revenues. By 1980 it is expected that data transmission time will quadruple and its revenue contribution to common carriers will rise to at least 10% of the total communications revenues.

FIGURE 1

GROWTH OF DATA COMMUNICATIONS REVENUES (1970-1980)



Source: U.S. Department of Commerce
Industrial Outlook 1972 and
AFIPS 1972 SJCC Proceedings
"Data Communications 1980"

Growth of Data Communications Revenues

Our forecast of data communications revenues is based on the growing population of data terminals, which are the basic sources generating data traffic. The purpose of this forecast is to put the transmission revenues derived from data communications in perspective with all communications revenues of the common carriers.

We estimate that on the average a terminal will generate about $1,750 in data revenues per year, which is based on the existing estimated terminal population and the known data transmission revenues of over $500 million already enjoyed by telephone carriers. However, we feel data revenues per terminal will decrease slightly over the years with the proliferation of data terminals and progressively more efficient use of communications facilities,to an estimated $1,200 to $1,400 per year by 1980.

TABLE IV

GROWTH OF DATA COMMUNICATIONS REVENUES, 1970-1980

Year	No. of Terminals	Averaged Revenue Per Terminal	Annual Data Revenues ($ Billions)	% Growth for Data Revenues
1970	280,000	$1,800	.50	50%
1971	384,000	1,800	.69	38%
1972	545,000	1,750	.96	38%
1973	720,000	1,700	1.23	29%
1974	960,000	1,650	1.58	28%
1975	1,250,000	1,600	2.00	27%
1976	1,620,000	1,550	2.50	25%
1977	2,120,000	1,500	3.20	27%
1978	2,650,000	1,450	3.86	21%
1979	3,300,000	1,400	4.60	20%
1980	4,100,000	1,350	5.55	20%

Based on average terminal revenues, our forecast closely parallels AT&T predictions that data communications will account for a volume of about $5 billion in 1980.

Growth of Markets for Data Communications Equipment

In order to continue the expansion of information services and on-line use of computers, there is a parallel growth in the markets for data communications equipment required to make this expansion possible. This study is primarily concerned with the markets for modems, multiplexers and communications processors.

The data communications revenues will go to the communications carriers and are a good measure of the requirements for equipment to transmit the increasing amounts of data. There are four distinct markets for this type of equipment, as outlined below.

1. Common Carriers. This market consists mostly of the Bell operating companies which are, for the most part, supplied by Western Electric, the manufacturing company of AT&T. Other common carriers such as GT&E and United Telecommunications, also have manufacturing subsidiaries, Automatic Electric and Rixon, respectively. But 1,800 small independent telephone operating companies are free to buy equipment wherever they wish. The new common carriers such as MCI Company and Datran are emerging as a major market for much of the data communications equipment.

2. Government and military agencies of the United States.

3. Computer service suppliers and cooperatives, time-sharing bureaus and information services, including data banks.

4. Computer End Users. These include the airlines, banks, insurance companies and corporations with many plants and offices scattered throughout the continent and the world. Control of many multinational corporations from the United States makes this country one of the largest markets for international data communications systems.

Specialized Common Carriers as Markets

Significant additional markets for modems, multiplexers and microwave transmission are expected as a result of the construction and coming on stream during the mid-seventies of the two major specialized common carriers DATRAN and MCI Communications Corp.

DATRAN (Data Transmission Company), a subsidiary of University Computing Company, proposes to operate a nationwide switched digital common carrier network with an exepcted total capital investment currently around $300 million. Its plans are somewhat indefinite at time of writing (Sept. 1972).

MCI Communications Corp. and several smaller private carriers are designing point-to-point smaller transmission facilities expected to cost over $150 million initially, but rising to over $500 million, as domestic satellites come on stream in the mid-seventies.

DATRAN's basic concept will present a large, although only a one-time market, for TDM multiplexing equipment and digital microwave radio transmission facilities. MCI network is designed to offer the user the advantages of a private microwave system, but without the extensive capital requirements. Users of MCI will have to connect locally via existing common carriers, thus presenting an important market for modems and multiplexers to both MCI and MCI's customers.

Primarily, however, the new common carriers present a market for microwave radio transmission equipment needed to establish their facilities (see Frost & Sullivan "Special Common Carrier" Market, 1971). But because these new carriers plan to accept data in either analog or digital form, their facilities must be equipped with TDM and FDM multiplexers and modems in the case of MCI, and local access to Datran.

Because Datran will offer switched facilities, it will also be in the market for communications processors. Datran plans to use COMTEN devices and spend at least $1.5 million on CPU's alone and up to $40 million on all peripheral data processing equipment required. But since Datran plans an all digital, end-to-end common carrier, it may obviate the need for modems, though this will depend on its ability to provide its own digital local distribution.

Peak demand by the new common carriers will occur in 1974-76 period, after which it will slacken and continue, dependent on the need to expand the new common carrier facilities.

Frost & Sullivan developed some estimates for modem sales to the new common carriers in the previously mentioned "Specialized Common Carrier Market." These indicate that the market is rather small, in the order of $0.2 million in 1972 rising to about $2.5 million in 1975 and doubling again by 1978-1980. Throughout this period, AT&T is expected to supply about 60% of the total.

Major Data Traffic Growth Areas

One of the most meaningful assessments of the overall potential for information transfer in the future comes from a study performed at Stanford Research Institute in 1970 for National Aeronautics and Space Administration (NASA).

This study is based on an extensive list of existing of potential information services which includes such future possibilities as electronic mail, remote library browsing and checkless society transactions. To calculate potential demand for data transmission facilities, the study determines for each information service an estimated volume of transactions in year 1990 and using conversion factors reduces all estimates to the common yardstick of bits per year to be transmitted.

While projections for 1990 may appear rather futuristic, it must be borne in mind that facing such incredible volumes of data it is already necessary to think about construction of the necessary facilities which will not become inadequate too soon. The value of the study lies in the fact that it presents a method of ranking all the potential information service markets by volume of data to be transmitted. It is thus easy to isolate services with highest information volumes as the largest data communications markets.

The study includes such services as telephone, videophone and television and converts audio and video transmissions into bits per second equivalents for demonstration that these will remain by far the most voluminous of all information transfer services in the future. It is also interesting to note that already existing information services such as stock quotations, entertainment ticketing, hotel reservations and auto rental are ranked as rather the less voluminous services. Airline reservations is a medium volume service, while check and credit transfer makes the top ten volume services.

TABLE V

INFORMATION SERVICES RANKED ACCORDING TO VOLUME OF DATA TRANSMITTED PER YEAR

Rank	Information Service	No. of Transactions Per Year in 1990	Equivalent in Bits/Year
1 E	Telephone	482×10^9 calls	1.1×10^{19}
2 S	Videophone	1×10^9 calls	2.3×10^{18}
3	Electronic Mail	100×10^9 letters	3.0×10^{16}
4 E	Television (inc. CATV)	72×10^3 hours	1.7×10^{16}
5	Remote Library Browsing	20×10^6 accesses	1.2×10^{15}
6	Interlibrary Loans	100×10^6 books	1.0×10^{15}
7	Facsimile of "mug shots"	25×10^6 cases	7.5×10^{14}
8	Remote Medical Research	200×10^6 searches	1.8×10^{14}
9 E	Check and credit	340×10^9 transactions	1.4×10^{14}
10	Patent Searches	7×10^6 searches	1.3×10^{14}
11	Facsimile Newspapers	20 newspapers using	6.6×10^{13}
12 S	National Crime Info. Ctr.	70×10^6 messages	2.1×10^{13}
13	Remote Title and Abs., Sear.	20×10^6 searches	1.8×10^{13}
14 S	Stock Transfers	5×10^9 transactions	1.5×10^{13}
15	National Legal Info. Ctr.	30×10^6 searches	9.0×10^{13}
16 E	Airline Reservations	1.4×10^9 passengers	6.7×10^{12}
17 S	Remote Medical Diagnosis	200×10^6 ases	6.0×10^{12}
18 S	Electrocardiam Analysis	200×10^6 tests	6.0×10^{12}
19	Motor Vehicle Registration	245×10^6	1.5×10^{12}
20	Remote Book Printing	105×10^3 new books	1.1×10^{12}
21	Drivers License Renewals	90×10^6 items	5.4×10^{11}
22 E	Stock Exchange Quotations	4×10^9 transactions	4.0×10^{11}
23 E	Hotel/Motel Reservations	100×10^6 reservations	1.0×10^{11}
24 E	Auto Rental	40×10^6 transactions	4.0×10^{10}
25 S	Sports and Events Ticketing	200×10^6 transactions	4.0×10^{10}
26 E	Telegraph	35×10^6 messages	3.5×10^{10}
27	Stolen Property Info. Ctr.	7×10^6 cases	2.1×10^{10}
28	Stolen Vehicle Info. Trans.	5×10^6 cases	1.5×10^{10}

E = Service already exists.

S = Service started up in prototype or experimental form.

Source: Stanford Research Institute Study for NASA from article by Roger W. Hough (SRI), which appeared in IEEE COMPUTER monthly Sept./Oct. 1970.

Typical Requirements for Some Selected Information Services in Operations

Informational services cannot grow unchecked and all have a limit which usually depends upon their utility in a particular environment. The table below analyzes some typical services in terms of their requirements for economic operation.

Type of Service	No. of Inquiries Per Hour	No. of Terminals	Acceptable Response Time In Seconds	Typical Output
Stock quotations	20 - 50	1 - 8	20 - 60	Display
Bank deposits	20 - 40	2 - 10	20 - 60	Print
Hotel reservations	1 - 20	1	30 - 120	Hard copy
Airline reservations	40 - 120	1 - 6	20 - 40	CRT or ticket
Entertainment	10 - 20	1 - 2	60 - 180	Print & ticket
Medical (Poison info.)	1 - 5	1	30 - 120	Hard copy
Police car ID	60 - 300	1 - 2	10 - 60	Hard copy
Newspaper morgue	2 - 20	2 - 10	60 - 600	Hard copy
Railroad Car Control	10 - 50	1 - 4	30 - 100	CRT

Source: Center for Management Technology, New York.

The number of terminals in operation refers to a typical office of the organization providing the service. All such offices would be connected to a central computer data bank. Frequency of inquiries would also vary from location to location, but the table should serve as a guide in evaluating information services and their potential.

Growth of Specialized Remote Computing Services

Some idea of the directions and magnitude of growth of data communications markets can be gained by looking at the expectations of suppliers of remote computing services. Several major growth markets are listed below and some of the specific growth areas are discussed on the following pages. For more detailed study of the remote computing markets, the reader should consult a study published by Frost & Sullivan in 1972 entitled Remote Computing Services.

TABLE VI

GROWTH OF SPECIALIZED REMOTE COMPUTING SERVICES

Specialized Market	1971 ($ in Millions)	1975	1980
Banking and Credit	65	130	250
Brokerage and Financial	10	25	50
Transportation and Travel	15	30	70
Manufacturing and Inventory Control	10	20	55
Wholesale and Retail	7	15	40
Law Enforcement/Local Government	1	3	5
Utilities	3	5	10
Medical and Health Care	4	30	200
Miscellaneous	5	7	10
Total	120	265	690

Source: Remote Computing Services, 1972, Frost & Sullivan.

Banking and Finance

Banks already are one of the largest users of on-line computing services and data communication systems are revolutionizing the development of handling routine banking functions. Most of the largest banks in New York and California operate substantial teleprocessing systems and plan even more in the future.

In areas where small local banks predominate, suppliers of remote computing services provide access to on-line banking systems, particularly in many states where branch banking is not allowed.

A huge market potential exists in the Interbank transfer function area, although a number of legal restrictions may prevent complete automation of this function.

More specifically, application areas in banks using data communication systems are as follows:

- Teller inquiry for demand and time deposits.
- Passbook and account balance.
- Demand deposit and processing.
- Credit card authorization.
- Customer information inquiry.

Future expansion is expected to include such applications as FEDWIRE - connecting all Federal Research Banks, BANKWIRE - connecting the largest 200 commercial banks in the country, and special corporate services including funds transfer, balance reporting for commercial and corresponding bank customers. For more detailed examination of this end user market, see Frost & Sullivan's "Banking Information Systems Market."

Credit Checking Systems

This area is developing into a major market for data communications in the retailing industry during the 1970's. Specialized low-cost terminals and communication services are expected to boost installations of such systems in retail outlets of many industries. Traditional credit bureaus are converting to computer based remote access data bases and are automating credit evaluation services which may be tied in with the vast networks for credit card authorization.

The growth in this area is linked to development of suitable point-of-sale terminals. Some system will have special features combined in the cash registers, others use touch-tone telephone sets and audio response units. Experiments with magnetically coded credit cards for use at point of sale terminals and 24-hour banking services are pointing the way in which developments are taking place. See Frost & Sullivan study on Point of Sale Terminals for a complete discussion of this market.

Credit verification operations of all types present one of the most voluminous potentials for data communications. There are 2,900 credit bureaus in the country, of which 2,200 are grouped into the Association of Credit Bureaus of America, a national organization already taking steps to computerize credit verification operations. Estimates give a minimum of 100 million credit reports being issued every year.

There are at least 200 million credit cards already issued and as the usage increases, so does the need for credit card sales authorization. Specialized services such as Credit Data Corp. (TRW) and National Data Corp. will grow and additional services will form to provide this type of service in specialized industries. Check cashing verification systems are another form of credit checking already taking shape in several locations. Firms such as Telecredit and Telecheck are examples of the services being offered. All use computers, terminals and data communication systems of one type or another.

Securities Industry

The brokerage industry is not only well accustomed to the concepts of terminal oriented systems, but is also one of the most sophisticated users of data communications. Several services are supplied by relatively well established organizations such as Bunker-Ramo, which operated the NASDAQ system among others, Ultronics (GT&E) and Scantlin Electronics.

Still there are several needs of the brokerage industry that go unfulfilled and present additional potential for data communications solutions. These are automation or order entry and back office processing functions which have caused so many problems in the past. Additionally, opportunities appear to exist in automating investment advice and counsel, large block odd-lot trading and commodities in-house trading.

The trend in this industry is towards installation of large private networks by the leading brokerage houses such as Merrill, Lynch, Pierce, Fenner and Smith, Inc. There seems to be a reluctance to use outside services in the securities industry, but whichever way systems are developing, they will present markets for data communications equipment. There is always a multitude of small brokerage firms which are not in a position to automate their own operations and have to use outside services. Both types of operations will co-exist.

Services are also being developed to provide trading information for institutions which trade in large blocks, often on the third market outside of the main stock exchanges. One such service is AuTex and there are continuous arguments about the future possibilities of automating the stock exchanges. Such developments would require massive real time systems and would present very large markets for data communications equipment.

Transportation and Travel

This market consists of the many reservation systems for airlines, hotels and auto rental agencies. Some more specialized systems also handle theater and sports events and even camp sites, and may extend to other areas. While these systems are well established today, they present large markets for more efficient data communication devices and equipment which will effect cost savings and increase productivity of the existing systems.

Airlines are the leading users of reservation systems and are expected to eventually extend those to automatic passenger ticketing. In most cases, airlines support their own in-house systems and their investment in equipment reaches into the 2% to 3% range of the total corporate revenues.

This is also true of the major hotel/motel chains, where Holiday Inns is the leader with its well known Holidex system. Other hotel chains are operating similar in-house systems, but smaller groups rely on outside services, subscribing with several participating organizations. International Reservations (a subsidiary of Planning Research) and National Data Corp. provide such services.

Additional use of on-line systems is made in airline crew scheduling, spare parts control, freight handling and flight scheduling. Where railways play a significant role for passenger transportation, there is also room for reservation systems. Amtrak is automating its system and reservation systems exist in Japan, Western Europe and Soviet Russia.

The future lies in growth of interconnections between various reservation systems and increase of terminals in more remote areas not serviced this way at present.

Manufacturing and Inventory Control

Future growth of data communications in manufacturing will focus primarily on expansion of existing facilities. Communications oriented applications today include a variety of accounting, marketing, distribution, production and management operations.

The automotive and general manufacturing sector of this industry expects its data communication needs to increase 4 to 6 times during the decade of the seventies. Primarily this will encompass the expansion of the use of specialized systems from large corporations to smaller companies.

The applications expected to become more widely introduced will include:

Employee skills and personnel information data banks.

Payables and receivables clearing systems.

Automatic remote order entry systems.

On-line order status inquiry.

On-line price quotation and delivery estimates.

Supplies and parts ordering systems.

Centralized production control and scheduling.

Advanced interactive research computation systems.

Major economic sectors involved in manufacturing with the greatest market potential for data communications are automotive, aerospace, primary metals and general manufacturing industries.

Wholesale and Retail Industries

Use of data communications in wholesale and retail markets is closely tied to the availability of acceptable point-of-sale terminals. The three areas of most likely potential in the future are in general merchandising, food and gasoline and oil marketing.

Many applications today are basically credit authorization systems and, as such, have already been discussed under credit systems industry. But the industry has additional potential in accounting, distribution and warehouse inventory control. Future systems will combine credit, distribution and sales data analysis functions. The point-of-sale terminals will have to serve as data collection devices accepting standardized tags, as well as credit inquiry terminals,as the cost conscious industry is unlikely to support more than one device for the task.

In the gasoline and oil retailing industry, credit authorization and credit cards are widely used; but data communication applications are expanding into automated bulk fuel distribution to service stations. The expansion of point-of-sale systems depends on availability of low cost, specialized terminals such as the one being developed by a subsidiary of Hercules Powder Company which is being introduced by National Data Corp. to the users of its credit card authorization systems.

Electric Power, Gas and Water Utilities

These organizations are expanding their present use of computers for batch processing and billing to on-line use, incorporating terminals for querying and updating customers' records.

Meter reading is a time consuming and costly routine function of the utilities and appears to be the most promising area for application of extensive on-line recording methods.

Several companies, including IBM, developed techniques whereby gas and water meters can be queried remotely by a computer, using existing household telephone lines. As the use of such techniques grow, the utilities will present large and ubiquitous markets for specialized on-line data recording systems which will require data communications equipment.

Utilities may also operate their own private communications networks, using their own rights of way and thus do not come under the control of Federal Communications Commission. The data communications market potential in these organizations seems to be neglected so far, perhaps awaiting specialized meter reading equipment. With the lead taken by the more advanced utilities and the larger among them, pressures may develop for all utilities to take that route to data collection and offer improved services to their clients. Remote meter reading will then present a significant data communications market.

Medical and Health Care Industries

The health care function represents one of the largest "growth industries" in the nation. It is a vast network, alas not very well co-ordinated, of hospitals, laboratories, medical doctors and administrative organizations scattered throughout the continent.

To keep hospital costs stable and attempt to operate profitably, considerable automation of accounting, scheduling and billing functions is mandatory. More advanced applications, controversial and amenable to regulation, are the patient monitoring systems which use real-time sensor inputs, and medical diagnosis data banks remotely accessible to doctors at any time.

There seems to be a trend for outside services to organize groups of hospitals into cooperatives operating specialized computerized services for several hospitals throughout a region, thereby requring data communication systems for the purpose. McDonnell-Douglas Automation, for example, serves 37 hospitals on-line to a duplexed IBM 360/50 system.

During the seventies, the medical community may be experiencing strong pressures to improve services as a result of changes in public policies and attitudes. This will mean massive automation of services and organization of patient history data banks, hospital admission records, medical records and billing functions.

Numerous small hospitals unable to develop their own systems will continue to favor cooperative approaches or will subscribe to independent services specializing in provision of medical data bank information on-line to the user.

The Insurance Industry

Policy holder inquiry from terminals is a major existing application in this industry, but estimates indicate that less than 5% of all life policies in force are accessible for remote status inquiry.

Additional use of data communication systems is expected to include such applications as data collection for premium payments, medical data base inquiry, on-line status and value information and more use of on-line services to support the insurance sales function.

Property and casualty insurance will extend the use of data communications for similar status inquiry applications. In addition, transmission of claim and transaction data between field offices and central files will become a substantial area for future expansion.

If the widely discussed "no fault" insurance comes into being in the automobile insurance field, there will be additional pressures on competing insurance companies to speed up efficient claims handling systems.

IV - PRESENT DATA COMMUNICATIONS PROBLEMS

Summary

There is a basic mis-match between the data speeds of the originating business machines and the transmission facilities, which were not designed to carry such data. This is not only the difference between digital and analog plants, but also the fact that only rigid speeds within limits are available at which the facilities can carry data. These are usually different from the speeds at which business machines generate data. It should be noted that the new specialized carriers are planning a much wider offering of transmission speeds, both digital and analog.

This chapter discusses specific data rates of various business machines and transmission facilities. A list of the communication tariffs reflected in the specific services offered by the common carriers also underscores a further factor that must be considered by the data communications user.

By counterpoising system elements, transmission facilities, common carrier services,and operational responsibilities, we try to outline the magnitude of the problem and indicate the numerous and often confusing solutions to the user. But existence of problems also spells out a source of business to the knowledgeable manufacturer who can alleviate the irritation and unfair cost of transmission by offering cost-saving equipment and services.

Present Data Transmission Problems

Data communications as a concept dates back to about 1975 when it first became possible to connect computers with existing communications networks. It is not just the transmission of data from its origin to a destination. That function can be performed by teletypewriter networks (TWX and TELEX) and does not involve computers for processing of data even if a computer is used for switching of messages. Data communications, by definition, involves a computer which plays a vital role in processing the contents of messages being sent to it.

Ideal data communication facilities would offer wide band digital transmission, but in practice installations of such facilities would be a lengthy, expensive and regulated activity. As a result, data communications today utilizes existing common carrier switched telephone plant which, of course, was primarily designed for voice communication.

However, the very ubiquitousness of the telephone systems makes them particularly attractive for data transmission and various service companies are constantly looking for the most efficient method of exploitation of the existing telephone plant. Because modems are mandatory for transmission of digital signals over analog networks, manufacturers of these devices have received considerable attention.

The use of existing voice networks is only possible for data communications because electrical pulses generated by business machines are converted to audible tones approximating the range of the human voice. Modems make this conversion possible.

Multiplexers are also of significance in bringing down the cost of long-distance communications and thereby help to get the most out of the existing rate structure which were conceived with the voice communication in mind.

Elements of a Data Communications System

A data communications system typically consists of several well defined groups of elements. In design and operation of such a system, all elements play a role affecting the cost and overall performance and because of their great number and variety, present a difficult choice of numerous solutions to the end users.

System Components

These consist of end users, operators and clients of information services as well as data terminals, data collection devices, modems, multiplexers, concentrators, communications processors, data transmission control devices, central computing and processing facilities.

Transmission Facilities

Telegraph lines (sub-voice facilities)
Voice-grade network channels
Broadband facilities of common carriers

Common Carrier SErvices

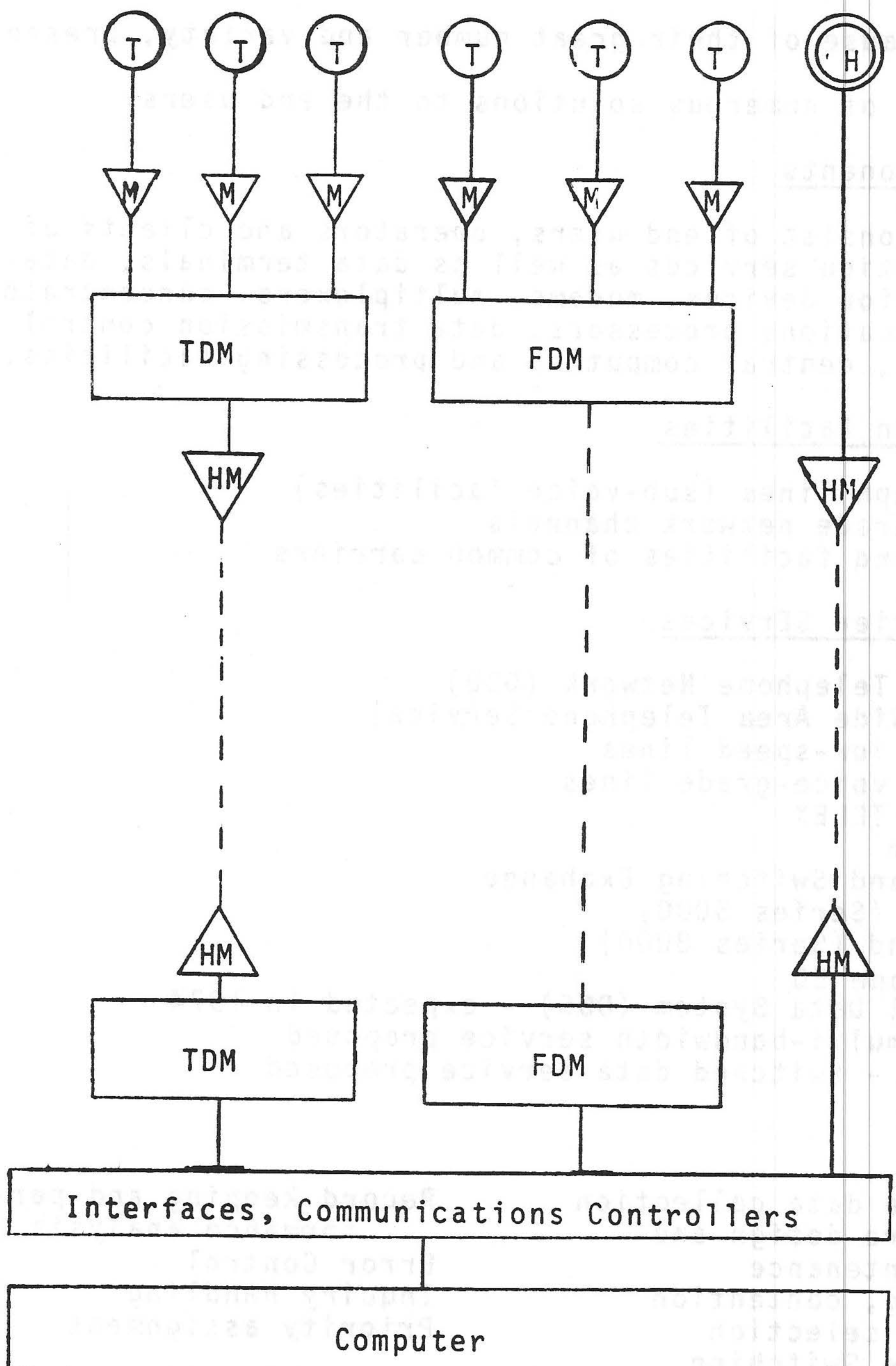
Public Telephone Network (DDD)
WATS (Wide Area Telephone Service)
Leased low-speed lines
Leased voice-grade lines
TWX or TELEX
Datacom
Broadband Switching Exchange
TELPAK (Series 5000)
Wideband (Series 8000)
Dataphone 50
Digital Data System (DDS) - expected in 1974
MCI - multi-bandwidth service proposed
DATRAN - Switched data service proposed

Operations

On-line data collection
Software design and maintenance
Polling, contention and selection
Message Switching
Data Management
Record keeping and performance analysis
Error Control
Inquiry handling
Priority assignment

FIGURE II

3. TYPICAL ELEMENTS OF A DATA LINK



Operating Speeds of Data Processing Equipment

In order to understand more fully the problems associated with data transmission over the existing telecommunications facilities, it is best to study the operating speeds of the various data processing devices such as terminals, printers, tape drives and central processors and then compare those speeds with those of the telephone transmission facilities.

The common carrier networks involve a huge plant, estimated to represent already an investment of $70 billion and developed over many years. While changes to accommodate data traffic more efficiently are under way, it will be a long time before specific facilities will provide as universal a network as the telephone. It is therefore necessary to design and use special data transmission devices such as modems and multiplexers in order to make the best possible use of the existing facilities.

Type of Data Processing Device	Speed of Operation in Bits/Second		
Paper tape punch	up	to	75
Teletypewriters	45	to	150
Card punches	1,500	to	5,300
Paper tape readers	2,800	to	8,000
CRT displays	up	to	8,000
Card readers	3,200	to	10,600
Line printers	6,000	to	19,400
Magnetic tapes and disks	120,000	to	2,700,000
Drum storage devices	up	to	8,000,000
Central Processing Units	2,000,000	to	16,000,000

Source: High Technology West, Data Communications 1970.

Available Data Transmission Facilities

To transmit data between the wide variety of terminals and computers, several line circuits are being offered by the common carriers. These are broadly categorized into low-speed, medium- and high-speed lines and their transmission speed ranges are given below.

Type of Facility	Common Carrier Service Classification	Facility Capacity in Bits per Second
Sub-voice	Type 1002	Up to 55 Baud
	Type 1005	Up to 75 Baud
	Type 1006	Up to 150 Baud
Voice-grade	Type 3002	1,200 to 2,400 BPS
	+C1 conditioning	to 2,400 BPS
	+C2 conditioning	to 4,800 BPS
	+C4 conditioning	7,200 to 9,600 BPS
Broadband	Series 5703, 8803, 11240*	Up to 19,200 BPS
	Series 5701, 8801, 11048*	Up to 50,000 BPS
	Series 5751, 11240*	Up to 250,000 BPS

*Series 11000 offerings are scheduled to end in Nov. 1972.

Source: Frost & Sullivan, Telephone Interconnect Market.

Faced with a variety of circuits with various transmission rates, the user is confronted with a difficult choice of equipment and facilities to make the most efficient use of his resources. To further make this choice more difficult, he is also confronted with several services made available by the common carriers using the various facilities described above. The different types of services available and their tariffs are listed on the following table.

Common Carrier Services

The user in design of a data communication system must consider both the dial-up and private lines alternatives available from the common carriers. While cost is the foremost consideration in selection, if a system is geographically dispersed and has a mixed population of a variety of terminal devices, the dial-up network may prove more economical.

But where the response time is a factor, the 15- to 20-second connect time delay in long distance dialing cannot be tolerated. Thus, airline reservation systems and business systems mostly rely on use of private telephone lines.

The problem with dial-up systems becomes severe when high transmission speeds and data volume make extended long distance transmissions very costly.

In general, dial-up facilities are good for transmission speeds of 3,600 to 4,800 BPS and higher speeds of 7,200 and 9,600 BPS are only possible with private lines. On dial-up systems, a 4,800 BPS connection, once achieved, is not assured because the user does not obtain the same circuit each time he dials.

Beginning data transmission users usually start with dial-up facilities until their data volumes build up to a level when private lines become economic to operate. In a way, the multitude of dial-up users now developing in various industries are a potential future market for more sophisticated data transmission equipment and facilities.

Type of Service	Common Carrier	Tariff No.
Leased low-speed lines	AT&T Western Union	260 254
Public Telephone Network (DDD)	AT&T	263
WATS	AT&T	259
TWX	Western Union	240
TELEX	Western Union	240
Leased voice-grade lines	AT&T Western Union	260 254
MCI leased lines	MCI	-
Datacom (45 cities only)	Western Union	257
Broadband Switching Exchange	Western Union	246
TELPAK (Series 5000 channels)	AT&T Western Union	260
Wideband Data Channels (Series 8000)	AT&T Western Union	260 254
Dataphone 50	AT&T	263

Source: Computer Decisions, Nov. 1971.

It is quite obvious that faced with circuits with specific capacity, the best way to optimize transmission is to use concentrating techniques or multiplexers to get the most value from existing analog facilities. In order to be able to use the analog facilities at all to transmit data streams, modem equipment is required. Thus, modems and multiplexers become the indispensable devices for data communication.

A third and increasingly important element is the communications processor whose importance increases with the complexity of communications systems being built today.

Adequacy of Carrier Facilities for Data Transmission

As far back as 1966 the Federal Communications Commission began an inquiry into the "Regulatory and Policy Problems Presented by the Interdependence of Computer and Communication Services and Facilities."

One of the topics considered was the adequacy of common carrier services and facilities for data transmission. Many of the computer users participating or commenting on the FCC inquiry identified serious deficiencies in the services of the telephone companies as well as in those of Western Union. These depositions were made about 1968 and urged the Commission to undertake certain improvements and modifications.

These specifically referred to provision of additional channel bandwidths, development of a widespread switched broadband service, reduction in the three-minute charge period on the dial network, reduction of error rates in data transmission in general, and more rapid introduction of digital transmission systems and digital microwave at lower costs. The awareness of many of these deficiencies of the existing switched telephone network for the transmission of data was instrumental in the design of the common carrier networks of the specialized common carriers.

The Regulatory Bottleneck

AT&T has dominated U.S. communications for almost one hundred years, effectively keeping real competition out of this industry which is one of the country's largest. Communication amounts to over $20 billion in annual sales, accounts for 8% of the business dollar and 2% of the Gross National Product.

Until a little over three years ago, communication users could use only telephone company equipment on switched telephone company networks. Until two years ago, users (apart from building their own networks) could choose only the telephone company if they wanted communication links and until recently, it looked as if the telephone company would successfully block the introduction of a Domestic satellite system.

The Federal Communications Commission, which exercises regulatory jurisdiction over the interstate common carrier communications services, tended over the years to become dominated by the industry and until recently protected its status quo.

But communications carrier services are provided on an almost monopoly basis. Each telephone company has a monopoly in providing service in its own geographic region and although Western Union provides private line services "competitive" with those of telephone companies, its offerings and rates are identical to those established by Bell and copied by all independent (non-Bell) telephone companies as well.

The Federal Communications Commission has broad powers to review rates and tariffs, determine investment and operating practices and review the applications for new plant installations. It is in effect the force shaping all of communications carrier industry, with local state and city regulatory bodies more often than not simply following FCC's lead in the matter.

The communications industry is regulated on two levels: Federal and State-City level. The Federal level, or the Federal Communications Commission, is responsible for interstate matters and the State and City agencies handle intrastate activities.

Specifically, the regulatory agencies govern pricing which in turn determines the profits the common carriers can earn by control of their tariffs. Policy and questions of "orderly development" are also the responsibility of the agencies. This includes approval of locating communications equipment, as well as investigation of complaints from the users. All agencies are involved in approval or rejection of applications from potential new common carriers.

So far the regulatory bodies have made no attempt to regulate the prices of equipment or services attached to the telephone networks and competition among suppliers of such equipment is looked upon as a satisfactory substitute to regulation. Potentially, however, the possibility of regulation in this area always exists and should not be overlooked.

Aside from the Federal Communications Commission, almost every State has a regulatory body as well as some cities in the State of Texas. All told, there are 47 local regulatory agencies.

Interfacing Problems

Use of independent modems with dial-up facilities now requires the user to interface to the line with a Direct Access Arrangement (DAA) which can only be rented from the telephone company. The device rents for $2 to $8 per month and, among other things, limits the signalling power of the attached modem so that excessive power surges and resulting crosstalk are prevented. Modems rented directly from AT&T do not require the use of DAA devices.

Acoustic couplers, which are low-speed asynchronous modems, with an acoustic connection to the line via the telephone handset, do not require the use of a DAA. While transmission speeds of couplers are limited to a maximum of about 600 BPS, these devices offer the advantage of low cost and portability.

Bell DAA units are only available on a rental basis from AT&T, but independent telephone companies are supplied by other sources. Firms like Elgin Electronics, Pulse Communications and Precision Components manufacture non-Bell DAA units equivalent to Bell's and will sell them even to end users at $85 to $200 per unit, though what users can do with them is a moot point.

A Dittberner Associates report made to the FCC concluded that manufacturers of modems could easily build protective circuitry into their products and suggests a standardization and certification program as an alternative, as well as licensing of installation and maintenance personnel.

Data Communications User Attitudes

Perhaps most insight of the problems existing in the data communications industry is given by the present attitudes of the users towards existing services and the common carriers who supply them. In a study by Booz, Allen and Hamilton prepared for Datran Corp. on data transmission markets of the 1970's, a survey of such attitudes was made and we pass on here some of the highlights. It must be borne in mind though that this study, while critical of existing conditions, was also assessing future markets for a client with vested interests in becoming a common carrier and trying to make a case for himself. Apparently unpublished parts of the study suggested that the proposed six-second minimum charging period for initial connection may have to be revised because of market considerations. Here are some of the user remarks.

Most users, it appears, recognize the potential of advanced data communications applications, but are discouraged by present services of the common carriers because of a limited selection, inadequate performance and high cost.

This general statement is good as far as it goes and must be considered in light of the fact that common carrier services were not developed for data communications users and the users are making the best use of what is available. It must also be remembered that in 1970 the revenues to the common carriers from data communications were but a small percentage of their total communications revenues, probably less than sales obtained from the yellow pages advertising. Faced with continuous vast investment in new plant just to keep up with the voice communications growth, the common carriers could hardly have taken a different course just to please a small group of data communications users.

Most often quoted problems experienced with data transmission services by the users were: lack of carrier responsiveness; insensitivity to customer needs; poor coordination with equipment suppliers; and inflexibility in design of services. Users also claimed poor service and maintenance of transmission equipment.

To compensate for these inadequacies, determined users claim to have installed excess facilities, operated under rated speeds, designed own error detection and correction systems and often redesigned computer applications to fit available transmission facilities and services.

Users generally feel that unless data transmission becomes less costly, more flexible and reliable, vital data communication applications will be delayed. Improvements suggested by the users include wider selection of services, lower cost and minimum charges, simpler rate structures, better performance and more responsive customer and field service of the common carriers.

It is clear that because of these attitudes there is a great demand for independent equipment which will improve the performance of the common carrier plant.

V - EMERGING DATA COMMUNICATIONS SOLUTIONS

The Changing Regulatory Climate

The past five years have seen tremendous changes in the regulatory climate, much of it as a result of rapid growth of computing and the need for efficient data communications.

Frost & Sullivan has identified 256 companies selling modems, multiplexers and communications processors equipment for attachment to the telephone networks. There are many more producing PABX units, telephone sets, answering machines and other devices.

All this is due to the fact that the Federal Communications Commission and major state regulatory bodies have recently become remarkably favorable to interconnection of customer-owned equipment to the telephone network.

FCC itself, in its landmark Carterfone decision of July 1968, broke the telephone company's monopoly on supply of terminal equipment and systems to be attached to or interconnected with the telephone network. This cleared the way for the rapid emergence of the independent modem, multiplexer and communications processor industries.

In August 1969, the FCC, in an equally precedent-setting decision, authorized Microwave Communications Inc. (MCI) to enter the market as a first specialized common carrier to compete directly with Bell and Western Union.

Following its "computer inquiry," the FCC also recognized the growing needs of the computer community for more adequate data transmission facilities.

The Commission also made an attempt to define some rules which allow computer users to install and operate message-switching subsystems, provided the message-switching feature relates to the data processing service and is not offered as a communications facility. This, in turn, is the basis for the emergence of the communications processor industry.

In response to these pressures, AT&T revised its tariffs permitting the attachment of customer-provided equipment such as modems, multiplexers and data controllers. They further now permit the interconnection of customer-owned communication systems through PBX switchboards, although several protective restrictions are imposed on such activities.

Another tariff revision permits the joint use of telephone voice-grade and telegraph private lines, a feature also proposed by MCI in its new specialized service.

The present restrictions imposed on the attachment of customer-owned equipment require: (1) the power and spectral energy distribution of signals....to stay within prescribed limits; (2) the use of a "protective connecting arrangement" supplied by the telephone company known as the Data Access Arrangement (DAA); (3) that all "network control signalling" be performed by telephone company equipment.

Significance of the Carterfone Decision

The changes brought about in the communications industry by the Carterfone decision can only be called revolutionary. It stimulated the industry with an influx of new technologies developed in defense and aerospace which so far could not find a commercial outlet. It also created a whole new "interconnect" equipment industry and in general benefitted the user by lowering the costs of data communication hardware.

The process is continuing with data terminals and multiplexer as well as communications controller manufacturers further reducing overall systems costs by incorporating modems into their equipment.

The common carriers responded to the sudden competition by revising their tariffs and cutting prices, all in favor of data communications users. In fact, in some instances the reduced rates for Bell modems are so low that the newly emerged competition is finding it tough to keep in step.

Equally important as a result of the Carterfone decision is the creation of a new outlook on the communications in general and common carriers' role in particular. No doubt it was an accelerating factor in reaching the following year a decision to allow new "specialized common carriers" to compete with the intercity telephone network itself. This triggered a flood of over 1,900 new microwave station applications from several firms proposing more than 40,000 miles of new carrier facilities in the country.

Emergence of the Interconnect Industry

It seldom happens that a completely new industry is created as a result of a regulatory decision, but that is exactly what happened after the Carterfone decision. Connection of customer-owned equipment to the telephone networks is breaking up a solidly-set structure of the communications industry and creates new opportunities for numerous entrepreneurs.

Major industrial markets developing as a result,are the private automatic branch exchange (PABX), telephone answering machines, speaker phones -- possibly even private videophones, modems, multiplexers and communications controllers operating as message switching devices. Mobile radio, microwave transmission, CATV and remote meter reading are also industries significantly affected by the interconnect opportunities.

Parallel to the industrial interconnect equipment, there is also a household interconnect market for decorator telephones, answering devices and telephone gadgetry of interest to specialized suppliers. The Carterfone decision in fact opened up a communications Pandora's Box and new companies are appearing all the time, eager to cash in on the new opportunities.

By far the most important to the data communications user is the freedom to connect to the telephone network independently manufactured modems, multiplexers and controllers. This study focuses on the markets for these devices which specifically refer to data transmission. We do not discuss terminals and peripherals which are also connected within the data communications systems. Readers interested in more insights into such markets are referred to the "Remote Computing Services Study" which was published by Frost & Sullivan in March 1972.

Specialized Common Carriers

Major new common carriers that are of interest to the data communications user are the MCI and its affiliated subsidiaries; Datran, a subsidiary of University Computing; and Western Tele-Communications. Additional organizations are planning to offer regional services of this type.

MCI already went on the air in January 1972 with its first link between Chicago and St. Louis. Within two years, MCI will have constructed a nationwide communication network. MCI offers initially 20 data speeds: 75, 110, 134.5, 150, 200, 300, 600, 1,200, 2,400, 4,200, 4,800, 5,400, 6,000, 6,600, 7,200, 9,600, 14,400, and 19,200BPS. This service is not radically new and basically offers the advantages of private microwave systems on a monthly basis.

Datran will offer several new features and proposes a wholly end-to-end digital network, obviating the need for modems for the user who can connect directly to that network. Datran plans transmission at four speeds of 150, 4,800, 9,600 and 14,400 BPS and hopes to be on the air with its initial links in the mid '70s.

when?

Both new carriers are promising error rates better than 1 in 10 million bits. Datran proposes a minimum call of only 6 seconds, instead of 3 minutes in telephone networks today. MCI and all other specialized common carriers offer a leased line service on a month to month basis. Whether Datran's minimum 6 second charge period will turn out to be practical remains to be seen, as studies show that future data communications traffic may indeed be composed of very short bursts. Both new carriers must also solve local loop questions to be fully accepted by the data communications user.

The new independent common carriers are also creating markets for the independent manufacturers of data communications equipment. MCI, for example, is installing Time-Division multiplexers on its Chicago to St. Louis link. MCI has installed modems and multiplexers purchased for outside suppliers in the Chicago to St. Louis route. Use is made there of Timeplex TDM units among others,permitting simultaneous transmission of multiple data streams from 75 baud to 9,600 bits per second, over the wideband sections of the MCI microwave system.

The advent of the new carriers is also forcing the present common carriers to update equipment faster than they may have originally planned in order to meet the competition. Thus, the new carriers are not only themselves immediate customers for new equipment, but may be acting as catalysts for additional sales to the established networks as well.

The Bell system already announced that its goal is to have an all computer controlled system by the year 2000. This traditionally means that independent telephone companies will be falling into line to conform to Bell System plans.

Neither Datran's nor MCI's final nationwide communications rates have been announced; estimates indicate they will be only slightly less than Bell & Western Union.

Readers wishing to obtain additional information about these new common carriers are directed to a previous study by Frost & Sullivan entitled "Specialized Communication Carriers Market," published in 1971.

The Bell Digital Data System (DDS)

To meet the increasing demand for specialized data communications services and to meet the competition from emerging new specialized common carriers, AT&T is planning to inaugurate the proposed Digital Data System (DDS) for private line users in 1974. The first point-to-point channels will operate in about 24 metropolitan areas by the end of the first year, according to L. R. Pamm, director of Data Communications Planning at Bell Laboratories.

DDS will offer full duplex, synchronous channels at 2,400, 4,800, 9,600 and 56,000 BPS speeds. Within metropolitan areas, the Ti channels will provide transmission facilities. At present there are 2,500 Ti systems in service in the Bell system, providing over 50,000 digital voice channels.

Data Under Voice (DUV) technique will play a large role in early years of DDS. It will convert Multiplexed 1,500,000 BPS streams into a form suitable for transmission in bandwidth underneath message channels on existing microwave links.

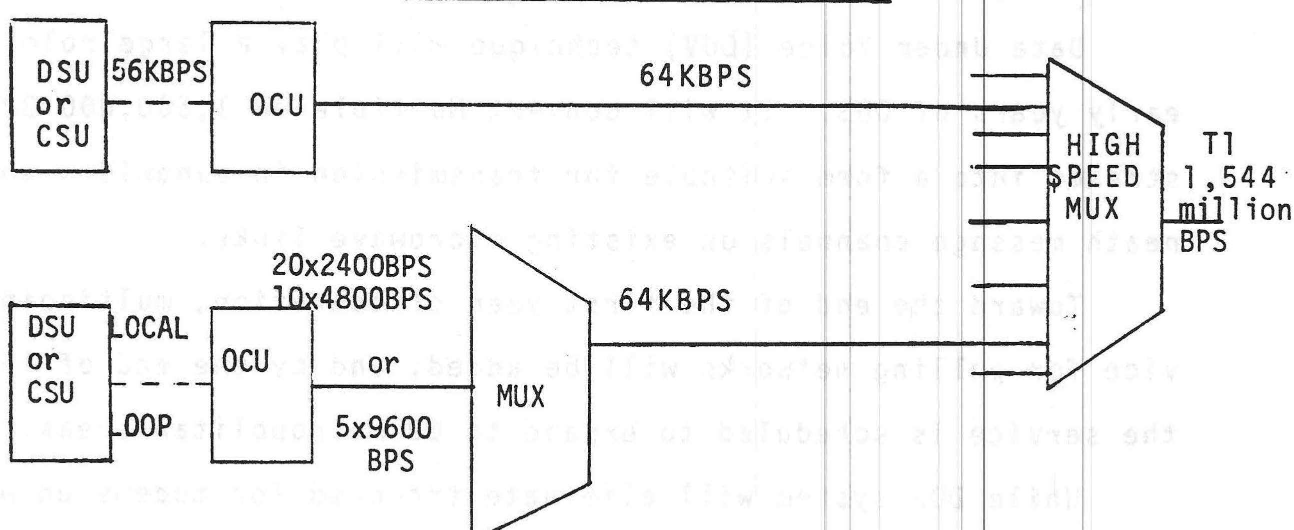
Toward the end of the first year of operation, multipoint service for polling networks will be added; and by the end of 1975, the service is scheduled to expand to 60 metropolitan areas.

While DDS system will eliminate the need for modems on private lines, users face the problem of signal translation from digital data in the wires to microwave and back. Bell is already working on an inexpensive device known as Channel Terminating Unit (CTU) designed to replace modems for this application.

In a recent statement and article, Mr. Leonard R. Pamm, who is the director of Data Communications Planning Center of Bell Telephone Laboratories at Holmdel, N. J., explained in more detail the interfacing requirements between the customer and the Digital Data System. Bell plans to provide two alternative interface units known as Data Service Unit (DSU) and Channel Service Unit (CSU), a simpler interface designed for customers who prefer to perform their own signal processing.

Corresponding units will exist at central service offices of the Bell network, but will be known as Office Channel Unit (OCU), which will regenerate the data and prepare it for transmission through multiplexing hierarchies. The diagram below outlines the proposed system configuration.

FIGURE III
BELL DIGITAL DATA SYSTEM



OCU units exist only at Bell central service offices, while the DSU or CSU units are installed at customer locations as required.

Domestic Communications Satellites

On April 1970 an FCC decision favored allowing anyone with demonstrable technical and financial skills to establish and operate a domestic satellite system and already eight companies have applied for licensing. Benefits of such satellite systems to the data communications user include a distance-independent cost structure with circuit costs only a fraction of corresponding microwave and cable costs for long distance circuits. The drawback is difficulty for interactive data transmission because of a delay due to very large distances involved.

Satellite systems also offer a wide variety of channel bandwidths lower error rates than those experienced on present long distance connections and relatively easy and economical access to remote areas of the country without adequate transmission facilities today.

The proposed domestic satellite (DOMSAT) system participants are listed below. For orientation, each transponder has a capacity of some 900 one-way telephone channels, one color TV channel or some 35 million bits per second of time-division multiplexed data.

TABLE VII

DOMESTIC SATELLITE BIDDERS

Operator	Operational Satellites	Total No. of Transponders	Total No. of Earth Stations
AT&T/COMSAT	2	48	5
COMSAT	2	48	5
Fairchild Hiller	1	120	6
Hughes/GT&E	2	24	13
MCI Lockheed Satellite	1	48	20
RCA Global/Alascom	1	12	13
Western Telecommunications	2	24	6
Western Union	2	24	13

Source: AFIPS, SJCC Proceedings, May 1972.

These applications are very much up in the air as of writing (Sept. 1972). Latest development is that MCI, Lockheed and Comsat propose a joint system. If approved, Comsat would withdraw its proposal for its own system, but still operate one in conjunction with AT&T to serve only non-competitive portions of AT&T's business.

VI - THE MODEM MARKET AND INDUSTRY

Summary

Without a modem, transmission of digital data over telephone facilities cannot take place. This unique position that a modem holds in a data communications system attracted numerous manufacturers to this business, unwary often of the fact that it is a relatively simple device and it is not difficult to enter this business resulting in a multitude of competitors.

After a brief explanation of the various modulation techniques, we define some basic characteristics of modems and present a complete list of units available on the market today. We also present for comparison purposes modems offered by the common carriers.

Because the modem industry is going through a shakeout, we discuss at length the price erosion and the cutthroat competition which is responsible for the situation. There is a great possibility that the modem of the future will end up in the terminal, the multiplexer or even within the computer interfaces, primarily thanks to advancing electronics technology and introduction of MSI and LSI techniques in this field.

The chapter also outlines our market projections for modems through 1980 and assesses the market shares of modem suppliers and their future in this business.

The Reason for Modems

Terminal, peripheral and data processing equipment in general produces binary, direct current (DC) signals, which must be transformed into analog form (modulated) for transmission over common carrier facilities. At the receiving end the analog signals are reconverted back onto digital form (demodulated) for processing in a computer or operation of terminal devices.

Typically the business machine produces a positive DC voltage signal to represent a "1" or "mark" condition and a zero or negative voltage for a "0" or "space" condition. Such signals can be transmitted over an actual wire without modification, but only if transmission distance and speed are not too great. Normally this is not the case and modern communications systems employ carrier equipment to permit many individual voice or data channels to be transmitted over a single wire, cable or microwave facility.

Such analog channels will not pass direct current signals and therefore all signals for transmission must be in alternating current (AC) or analog form. Voice signals are analog to start with and can be transmitted without modification because common carrier networks were built for that purpose. Binary (DC) signals must be converted into analog (AC) form.

The device which performs the electronic signal translation in both directions is called a modem (abbreviated from Modulator-DeModulator) and also known as Data Set (AT&T name). Until 1969, modems were only available from the telephone companies, although several manufacturers made these devices for private networks and military uses. Since then, independent modems are permitted on telephone networks and many new manufacturers of these devices have appeared on the scene.

Modulation Techniques

There are three basic modulation techniques: frequency modulation (FM); amplitude modulation (AM); and phase modulation (PM).

Frequency modulation is the simplest and most popular method, often employed in many low-speed modems. It depends on the change in the frequency of the carrier signal to represent the "1" or "0" condition. In its simplest form, it is the on-off modulation varying between no frequency and some carrier frequency in a binary manner. Frequency modulation is quite suitable for transmission speeds up to 1,800 BPS.

In amplitude modulation, the amplitude of the carrier frequency is varied to represent the two binary conditions. Usually the larger amplitude represents a "mark" and the smaller the "space" conditions. Several levels of amplitude modulation are possible, allowing twice as much data to be sent in the same time frame.

Frequency modulation has a noise advantage over amplitude modulation employed over identical transmission facilities. But amplitude modulation is capable of more efficient use of available bandwidth.

Phase modulation uses a change in the phase angle of the carrier frequency to indicate the two states. Four- and eight-phase modems are available, permitting up to twice or three times the same bandwidth. Modems operating on phase modulation principle, generally fall in the high-speed category of 2,000 BPS and above.

Amplitude modulation, phase modulation and more complex techniques based on combinations of the above are used in medium- and high-speed modems. These special techniques are pulse-amplitude modulation (PAM) vestigial sideband, and quadrature-amplitude modulation (QAM).

Characteristics of Modems

All modems designed to operate on dial-up or leased voice grade telephone lines fall into synchronous or asynchronous data handling categories.

Asynchronous data is typically produced by low-speed terminals such as teletypes and transmission of characters requires start and stop bit information. Asynchronous modems are low-speed devices of up to 1,200 BPS over dialed networks and 1,800 BPS over leased circuits.

Synchronous transmission uses internal clocking within the modem and results in better use of transmission facilities by allowing higher transmission speeds. Because more complex circuitry is required, synchronous modems are considerably more expensive.

The modem is an important element in a data communications system because its choice determines the bandwidth efficiency of the transmission channel used. It is also a factor in overall cost and error performance of a system. Therefore all factors which govern maximum practical transmission speed of a modem are of significance to the user.

1. Bandwidth and quality of transmission channel.
2. Acceptable transmission error rates.
3. Choice of specific modulation technique.
4. Sophistication of signal detection methods used.
5. Error detection/correction provisions.
6. Automatic or manual line equalization capability.

Because communications channel bandwidth is expensive, it must be used as efficiently as possible. On the other hand, cost of modems increases rapidly for more bandwidth-efficient products which use sophisticated modulation or equalization techniques. A designer is best advised therefore to attempt to optimize the entire system, considering both modem and channel costs at the same time.

If a communications system already uses Bell Data Sets, it is also important to make sure that independent modems proposed will be compatible with each other. Although each may be compatible with the standard Bell Data Sets, this does not guarantee mutual compatibility, strange as it may seem.

In choosing a modem, price will be a major consideration to the user but as one modem specialist points out, in many applications the loss of revenue from one hour's downtime will be greater than the difference in price between a quality modem and a lower priced product. In short, it pays to buy the very best when it comes to modems and in the long run this consideration is working very much against many small firms offering cut price modem equipment.

A good measure of modem efficiency is the ratio of its speed in BPS to the output bandwidth, sometimes called the Figure of Merit of the modem. Other parameters used in judging competitive equipment are mean time between failures (MTBF) and mean time to repair (MTTR).

Rapidly becoming most important to the user also are the operational features of a modem, particularly on medium- and high-speed devices. Some networks may require simplex, half-duplex or

TABLE VIII

INDUSTRY STANDARDS DICTATED BY AT&T UNITS PREVAILING IN LOW AND MEDIUM-SPEED MODEMS

Transmission Speed Range	AT&T System Equivalent	Method of Modulation	Important Features	Type of Lines Required
Up to 300 BPS (Asynchronous)	103A 103F 113A 101C	FSK	Channel separation, receive level capability	Dial-up network
1,200 BPS (Asynchronous)	202C series	FSK	Receive signal level capability, Carrier detect function, Noise suppression, Status indicators	Dial-up networks
1,800 BPS (Synchronous)	202D	FSK	Receive signal level capability, Need not be as many functions since private lines are used	Type 3002 + C1 and C2 conditioned lines must be used
2,400 BPS (Synchronous)	201A 201B	VSB Dou-binary FSK PSK	Equalizers, manual or automatic, Set-up time	Dial-up, up to 2,000 BPS C2 conditioned lines for 2,400 BPS
Above 2,400 BPS	208A was only recently introduced by AT&T but until now no industry standards prevailed such as dictated by Bell devices in the lower speed ranges. A variety of modulation schemes are in use, depending on individual suppliers, but the trend is to compete more on special features basis for comparable performance units.			

full-duplex transmissions and modems should be adaptable easily to any of those situations. Performance monitors and indicators, as well as ability to perform diagnostic test routines may be important to the user.

AT&T refuses to sell modems to users, leasing them instead at what are considered relatively high lease prices. It is this position of Bell operating companies which allowed many independent manufacturers to take advantage of Bell pricing umbrella and offer compatible modems at sale prices equivalent to 24 to 36 monthly lease payments to AT&T. Of course several plans are being offered by the independents, including leasing; and the main advantage a user gets is in choice of units and flexibility of prices.

Recently AT&T announced the 208A modem for the 4,800 BPS range at leased prices of about $100 which caught the independents unaware since they had leased such units at prices in the $150 to $250 range. Now many independents are trying to equal the Bell lease of $100 which is threatening to put them out of what they hoped was one of the most secure modem speed ranges.

The tables following list the available modems from independent manufacturers which we could identify and approximate purchase prices for basic units. We also included a list of modems available from the common carriers at monthly lease prices for comparison purposes.

In the low speed areas, the important factor is compatibility with Bell modems which a user can get readily from his local telephone company. Above 4,800 BPS speeds, there are no such industry standards as at lower speeds and the user must evaluate carefully any modems being considered to make sure he is getting the best unit to do his particular task.

TABLE IX
MODEMS AVAILABLE FROM INDEPENDENT SUPPLIERS

Manufacturer	Model	Speed (BPS)	Type	Mode	Approx. Price
Acrodyne	VTC-1/VTC-2	to 300	FM	A	$325,625
Alcatel (France)	Transal 102	1,200	n/a	A/S	n/a
Ambac Industries	7103F	to 300	FM	A	$170
	7113A	to 300	FM	A	98
	7104D	1,800	FM	A	$170-280
	7201B	2,400	PM	S	
American Data Systems	ADS-448	1,200-4,800*	AM/PM	A/S	$6,000
	ADS-496	9,600	AM	S	9,000
	412/424/436	1,200-3,600*	FM	A/S	$580/950/1,300
	403	300	FM	A	$550
Anderson Jacobson	240/241/242	to 300	FM, C	A	$375-475
	260/262/300	to 300	FM, C	A	$450-570
	1200 series	1,200	FM, C	A	$785-985
Astrocom Corp.	Astroset 110	to 300	FM, C	A	$295
	Astroset 120	to 1800	FM	A	$430
	Astroset 130	to 300	FM	A	$375
	Astroset 200	2,000-9,600	PM	S	$925
	Astroset 320	2,400	PM	S	
	Astroset 348	4,800	AM	S	
Badger Electronics	DTS2020	2400-9600	PM	S	$875
Bonnar-Vawter	Expedate 402	75		A	$300
Bowmar/ALI	6103A	to 300	FM	A	$600
	6000A	1,200-2,400	PM	S	$1,250
Burroughs	TA783	to 1,800	FM	A	$890
	TA713	up to 1,200	FM	A	$520
	TA734-24	1,200-2,400	PM	S	$2990
	TA733-48	4,800	PM	S	$5990
Codex	4800	3,200-4,800	PM/AM	S	$5,575
	7200	4,800-7,200	PM/AM	S	$8,000
	9600	4,800-9,600	PM/AM	S	$11,500
Coherent Communications	TYM-1	50-150 Baud	FM, C	A	$600
	DAM-1	50-600 Baud	FM	A	
	DAM-5	50-1,800 Baud	FM	A	$350
Collins	TMX201	up to 150	FS	A	$650/channel
	TE236				
	TMX-202C/E/6	1,200-2,400	PM	S	$1,750
	TE-216A	110-1,800	FM	A	$667
		4,800	PM	S	$6,400
ComData	Series 301	to 300	FM, C	A	$265-365
	Series 302	to 300	FM, C	A	
	Series 320	to 300	FM, C	A	

TABLE IX - Cont'd.

Manufacturer	Model	Speed (BPS)	Type	Mode	Approx. Price
Computer Complex	Coupler II	to 300	FM, C	A	$295
	C-301/311	to 300	FM, C	A	$270-340
	C-1200	1,200	FM	S	$695
	C-1,800	1,200-1,800	FM	A	$450
	C-2400	2,400	PM	S	$1,495
Computer Terminal	2200-401	to 300	FM	A	$1,500
	2200-402	to 1,800	FM	A	$1,500
Computer Transmission	OPTRAN 1811	2,400-9,600	PM	S	$2,950
	INTERTRAN 911	2,400-9,600	PCM	S	$1,850
	INTERTRAN 915	20,000	PCM	S	$1,875
	INTERTRAN 916	250,000	PCM	S	$1,925
	INTERTRAN 917	1,000,000	PCM	S	$1,925
Credex Corp.	3300 Series	to 300	FM	A	$350-475
	1100 Series	to 300	FM	A	$119-139
Computer Conversion	502	to 300	FM	A	
	502	1,200	FM	A	
Datamax	QB-48	2,400-4,800	AM	S	$5,900
	QB-24	2,400		S	
Control Data	Model 358-1	9,600	AM	A	$1,010
	Model 358-2	9,600	AM	S	$1,855
	Model 358-3	40.8K or 163.K	AM	S	$3,180
	Model 358-4	200,000	AM	S	$3,290
CSEE	ETT 200F	100	FM	S	
	ETT 1200F	600	FM	S	
Design Elements	Design 76/80/88	300	FM, C	A	$340-430
	Design 101/113	300	FM	A	
Digidata	DD103AC	to 300	FM	A	$210
	2202EZ	to 1,800	FM	A	$130
Digital Techniques	3300	150	FM, C	A	$289
	2301	300	FM, C	A	$317
	4320/4520A	300	FM	A	$149-389
Direct Access	TELEMATE 300	300	FM	A	$250
Data Access Systems	701B	to 450 Baud	FM	A	
	702/703	to 300 Baud	FM	A	
Data Products	1B/C	150	FM	A	$275
	DATAPAK	1,800	FM	A/S	$500
	703AC	300	F	A	$380
	802	1,800	FM	A/S	$650
	901	2,400	AM	S	
	1002	9,600		S	
Dataserv	1310/1340	to 300	FM	A	$575
Da-Tel Research	G-7106/7001	600	FM	A	
	G-7002/7C01	300	AM/FM	A	

Notes: FM = Frequency modulation; AM = Amplitude modulation; PM = Phase modulation;
A = Asynchronous; S = Synchronous; C = Acoustic coupler

TABLE IX - Cont'd.

Manufacturer	Model	Speed (BPS)	Type	Mode	Approx. Price
Digital Communications	S-1	20 to 150	PM	A	
	S-2	1.544M to 63M	PM	A	
	P-1	10K to 120M	PM	A	
Dorado Systems	128	150	FM	A/S	
Dynatronics	EDX 1400 series	to 4,800	AM	S	$6,000
ESE LIMITED (Canada)	48/QM-M100 series	2,400-4,800	QAM	S	
ESL Inc.	5000	4,800	AM	S	
Ford Industries	For Data 1210	to 300	FM	A	$295
	ForData 1610	to 300	FM	A	$395
General Electric	110D10	300	FM	A	$645
	111	300	FM	A	$750
	114B/115B	300	FM, C	A	$410
	210D30	1,200	FM	A	$740
	210D16	1,800	FM	A	$840
	Diginet 1103	300	FM	A	
	Diginet 400	50,000		A/S	$3,850
	Diginet 500	230,000			$4,850
GEC Telecommunications	TED 0299	200	FM	A	
	TED 0136	1,200	FM	A	n/a
GEC-Tel. (Australia)	DM 202	300	FM	A	
General DataComm	402 series	600	FM	A	$520
	108-1/2(R)	300	FM	A	$300
	103-4R	300	FM	A	$440
	202-5(R)	1,200	FM	A	$540
	202-9(R)	1,800	FM	A	
	201	2,400	FM	A	$1,000
General Dynamics	EDX 1402	1,200	PM	A	
	EDX 1403	4,800	FM	S	$6,150
Hallicrafters	BICOM	4,800			
	FFT 9600	9,600	PAM	S	$10,600
Honeywell	HCC 24-48	4,800	AM	S	
	HCC 48/96	9,600	AM	S	
	AN/USC 32	14.4K	AM	S	
Hughes Aircraft	HC 279	75	FM	S	Military
	HC 278	1,200	FM	S	$2,000
	HC 276	2,400	FM	S	$2,500
IBM Corp.	3872	2,400	PM	S	$2,975
	3875	7,200	PM/AM	S	$8,400
	4872	4,800	AM	S	$4,400
	RADC 9600	9,600			
	103F (Line Adapt)	up to 600	FM	A	$500-1,050
Info-Max	310 series	300	FM	A	$325
ICC (Milgo)	2200/20	2,000	PM	S	$2,250
	2200/24	2,400	PM	S	$2,550
	2200/36	2,400-3,600	AM	S	$3,620
	4500/48	4,800	AM	S	$5,980
	4500/72	4,800	AM/PM	S	$4,750
	4800/72	7,200-4,800	AM	S	$7,500
	5500/96	4,800-9,600	AM	A/S	$11,500
ITT Corp.	2003 R/V	1,200-2,400	FM	S	$1,430

TABLE IX - Cont'd.

Manufacturer	Model	Speed (BPS)	Type	Mode	Approx. Price
Intertel	1033	300	FM	A	$300
	2021	1,200	FM	A	$500
	2026	to 1,800	FM	A	$1,100
	2011	2,000	PM	S	
	2010	2,400	PM	S	$1,100
	2012	2,400	PM	S	
		3,600-4,800	PM	S	$2,500-$3,500
II Communications	201A/B	2,000-2,400	PM	S	
	113	300	FM	A	
Livermore Data Systems	71 series	to 300	FM, C	A	$235-360
	Classic r	to 300	FM, C	A	$250-365
Lenkurt (a GT&E Sub.)	25C	75-600	FM	A	$450/channel
	25B/10B	to 300	FM	A	$355
	26C	to 1,800/2,400	FM	A/S	$1,700-2,200
	26D	4,800	FM	S	$2,700-3,300
LTV (France)	R 664	200	FM	A	
LM Ericsson (Sweden)	ZAT 200	300	FM	A	
	ZAT 1200	1,200	FM	A/S	
	ZAT 2400	1,200-3,600	PM	S	
Lynch Communications	L 2103 series	300	FM	A	$570
	L 2202C	1,800	FM		
Multitech	440/MT/MP/MQ	150-300-600	FM	A	$250-635
	440 MS/MX	1,200-1,800	FM	A	$1,025
	432 series	to 1,800	FM	A	$835-$1,035
Mohawk Data Sciences	6600/812	1,200			
	6600/818	1,800			
	6600/820	2,000			
	6600/824	2,400			
Muirhead Addison Ltd.	8508A/8509A	40.8K to 50K	AM/DSB	A/S	
Memorex	1228	120 to 1,200	FM	A	
Magnavox Research	MX 170b	2,400	PM	S	
	MX 220	1,800,000	PM	S	
	MX 180	19,000,000	PM	S	
Marconi Instruments	U 1110	1,200	FM	A	
National Midco	ADC-300	to 300	FM	A	$369
Novation	DM-102/103/104	to 440	FM	A	$90-$600
	ATM 103D	to 300 Baud	FM	A	$315
Modex		1,200 & 1,800		A	
Omnitec	Series 700	to 450	FM	A	$285-$445
Philips Telecommunications	8TR 651	200	FM	A	
	8TR 652	1,200	FM	A/S	
	8TR 653	1,200-2,400	PM	A/S	
Paradyne	M-48	4,800	PAM	S	$4,250
	MARQ-48	4,800	PAM	S	
	BISYNC-48	4,800	PAM	S	$6,450
	PIX-600	4,800	PAM	S	$6,450

Notes: FM = Frequency modulation; AM = Amplitude modulation; PM = Phase modulation
A = Asynchronous; S = Synchronous; C = Acoustic coupler

TABLE IX - Cont'd.

Manufacturer	Model	Speed (BPS)	Type	Mode	Approx. Price
Plessey (England)	M 200	200		A/S	
	M 600/1200	1,200		A/S	
	M 2400/3600	3,600		A/S	
Penril Data Communications	PDC-100 series	to 300	FM	A	$400
	TTY-300	300	FM	A	$400
	PDC-1200	to 1,200	FM	A	$500
	PDC-1800B	to 1,800	FM	A	$400
	PDC-2000A	1,000-2,000	AM	S	$1,475
	PDC-2400B	2,400	AM	S	$1,100
	PDC-2400B-1	1,200-2,400	PM	S	$1,475
	PDC-4800B	4,800	AM	S	$3,500
	PDC-4800B-1	2,400-4,800	PM	S	$2,800
Philco-Ford	MC-48S	2,400-4,800	AM	S	
	MC-96D	4,800-9,600	AM	S	
	MC-50	75-2,400	PM	S	
Prentice Electronics	P-103	to 300	FM	A	$250
	202CD	1,800	FM	A	$300-350
Phoneplex	DVM 1300	1,300	PM	S	$2,600
Pulse Communications	4000 series	to 300	FM	A	$225-300
PYE TMC Ltd. (England)	01200A	600-1,200	FM	A	
Quindar Electronics	QDM 103/60	300	FM	A	$585
	QDM 600	600	FM	A	$665
	QDM 1200/600	1,200	FM	A	$990
	QDM 200	0-1,200	AM	S	$1,990
RCA	6711	to 1,800	FM	A	$800
RFL Industries	13AF	to 300	FM	A	$860
	222DB	to 1,200	FM	A	$830
	32DT	1,200	FM	A	$785
	3952	2,400	PM	S	$2,400
Rixon Electronics (UBC)	DS-180	to 1,800	FM	A	$500
	DS-2400	1,200-2,400	PM	S	$1,700
	DS-4800	4,800	PM	S	$3,600
	DS-7200	3,600-7,200	AM	S	$8,000
	DS-9600	3,600-9,600	AM	S	$9,600
Sanders Associates	12AA	to 1,200	FM	A	$321
	12AR	to 1,200	AM/FM	A	$400
	312A/123A	150-1,200	FM	A	$350
	18A	to 1,800	FM	A	$296
	24S	2,400	PM	S	$950
Sangamo Electric	T103 series	to 300	FM	A	$483-535
	T/C 113 series	to 300	FM	A	$99-$203
	T/C 202 series	to 1,800	FM	A	$420-$975
	T 201 series	2,000	PM	S	$2,285
	T201B3/4SC	2,400	PM	S	$2,396
	T4800	4,800	PM	S	
Siemens	4800	4,800		S	
	GDN 4800	50-9,600	PM	S	

TABLE IX - Cont'd.

Manufacturer	Model	Speed (BPS)	Type	Mode	Approx. Price
Singer Tele-Signal	883A/F	to 300	FM	A	$178
	883P	100-2,400	AM/PM	S	$1,450
	883R	to 2,400	AM	A	$825
	898	to 1,800	FM	A	$575
	Autoset 300	to 300	FM	A	$275/channel
Sonex (1/0 MX)	Model 31	to 300	FM	A	$280
Standard Radio & Telefon	GH 1101	300	FM	A	$200
	GH 2002	1,200	FM	S	$1,700
	GH 2003	2,400	FM	S	$1,700
	GH 3001a	40,800	FM	S	
Stromberg Carlson	SC 835	150	FM	A	$650
Sycor	Model 3460	to 1,200		A	
Tel-Tech	TT-103	to 300	FM	A	$390
	TT-202	to 1,800	FM	A	$515
	TT-201A/B	2,000-2,400	PM	S	$515-$495
Tuck Electronics	1067/1075 series	to 300	FM	A	$400-$450
	1033 series	to 300	FM	A	$350
	1042 series	to 300	FM	A	$350
	1048 series	1,200	FM	A	$400-$500
Tycom Systems	900	300	FM	A	$69.99
Thomson-CSF (France)	598	200	PM	A	
	585-6	1,200	PM	A/S	
	587	2,400	PM	S	
	595	48,000		S	
TRT (France)	MD 200	to 200	FM	A	
Ultronics (GT&E)	Data Pump 103	to 300	FM	A	$325
	Data Pump 1200	to 1,200	FM	A	$500
	Data Pump 2400	2,400	FM	S	$1,495
	Data Pump 4800	4,800	AM	S	$3,175
Universal Data Systems	202 series	to 1,800	FM	A/S	
	UDS 103	to 300	FM	A	$90-$200
	UDS 207SS	1,200	FM	S	$560
	UDS 207-M5	to 1,800	FM	A	$675
University Computing	UCC 90 series	to 300	FM	A	$120-$415
Vadic Corp.	VA 300 series	to 300	FM	A	$300
	VA 1200	to 1,800	FM	A	
	VA 2700	600	FM	A	
	21/23	1,200	FM	A	
Vernitron	BTC 1/2	300			$550-$1,200
Westinghouse Electric	FS-560	1,800	FM	A	
Western Telematic	CL-103	to 300	FM	A	$315
	CL-202	to 1,200	FM	A	$315-$430

Notes: FM = Frequency modulation; AM = Amplitude modulation; PM = Phase modulation
A = Asynchronous; S = Synchronous; C = Acoustic coupler

TABLE X

MODEMS AVAILABLE FROM COMMON CARRIERS

Common Carrier	Maximum Data Rate (Bits/Second)	Model	Monthly Rental	Remarks
AT&T	150	103E	$ 10	
	300	103A	25	DDD or Private
	300	103F	25	" " "
	300	113A	12	DDD
	600	401	25	DDD or Private
	1,200		35	DDD " "
	1,800	202C/D/E	40	" " "
	2,000	201A	72	" " "
	2,400	201B	72	" " "
	3,600		85	" " "
	4,800	208A	100	" " "
	7,200	203	85-210	Private only
	9,600	None		Not available
	19,200	303B	*	Wideband
	40,800	301B	*	"
	50,000	303C	*	"
	230,400	303D	*	"
	1,344,000	306	*	"
		602C		Facsimile
		603		Medical data
		604		" "
GT&E	200	AE 401A/E		
	200	AE 890		
	300	AE 103A	$580	Purchase price
	300	AE 103F	530	" "
	1,200	AE 2025	1,110	" "
	1,600	AE 2024	875	" "
	2,400	AE 2026	1,200	" "
Western Union	180	1181-A	$ 30	
	200	100		
	600	1601-A	50	
	1,200	2121-B	40	
	2,400	2247-A		
	2,400	200		
	4,800	2481-A		
	40,800	300		

*Price of modem is included in the rental for high speed transmission facility.

Choosing An Independent Modem Supplier

When a user selects his modem equipment today he has, aside from the telephone company, a choice of almost 250 models from at least 90 different vendors. This situation is reflective on the sudden growth of the data communications market, although it is not necessarily a healthy sign any more due to the proliferation of many small companies without adequate resources to make a go of it in the long run.

While most manufacturers provide "fully compatible" modems with those of the telephone companies (Western Electric 103 Data Sets), sometimes even very small timing differences may not be tolerated by some systems.

Users must consider several points before commiting themselves to independent equipment purchases. For example, a group of terminal units which is capable of a maximum data rate of 3,600 BPS should not be connected to the carrier facilities through 4,800 or 9,600 BPS modems because modems cannot "speed up" lower data rates. By the same token, a slower speed modem would be wasteful of line capacity when connected to a higher speed terminal and in effect would act as a bottleneck.

Even when impressive savings can be obtained by purchasing independent equipment (about 20% over telephone company rates), the user must investigate maintenance and systems support in case of problems. In real-time environments it is vital to have the means to rapidly isolate operational malfunctions and quickly obtain assistance in repairing the system.

Independent modems now come with test lights that allow the user to find out whether the problem lies in the terminal, the modem itself or the transmission line. There is evidence that even Bell is becoming responsive to this need of the user and its new 208 Data Sets, designed to transmit at 4,800 BPS, features test indicators to check for a number of such conditions.

Future Improvements in Modems

Automatic error correction is considered one of the most desirable features as users become more sophisticated, but only a few modem vendors offer this capability today. Since the most common error is usually due to some form of degradation in data line transmission quality, it is very difficult to build error-correcting techniques into modems in anticipation of a condition which occurs only at random and outside of the unit itself.

Paradyne Corporation, a new vendor who recently entered the market, is one of the few which includes such features on its 4,800 BPS modems.

Another development is that of a "smart" modem signalling line malfunction to the CPU, which would automatically switch transmission onto an alternative clear circuit.

Also a new development is the capability of a modem to signal its counterpart in a remote and unattended location to automatically loop back audio or DC signals for test purposes.

All of the above features are attractive to the user today and their technology is known. In many cases these are not built into the units as competitive pressures require manufacturers to cut costs to the bone and exclusion of non-essential features is one obvious way to do it. As MSI and LSI techniques become more common in modem manufacture, competition no doubt will proceed on the basis of availability of special features and modem performance.

Trend to Include Modems in Data Terminals and Miniaturization

Future developments in modems appear to depend largely on the FCC regulations pertaining to the possibility to eliminate in time the Data Access Arrangement (DAA) and substitute instead some form of certification for specific modem devices.

Depending on such certification and LSI developments, the modem seems to be destined to become integrated into the various terminals to which it is now connected by wire and plug as a separate unit. Some low-speed terminals with built-in modems already exist. IBM 2740 includes private network line adaptors and Teletype offers a line of teleprinters with built-in modems.

On the other hand, at higher modem speeds there appears to be a lesser need to integrate the modem into the terminal. Users are actually comfortable with discrete components in their systems because it simplifies isolation of malfunctioning equipment.

It is expected that LSI techniques will be applied to low-speed modems first, producing a "modem on a chip" and indeed a few semiconductor component manufacturers already announced such devices at prices in the vicinity of $50 per modem in quantities of 100. Such a device will be made available as a discrete component to makers of various data terminals in the future, contributing significantly to the eventual disappearance of the low-speed modem market.

Already computer and terminal manufacturers are increasingly purchasing "stripped down" modems which they incorporate into their terminals. It is, as a matter of fact, the general belief that the low-speed modem market will first become an OEM market and, in the longer term, disappear entirely as modems become components of the terminal and peripheral devices.

The expectations that modems will be included in terminals led several modem manufacturers to prepare for that market as suppliers of OEM card-type modems. This market was expected to take off during 1971 and boost modem sales, but it did not meet the expectations of the vendors.

Apparently the end user is not particularly concerned about this feature, being much more interested in data concentration and optimization of transmission. This may indeed be the reason why Codex introduced a Time Division multiplexer integrated into its high-speed modems at an optional price of only $2,000. More modem suppliers may be taking this marketing approach or getting together with multiplexer and communications processor suppliers.

There is also the very real possibility of terminal suppliers developing their own modems while designing the terminals, which again does not help the independent modem manufacturer. On the other hand, it points to the direction in which modem makers could be moving, namely to merge or develop collaborating arrangements with terminal and peripheral manufacturers and piggyback on their marketing effort which is also directed at the same end user. The alternative is, of course, merging into some of the peripheral and terminal manufacturers.

Sycor, Inc., for example, is a terminal manufacturer who introduced a Model 3460 modem for use on any of its terminals which require Bell 202C compatibility. The unit leases for $25 per month and handles up to 1,200 baud in asynchronous mode.

Milgo, the largest independent modem maker, provides printed circuit card modems to Bunker-Ramo on an OEM basis. These are integrated into an existing Bunker-Ramo data terminal and are claimed to increase its speed from 1,200 to 2,400 BPS. Milgo also supplies OEM modems to Western Union and University Computing Co. for use in the latter's COPE terminals. In the low-speed area Milgo provides several, up to 300 BPS, OEM modems including the specialized Teletype compatible units.

Industry specialists also think that present production volumes of different modem product lines do not justify OEM sales where large production could amortize costs. There is increasing belief that many of the large peripheral builders will be able to build their own modems as MSI and LSI techniques advance. This is a very reasonable assumption because terminal or peripheral construction is sophisticated work, with much of the equipment and know-how readily available for production of relatively simple devices such as modems.

The investment in technology and manufacturing facilities to become a low-speed modem supplier is rather small and this explains the multitude of the small companies which compete in this market. We believe that the price competition alone will reduce the number of entrants severely in the next two years and introduction of integrated circuit technology will settle the remaining to a performance competition and result in additional mergers with peripheral manufacturers.

Markets for Modems

The number of modems attached to switched and leased telephone lines is expected to increase tenfold during the seventies to about 4.8 million units, a number only slightly larger than the number of terminals estimated to operate on-line to computers by the end of 1980.

This exponential growth in the number of modems will not be reflected to the same extent in the growth of modem markets. First, at present at least 70% or so of all the units are still AT&T modems which are rented by the Bell operating companies and although the market share of independent suppliers is increasing, it is not expected that Bell's share will fall much below 50% of the total modem market at any time.

Secondly, the cutthroat competition among the almost 100 modem manufacturers has had the effect of reducing the prices for modems to a level where it is very difficult to make a profit in such operations. This rapid price erosion counteracts to the rapid increase in numbers of units and the resulting modem sales are not growing spectacularly.

Thirdly, AT&T is slowly but surely meeting the challenge of the independent modem manufacturers. Considerable expectations were attached to the 4,800 and 9,600 BPS modem speed ranges where, until recently, AT&T did not offer a product or lease prices of Bell units were considerably higher than comparable independent prices. Recently AT&T announced the 208A data set which rents for $100 per month, a price considerably less than independent units in that speed range.

TABLE XI

ESTIMATED GROWTH IN CUMULATIVE NUMBER OF INDEPENDENT MODEMS AS PERCENTAGE OF TOTAL MODEMS ON SWITCHED AND LEASED NETWORKS

Year	Estimated Total Modem Installations	Estimated % AT&T Modems	No. of Independent Modems
1970	178,000*	72%	49,700
1971	376,000	71%	109,400
1972	640,000	70%	192,000
1973	950,000	68%	317,600
1974	1,500,000	66%	510,500
1975	2,060,000	64%	741,500
1976	2,604,000	60%	1,061,500
1977	3,270,000	57%	1,407,500
1978	3,880,000	55%	1,748,500
1979	4,340,000	52%	2,082,300
1980	4,832,000	50%	2,416,000

*Based on AT&T estimate to Jan. 1971 of total of 128,000 modems attached to switched and leased lines. Other estimates of Frost & Sullivan

Our estimates of the total number of modems, particularly during the mid-seventies, fairly parallels the number of terminals projected to operate with general purpose computers. In fact, it is higher somewhat to account for the high speed modems and additional units to be used with a variety of data collection devices, as well as acoustic couplers used extensively with portable terminals.

These numbers also include all of the Data Service Units (DSU) and Channel Service Units (CSU) which will be required when Bell's Digital Data System comes into being. Such devices will replace the modem in all digital transmission and will be relatively simple to manufacture. Present modem manufacturers may choose to supply these units in the future, but because their unit prices are likely to be below $50 per unit, these will not contribute significantly to "modem" sales,while increasing somewhat an already serious price erosion in all modem speed ranges.

On the other hand, some industry observers speculate that increasing numbers of terminals actually will require a relatively smaller number of modems as clusters of terminals develop within a single location. Once ten or more terminals exist within a company at the same plant, they can be directly multiplexed with time-division multiplexers, obviating the need for low-speed modems. For the purpose of our estimates, Frost & Sullivan, while acknowledging this factor, does not consider its impact significant during the time span of our forecast.

On the following page, we present a forecast of the estimated growth in total number of modems and the growing percentage of the independent modem manufacturers. Following this analysis, we break up the total independent modem growth projections into low-, medium- and high-speed ranges and estimate cumulative numbers of units in each range. The number so derived will later be used for projections of total modem markets by applying unit prices.

TABLE XII

ESTIMATED GROWTH IN CUMULATIVE NUMBERS OF INDEPENDENT MODEMS BY MODEM SPEED CATEGORY

Year	Low-Speed Modems (to 300 BPS)	Medium-Speed Modems (to 4,800 BPS)	High-Speed Modems (Over 4,800 BPS)	Total No. of Modems
1970	43,000	4,700	2,000	49,700
1971	93,000	12,400	4,000	109,400
1972	163,000	22,900	6,100	192,000
1973	273,000	36,000	8,600	317,600
1974	443,000	55,900	11,600	510,500
1975	643,000	82,900	15,600	741,500
1976	923,000	117,900	20,600	1,061,500
1977	1,223,000	154,900	26,600	1,407,500
1978	1,523,000	191,900	33,600	1,748,500
1979	1,813,000	227,900	41,400	2,082,300
1980	2,103,000	263,900	49,100	2,416,000

Source: Telephone Interconnect Market Study, F & S, 1972.

The figures above are developed for the purpose of estimating the magnitude of markets in each modem category. This is done later in this study, where changing modem prices are used to compute corresponding modem sales for each category. We believe the growth of modem installations will continue at high growth rates, averaging 50% to 70% per year and even more for independent modem installations. But the total dollar volume realized from the sale of modems will not increase at such rates due to the previously mentioned price erosion.

Modem Price Erosion

Because significant price reductions are currently taking place in the modem industry it is difficult to project the markets for modems without a thorough analysis of the factors affecting manufacturing costs and the marketing practices.

The graph following is a plot of unit price ranges for modems at various transmission speeds. The price ranges indicate not only degrees of sophistication of modems at each speed but probably also to some extent the price erosion that has been taking place during the last three years.

As more users buy large quantities of modems at a time (and orders of 250 to 500 units are considered large) suppliers are forced to bid for these contracts. Because of large quantities they offer unit prices in the order of $400 to $750 per unit even for medium speed (2400 BPS, Bell 201 compatible) modems which otherwise are listed at $1,200 to $3,000 per unit. This practice reduces the real overall revenue per modem on an average basis.

One supplier, II Communications sold large numbers of 201 class modems to the Army at $600 per unit as long ago as 1970. Western Union more recently was offered several thousand of 201 class modems at unit prices in order of $400 per modem.

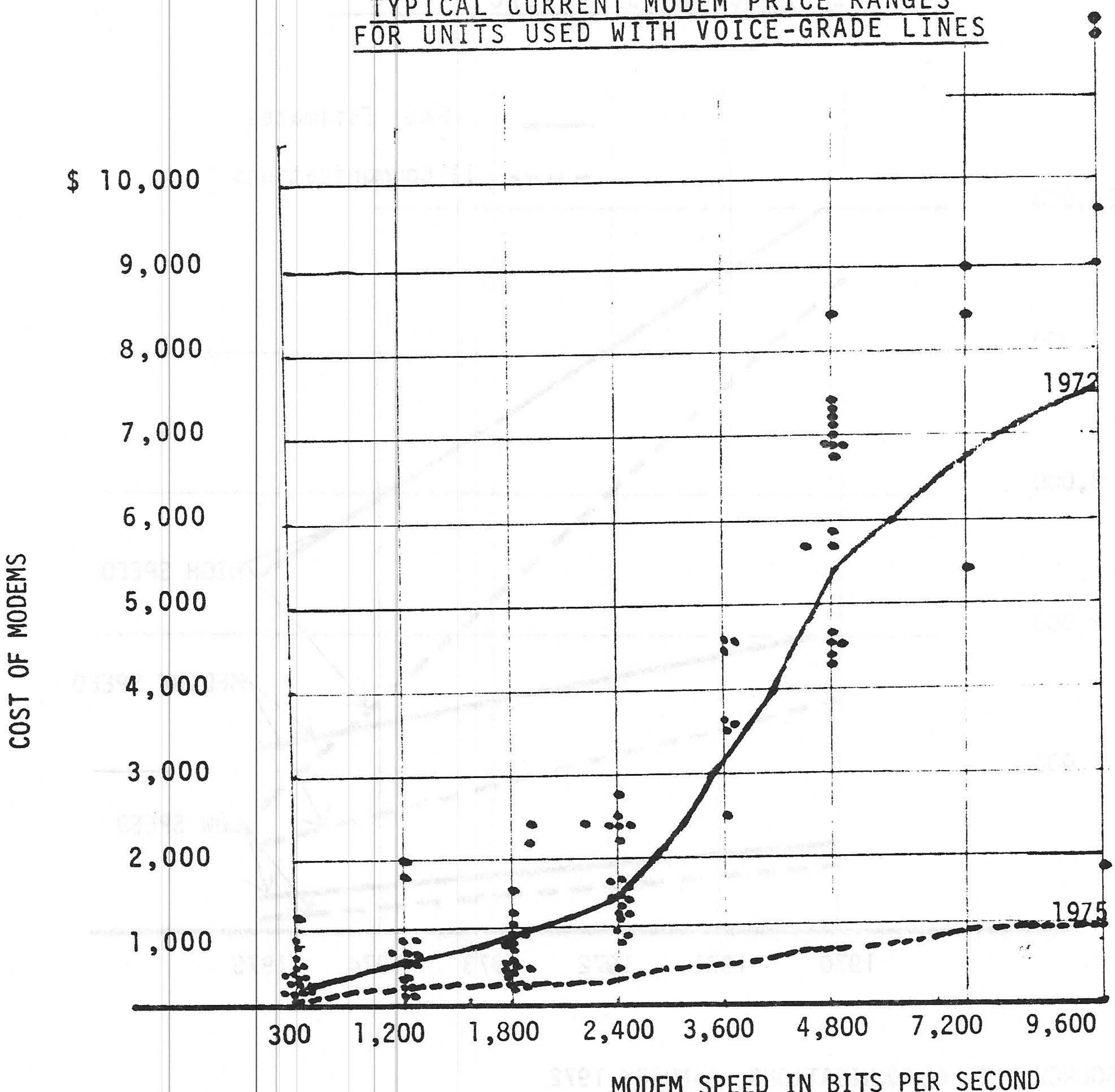
Intertel recently introduced a 201 compatible modem at a unit price of $1,100 but in quantities of about 1,000 units it is willing to sell the modems for about $700 per unit. The same company has a 4800 BPS modem which lists for $3,500 but already is developing a card version of the unit which will sell for about $2,000 each, clearly a 33% price reduction by design.

Following AT&T's introduction of the 208A data set at a monthly lease of only $100, even Milgo was forced to slash its prices on 4800 BPS modems by 2% to 17% on sales, and as much as 14% to 50% on its leases.

As additional evidence of price erosion, we have plotted certain price and shipment estimates made by II Communications. On the same graph are shown Frost & Sullivan projections for modem prices.

FIGURE IV

TYPICAL CURRENT MODEM PRICE RANGES FOR UNITS USED WITH VOICE-GRADE LINES

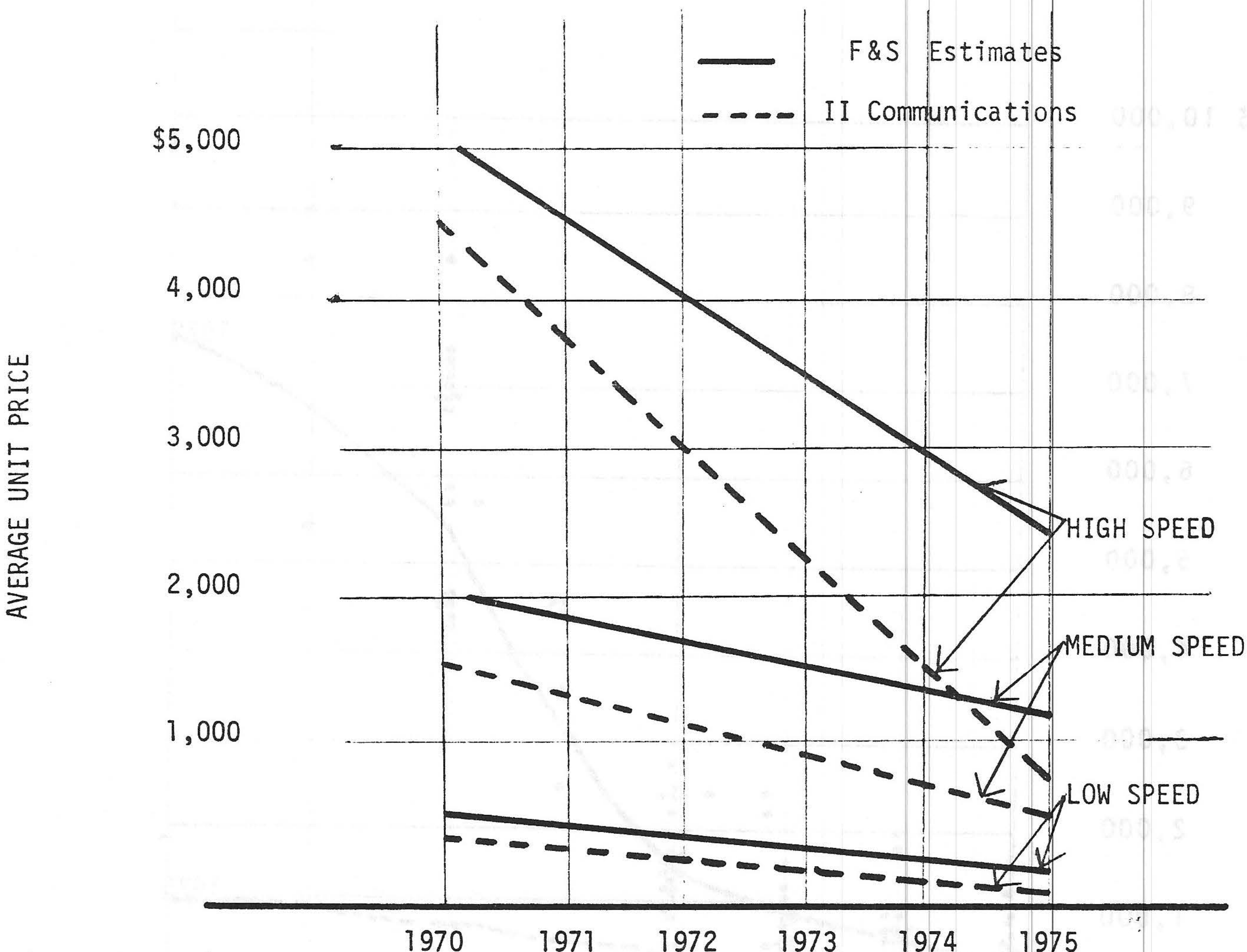


SOURCE: FROST & SULLIVAN, OCTOBER 1972(BS)

This graph is a result of plotting some of the typical modem prices from the characteristics of modems tables on preceding pages against modem speeds. The prices are plotted as ranges at each modem speed and an average point is used to draw the curve. The ranges are indicative of the dropping prices within each modem group but modems are not comparable on price alone because of the many non-essential features which they may have.

FIGURE V

MODEM PRICE EROSION 1970 - 1975



SOURCE: II COMMUNICATIONS, JANUARY 1972
FROST & SULLIVAN ESTIMATES, OCTOBER, 1972

Reasons for Modem Price Erosion

Ease of entry into the modem business coupled with rapidly falling component prices is the primary cause of the severe price erosion in the modem market. The following specific reasons are major factors affecting this price erosion:

1. Prices of integrated circuits, resistors and capacitors which are modem components, used in the manufacture, have been falling steadily for several years.

2. Technological advances in the higher-speed modems and increased use of LSI - MOS devices.

3. Many large quantity buys by large corporate users, common carriers or government agencies at significant discounts from listed and quoted prices.

4. Large number of competitors in the low-speed modem area and consequent attempts to obtain contracts and sales at any price in order to stay in business.

5. OEM discount sales of modems for integration in various terminals.

6. Appearance of low-speed "modem-on-a-chip" for large volume sales to OEM suppliers of terminals and peripherals of certain type.

7. Increasing responsiveness of AT&T and telephone companies providing competitive services to users of small number of modems who are not in a position to command impressive discounts by volume buys.

8. Introduction of Digital networks by Datran and Bell which will not require modems as we know them today, but simpler devices such as data Service Unit (DSU) and Channel Service Unit (CSU). Both will replace modems and will be simpler to manufacture selling at a low unit price thereby reducing the average "modem price to the $50 per unit level.

Modem Market Forecast

The results of our previous analysis are combined in the modem market forecast which appears on the following page. It shows a relatively slow growth in modem dollar revenues, which we believe will peak out in 1976 and continue as a stable market of about $40 million after that date.

In this forecast, we disagree with several previous projections showing a much more pronounced growth of the modem markets. Some of those may have included total modem populations of which AT&T equipment will continue to have a 50% market share and should be subtracted from estimates of independent modem markets.

We also believe that some of the earlier projections did not expect as serious a price erosion as has occurred in this business and this would explain their much higher modem sales estimates. Events of the last two years, however, suggest that prices are falling faster than expected and OEM markets are not developing fast enough. Economic downturn and poorer business conditions were also a contributing factor, but we feel the crowding of manufacturers and resulting price erosion a much more significant factor in this market.

This forecast considers the serious unit price erosion which is expected in the modem market. It is most rapid in the low-speed modem category, where the average $300 price today is falling rapidly and is expected to be as low as $50 per unit in only a few years. Medium-speed and high-speed modems will also drop sharply in price per unit, but not to the degree of low-speed modems. By the end of the decade, most modems will be considered as components of terminals or other communication devices.

TABLE XIII

ANNUAL MODEM SALES BY CATEGORY, NUMBER AND VALUE OF INDEPENDENT MODEM MANUFACTURERS (Sales in $ Millions) (1970-1980)

	Low-Speed Modems			Medium-Speed Modems			High-Speed Modems			
Year	Number	Unit Price	Total Sales	Number	Unit Price	Total Sales	Number	Unit Price	Total Sales	TOTAL
1970	43,000	300	$ 13	4,700	2,000	$ 10	2,000	5,000	$ 10	$ 33
1971	50,000	260	13	7,700	1,175	14	2,000	4,500	9	36
1972	70,000	200	14	10,500	1,500	16	2,100	4,000	8	38
1973	110,000	150	16	14,000	1,300	18	2,500	3,500	9	43
1974	170,000	100	17	19,000	1,200	23	3,000	3,000	9	49
1975	200,000	100	20	27,000	1,100	30	4,000	2,500	10	60
1976	280,000	75	21	35,000	1,000	35	5,000	2,250	11	67
1977	300,000	60	18	37,000	750	28	6,000	2,000	12	58
1978	300,000	50	15	37,000	600	22	7,000	1,750	12	49
1979	290,000	50	14	36,000	500	18	7,500	1,500	10	42
1980	290,000	50	14	36,000	500	18	8,000	1,000	8	40

Source: Yearly sales numbers from Frost & Sullivan's Telephone Interconnect Market Study, 1972.

Market Shares of Modem Manufacturers

Of all the modems supplied every year, AT&T provides almost 70%, although this market share is dropping every year as independent modem manufacturers expand their production and lower the prices. AT&T does not sell its modems, however, but leases the units to users and therefore it is not directly comparable to the independent manufacturers. Until July 1972, AT&T monthly rates for modem equipment were such that independents could easily get a market share on the basis of price alone.

On July 3, 1972 new tariffs filed by AT&T went into effect which reduce the monthly rents on some of the low-speed modems by as much as 35%. This created considerable concern among the independent modem manufacturers and may, in the long run, keep a bigger market share for AT&T than expected. For the purpose of this study, we feel that due to very severe price competition and miniaturization, independent modem manufacturers may obtain as much as 50% of the total modem market by 1976 and this is considered in our projections.

The latest moves by AT&T assures the Bell companies of the numerous small user market where leasing a few units makes sense. The independents now see their best chance in serving the large user who buys several hundred modems at a time and to whom they can offer very attractive terms on sales, which are still not available from AT&T.

Of all the modems in use, an estimated 75% or more than overall average, on the telephone networks are supplied by AT&T telephone operating companies, while a somewhat smaller percentage in the order of 50% to 60% of modems used on leased lines fall into that category. An even smaller percent of the modems is provided by AT&T for higher speeds, particularly in the 4,800 to 9,600 BPS categories, but virtually all wideband speeds modems are again provided by the telephone company.

The independent modem suppliers control about 30% of the up to 300 BPS modem market, but a larger share of the 1,200 to 2,400 BPS market and practically all of the 4,800 to 9,600 BPS market. As stated before, very high-speed modems are virtually only supplied by the common carriers, primarily for their own high-speed links.

There is a cutthroat price competition among the independent suppliers and between 1970 and 1971 prices for low-speed modems dropped drastically from around $450 to $350 per unit. This price erosion continues, with integrated circuits being the main culprit for the drop.

1971 was also a rather disappointing year for many modem suppliers who anticipated increasing large number sales to OEM suppliers of terminal equipment. These did not materialize, which was not very welcome news to the industry, as several low-speed modem manufacturers rely on OEM sales for their survival.

The OEM modem suppliers do not see profitable operations in supplying low-speed modems to end users. The price of the unit, small quantities bought and marketing and service costs do not make the low-speed modem end user market attractive on its own.

TABLE XIV

ESTIMATED MODEM SALES OF MAJOR INDEPENDENT MODEM MANUFACTURERS DURING FISCAL 1972 (*)

Manufacturer	Estimated modem sales (in millions)	% of total
International Communications (Milgo)	$10.0	26.3
IBM Corporation	4.0	10.5
Lenkurt Electric	4.0	10.5
Collins Radio	3.0	8.0
Sangamo	2.0	5.2
American Data Systems	1.5	4.0
Data Products	1.5	4.0
Codex	1.5	4.0
Inertel	1.5	4.0
Penril Data Communications	1.0	2.5
10 Leading modem manufacturers	30.0	79.0
All other independents	8.0	21.0
Total Independents	38.0	100.0
AT&T modem leasing revenues	100.0	-

(*) Fiscal 1972 is not necessarily coincident for all the companies identified.

Among the independent modem manufacturers, Milgo Electronics has been the leading supplier and we estimate it has at least 26% of the independent modem market. Milgo, however, does not have the greatest number of units in the field because most of that company equipment is in the medium- to high-speed modem product line. Because of intensive competition and price erosion, Milgo is pretty much out of the low-speed modem market and never pursued that product line.

Last December, IBM announced two new modems (IBM 3872, IBM 3875) in its product line which also consists of medium- to high-speed modems. While IBM prices are generally above those of independent suppliers or even Bell telephone in some cases, the company has a solid base of 70% of all computers in the world and this presents a huge potential market. If the same ratio is applied to all the computers presently estimated to operate in communications mode, this would give IBM about 16,000 computers whose systems and terminals will require numerous modems.

In some estimates, IBM is not considered as an independent modem supplier, but we feel that due to the latest moves by the company in the modem area as well as in the communications processor field, IBM may well become a substantial modem supplier within a very short time. Already IBM has a Time-Division multiplexer product, high-speed modems and the front end communications processor. The next logical step is to capture a market share and develop an integrated approach to data communications where the multiplexing and modem functions can be included in the mainframe hardware.

We estimate IBM to have only a 10% market share of the independent modem business which is roughly about $4 million per year. We arrive at this figure by considering that only about 5% of the 16,000 IBM on-line systems actually use IBM modems and apply some typical prices which for those high-speed units are in the order of $5,000 per unit.

The direction IBM is taking is also indicated by its introduction in May 1972 of the "integrated modem feature" into three basic data communications devices. These are a controller, a programmable buffered terminal and a data adapter. Long predicted by the industry, this move was made by IBM which once again turned out to be the technology and marketing leader in the industry. It should be considered that further IBM expansion into the data communications area is certain.

This supposition is reinforced by the fact that in the last two years or so, sales of central processors have been leveling off and IBM was one of the first to feel and react to this situation, as it is forced to maintain a reasonable growth of its sales and profits and as a very large corporation must look for product lines with the greatest possible rate of growth. Data communications provides such a product line and at the same time enhances IBM's basic product, the computer.

Following those are well established firms like Collins Radio, Lenkurt Electric, and Sangamo and then come the newer companies more recently entering the business. These include Data Products and American Data Systems, Codex and Intertel which we believe each sold about $1.5 million worth of modem equipment during the last 12 months. Data Products is a well established peripherals manufacturer with significant sales to Government agencies. Its data communications base comes from the acquisition of Stelma, a Connecticut company which has a data communications product line including modems, couplers and terminals. While we feel Stelma sales of modems are at the $1.5 million level it is questionable if the present climate of receding government contracts will turn out to be healthy for this company which must compete with the newcomers offering comparable equipment at significably lower prices.

American Data Systems is a different proposition. It is a much younger company which started as a time-division multiplexer manufacturer and added very soon high-speed modems to its product line. Later the company rounded off its data communications offerings with a frequency division multiplexer, data terminals and, now, a communications processor. It is probably the most complete house in the data communications hardware area which is dedicated to that industry and has no other interests. It is still a private company, but enjoys very solid financial sponsorship and developed its basic modem from North American Rockwell (Autonetics) patents which were made available to it. North American Rockwell owns a considerable share of the company.

As we have pointed out elsewhere, ADS is one of three companies among more than 156 identified in this study, which offers a complete data communications hardware line. The other two with comparable equipment range are IBM and Collins Radio.

The 15 leading modem manufacturers account, according to our estimates,for about 90% of all independent modem dollars. This means that there are about 80 other modem manufacturers scrambling for but a few more millions of dollars in the independent modem market. Clearly this situation cannot last for very much longer and already several firms have decided to discontinue modem production or drop some of the less profitable modem lines.

In our market share table we also included at the bottom the estimated revenue which AT&T gets from its annual modem rentals. This is not comparable to the sales of the independents, but it indicates a certain relation and magnitude of the Bell umbrella. The $100 million estimated is based on the lower rates in effect since July 1972.

VII - THE MULTIPLEXER MARKET AND INDUSTRY

Function and Reason for Multiplexers

Basically, the multiplexing function is to converge a number of low-speed transmissions into a high-speed stream primarily for lower cost long distance transmission. At the receiving end demultiplexing, or divergence of the high-speed stream takes place for low-speed data distribution to specific terminal devices. The low-speed data may be continuous or periodic and random in appearance and typically multiplexing does not imply storage of low-speed line output.

Considered as a device which is able to assign a large number of communications channels to a single voice-grade channel of the switched and ubiquitous telephone network, the multiplexer becomes a viable and economic factor in data communications.

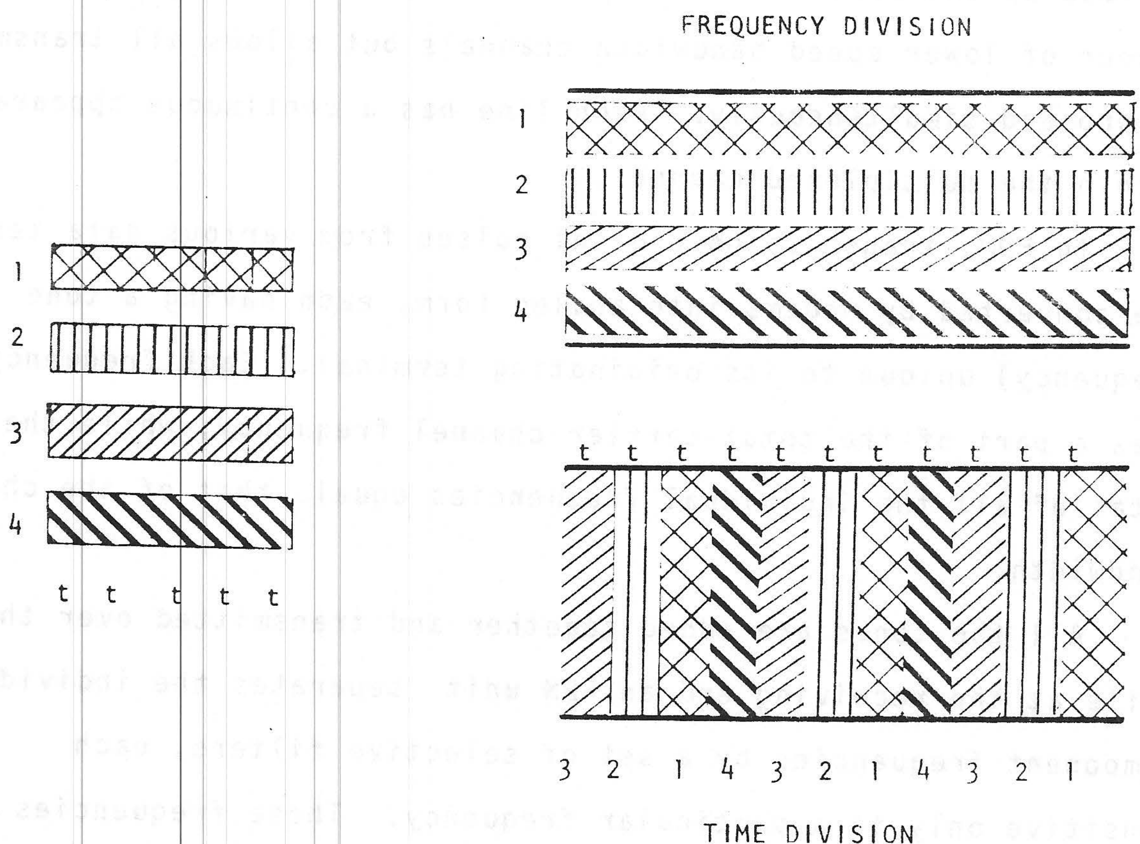
Multiplexing as a technique was used for some time in long-distance analog signal transmission by the telephone companies. Historically, the Frequency Division Multiplexing (FDM) technique was employed, but with increasing digital data traffic, Time Division Multiplexing (TDM) has come into use and offers certain definite advantages over the older method.

Multiplexing can also be performed by concentrators, which are devices using hardware and software to handle various computer-communications functions, mostly in time-shared multi-access computer systems. While a concentrator can function as a multiplexer, it must be quite clear that a multiplexer is usually limited to the multiplexing function only.

Some confusion arises from the fact that various devices, which are usually designed around a minicomputer, are known as concentrators and, among others, perform the multiplexing function. These are also called "store and forward units," communications front ends, pre-processors and all may perform multiplexing functions.

FIGURE VI

COMPARISON OF MULTIPLEXING TECHNIQUES



Diagrams illustrate the basic principles of the two techniques of multiplexing. In the Frequency Division method, guard bands are required between subchannels to prevent crosstalk interference during transmission, which wastes bandwidth of the line.

Frequency Division (FDM) Multiplexing

This multiplexing technique has been used by common carriers for more than 50 years in order to lower the cost of long distance transmission. Frequency division multiplexer, as its name implies, divides up the bandwidth of a telephone voice grade line into a number of lower speed bandwidth channels but allows all transmissions to proceed simultaneously. Each line has a continuous appearance within the multiplexed channel.

In FDM, transmission digital pulses from various data terminals are converted by modems into analog form, each having a tone (or frequency) unique to its originating terminal. Each frequency occupies a part of the total carrier channel frequency, while the total of all the individual frequencies equals that of the channel bandwidth.

All the tones are added together and transmitted over the line while at the receiving end an FDM unit separates the individual component frequencies by a set of selective filters, each sensitive only to a particular frequency. These frequencies are then demodulated by a modem into digital pulses which activate the receiving data terminal.

The filters used in FDM devices distinguish tones which originate from a particular data source. In order to keep filtering costs within reason, unused frequency "guard bands" are employed to separate the tones from one another. This limits the number of channels that can be derived from a single voice-grade telephone line and in this respect FDM is not as efficient in overall bandwidth utilization as the time-division method of multiplexing.

The maximum number of subchannels that can be derived from a standard voice-grade telephone line using DDM is easily predicted from the transmission rates of the low-speed devices which are providing the input. With the lowest practical speed of 50 baud, a maximum of about 24 subchannels can be obtained from a 3,300 Hz bandwidth of a voice-grade telephone line. This is because each subchannel needs 100 Hz for data and 10 Hz on each side as guard band to prevent crosstalk.

For international circuits, CCITT Recommendation No. R 31 describes FDM bandwidth standards for this situation and is perhaps the best illustration of the method. The table below indicates the available subchannels by number and their associated frequencies.

TABLE XV

AVAILABLE SUBCHANNELS BY NUMBER AND FREQUENCIES

Channel No.	Band Center Frequency (Hz)	Channel No.	Band Center Frequency (Hz)
1	420	13	1,860
2	540	14	1,980
3	660	15	2,100
4	780	16	2,220
5	900	17	2,340
6	1,020	18	2,460
7	1,140	19	2,580
8	1,260	20	2,700
9	1,380	21	2,820
10	1,500	22	2,940
11	1,620	23	3,060
12	1,740	24	3,180

In a similar way, frequencies of 75, 110, 150, 300, 600 and even 1,200 baud can be allocated to the available voice grade bandwidth, but the number of subchannels will diminish in each case. There are more subchannels possible, but on specially conditioned lines and with special modems, so for practical purposes an FDM device is considered limited to 24 low-speed channels.

TABLE XVI

SUPPLIERS OF FREQUENCY DIVISION MULTIPLEXERS AND THEIR PRODUCTS

Manufacturer	Model	Maximum No. of Low-Speed Channels	Approximate Minimum Unit Price
American Data Systems	ADS 680	25	$ 1,140
Aquidata	AQ-TX-1	22	
Coherent Communications	FDMA/FDMT series	37	$12,000
Collins Radio	TMX-201	22	
Comdata	200 series	16	$ 3,880
Communications Technology	8900	8	$ 5,000
Data Products	Data Pak	25	$550/channel
General DataComm	FDM 1101	35	$460/ "
	GDC 1100	38	
GTE Lenkurt	25C	18	$323/TDX channel
	25B	25	$537/TDX "
General Electric	Diginet 150	17	
	Diginet 160	17	
IBM	Shared line adapter	4	
LTT S.A. (France)	B 1681	12	
NCR	NCR 621-103	16	$21,000
Northern Radio	700 series	24	
Quindar Electronics	Q-60	27	
RFL Industries	2056	22	$400/channel
	5150	24	
RCA Commercial Data	CDM	24	$5,300
Singer Tele-Signal	2503H	12	
	2450	24	
Scantlin Electronics	201	16	
Sonex	TEX-5085	10	
Tuck Electronics	1145	22	
Tele-Dynamics	7260	16	FSK Modem
Ultronic Systems	9520/9521	22	$4,500
	8000	25	
Technitrend	FM-8000	7	$7,000

Note: Maximum number of derived channels for each multiplexer device depends on individual speeds of various data sources multiplexed. In the above table, maximum rates are based on 75 baud input devices. Higher speed devices will lower the number of maximum channels available. In some cases, line conditioning may also be required to develop full multiplexing capacity.

Time-Division (TDM) Multiplexing

Time division multiplexing is a technique of data communications over existing carrier transmission facilities which is rapidly increasing in importance. It differs fundamentally from the older frequency division (FDM) multiplexing method. With TDM, the entire "baseband" frequency bandwidth being multiplexed is used for transmission of a single high-speed data signal. This signal consists of a number of lower-speed signals from the various data input devices.

A transmitting time division multiplexer scans each of the low-speed digital inputs in turn, taking an individual bit or character from each, and interleaves these on a time basis to form a high-speed data stream for transmission. At the receiving end, a reverse process occurs. The receiving multiplexor, which must be synchronized with the transmitting unit, distributes the individual bits or characters from the arriving data stream and creates a number of low-speed data outputs at the attached terminal devices.

Current TDM technology offers advantages when using conventional analog transmission networks. A TDM unit merges a number of independent low-speed subchannels into a single higher-speed signal which is passed through a high-speed modem for transmission. In transmission of multiple signals at speeds from 75 to 1,200 BPS, a TDM unit offers important advantages over frequency division multiplexers by combining all signals into single 2,400 to 9,600 BPS signals for transmission over a voice grade or other large analog channels.

There are two basic types of TDM equipment. One type interleaves individual bits from each subchannel. The other collects complete characters (consisting from 8 to 11 or even more bits) from individual data streams before interleaving them into a high-speed data stream.

If low-speed data input includes 'vertical' parity only, bit interleaving results in fewer undetected transmission errors. On the other hand, character-interleaved multiplexing results in fewer characters actually in error. Bit interleaving is preferred where 'echoplexing' is used where data input from a teletypewriter is transmitted to a computer and 'echoed' back before printing. Character interleaving would cause unacceptable delays in printing of 'echoed' characters.

Generally speaking, error checking is available only in character-interleaved TDM equipment. Such multiplexers also differ in maximum line speeds and, as a result, in maximum number of channels which is a derivative of the maximum speed characteristic.

Another important feature on some TDM units is the ability to intermix low-speed subchannels of different individual speeds. Where this can be done, the TDM's central clock mechanism generally runs at the fastest bit rate being intermixed, thus restricting the system's total subchannel capacity to that which is available at the highest subchannel speed.

Channel Capability of TDM Equipment

The channel capability of TDM units depends primarily upon the capability of the associated modem. The cost savings which can be produced by a TDM device by provision of additional channels in a voice grade line will be offset by additional circuit boards in the TDM and higher cost of high-speed modems, as well as in increased charges for better grade communication circuits. In general, however, more subchannels can be obtained with a TDM device than the FDM unit. The table below lists some typical terminal devices and possible subchannels depending on a particular high-speed modem in use.

TABLE XVII

NUMBER OF POSSIBLE SUBCHANNELS AVAILABLE FROM A SINGLE VOICE GRADE LINE USING MODEMS OF VARYING CAPABILITIES

		Modem Speed in Bits Per Second					
Terminal	Data Rate (Baud)	1,800	2,000	2,400	3,600	4,800	9,600
TTY 28	75	12	22	27	40	45	
TTY 33	110	12	14-22	18-27	28-40	38-45	80
TTY 35	110	12	14-22	18-27	28-40	38-45	80
IBM 1050 2740 2741	134.5	10	10-13	14-18	22-27	30-36	65
TTY 37	150	8	10-13	12-18	20-27	28-36	58

Source: Frost & Sullivan, Data Communications, 1970.

TABLE XVIII

SUPPLIERS OF TIME-DIVISION MULTIPLEXERS AND THEIR PRODUCTS

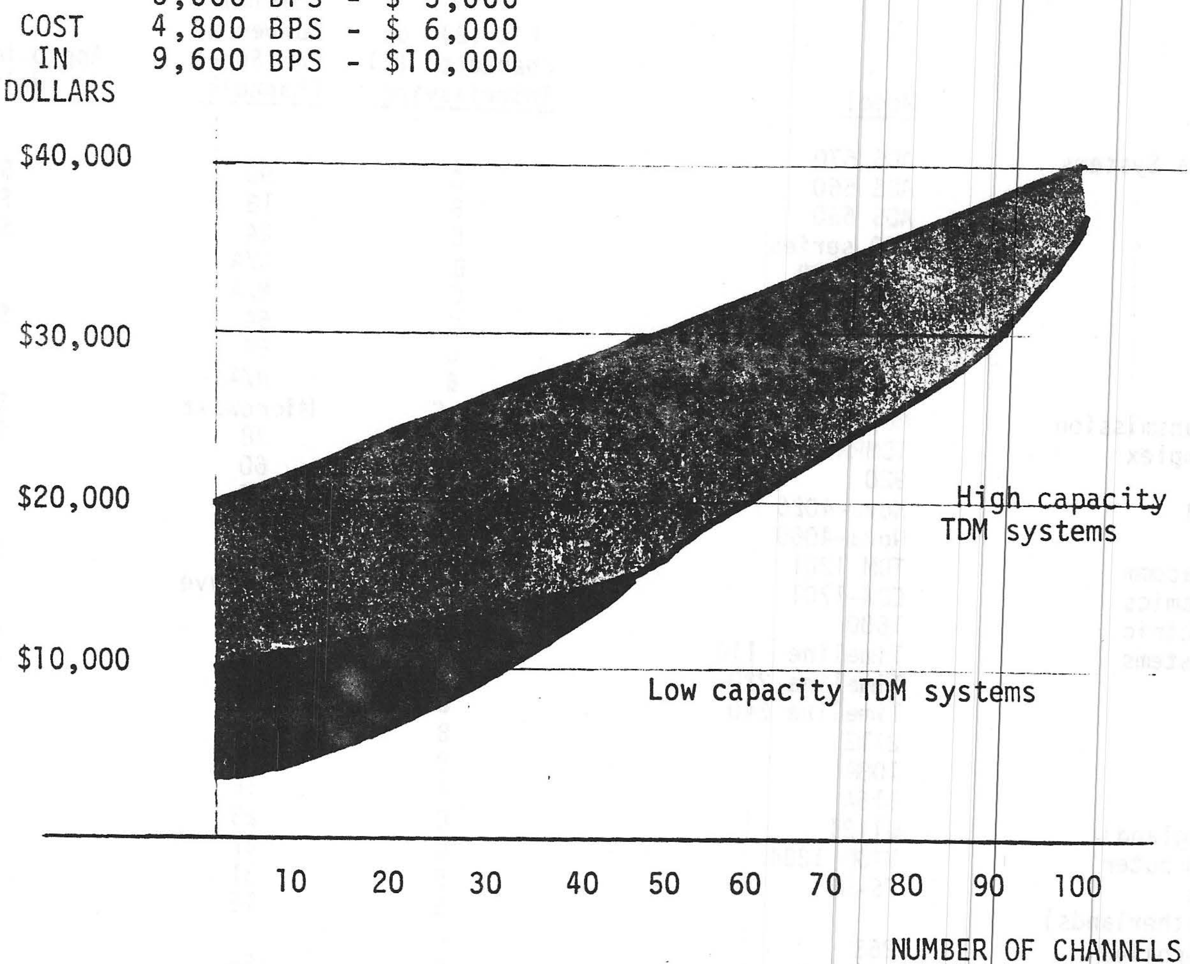
Manufacturer	Model	Bit (B) or Character (C) Interleaving	Maximum Number of Low-Speed Channels	Approximate Minimu Unit Price
American Data Systems	ADS 670			
	ADS 660	C	90	$5,000
	ADS 630	B	18	$2,750
Astrocom	500 series	C	24	$8,291
Bendix	TDM-150B	B	N/A	
	TDM-200A	C	N/A	
Codex	810	C	64	$2,800
	840	C	64	
	880	B	N/A	
Computer Transmission	MULTITRAN	B,C	Microwave	$7,500
Computer Complex	TDMRX-11	B,C	38	$4,500
Databit	920	B	60	
Data General	Nova-4026	B	16	
	Nova-4060	B	64	
General Datacomm	TDM 1201	C	112	$2,000
General Dynamics	EDX-1701	B	Microwave	
General Electric	1600	B	64	
Infotron Systems	Timeline 110	B	14	$4,400
	Timeline 220	B,C,	112	$9,960
	Timeline 240	C	156	$3,740
IBM Corp.	2712	B		
I/Onex	108A	B	8	$4,400
	116A	B	16	$8,000
Marconi (England)	U1131	C	23	
On-Line Computer	VTDM 1284	C	127	$6,000
Philco-Ford	FS-96	B	31	
Philips (Netherlands)		B	16	
Princeton Applied	263			
RFL Industries	TM 3000	C	156	
Rixon	TDM-8	B	8	$5,300
	TDX-2	C	88	
	TDX	B	24	$15,000
Singer Tele-Signal	842-B	B	30	
	842-A	B	15	
	2533	C	80	
Timeplex	SMC-200	B	32	$4,300
	Timeplexer	C	16	$1,250+
	MC-70	C	71	$5,515+
Tel-Tech Corp.	TTC 1000	B	112	$2,970
	TTC 2000			
	TTC 3000			
Ultronic Systems	9000 series	B	116	$4,500
	TSMU	C	175	$4,980
Xerox Data Systems	7			$8,200

FIGURE VII

TYPICAL COSTS OF TDM INSTALLATIONS

Average Modem Costs

1,800 BPS - $ 900
2,400 BPS - $ 1,800
3,600 BPS - $ 5,000
4,800 BPS - $ 6,000
9,600 BPS - $10,000



Relationships showing the ranges of TDM multiplexer costs relative to the number of channels that can be derived from an average voice grade line. Costs of the necessary modems for multiplexed line transmission have been included as these form a necessary expenditure for operation of TDM multiplexer systems. Number of possible channels also varies with the speeds of terminal devices and the intermix of various terminals at any one installation.

Comparison of TDM Versus FDM Techniques

For a given carrier network channel bandwidth, a larger number of subchannels of a given speed can be derived using TDM than FDM. Taking voice-grade line as an example (3kHz bandwidth), FDM equipment can derive approximately 25 subchannels each of 75 BPS speed, while several TDM units now available can derive nearly 100 such subchannels and some as many as 175.

Cost of equipment on a per channel basis ranges from $600 to about $1,000 per low-speed subchannel for either FDM or TDM units. Therefore, TDM equipment shows substantial cost advantages over FDM units when more than 20 low-speed subchannels are required.

Noise and signal distortion in an FDM are cumulative, while in a TDM system data signals are regenerated at each multiplexer unit. Therefore distortion of low-speed input is eliminated when demodulated as output at the receiving end. This means that a TDM unit offers lower error rates than an FDM unit operating over the same transmission line. In high-speed data communications between computers or terminal devices, this consideration is of paramount importance.

As a digital transmission device, a TDM can insert parity bits for error detection even when transmitting data from terminal devices which do not have parity insertion and checking features.

Terminal devices hardwired into a TDM unit may not require the use of modems, as both units transmit signals in digital form.

FDM offers multidrop features which may be important to a time sharing service operating on a wide regional basis. Subchannels cannot be dropped out of a TDM high-speed link without demultiplexing the whole transmission at each intermediate station.

Frequency Division multiplexing does offer advantages over TDM and it is erroneous to believe that with time, all multiplexing will be performed by TDM devices. When used in the servicing of small groups of data sources or terminals scattered over several remote sites, FDM can be more economical than TDM.

FDM is more terminal oriented and can accomplish more effectively the intermix of various terminal input speeds. The signals from each terminal are processed independently by FDM modem-filter assemblies with the individual frequencies proportional to the data terminal speeds. In TDM, terminals are serviced in a dependent manner and bandwidth can be wasted when sampling intermixed terminals.

Transmission line distortion and noise affect FDM and TDM in different ways. TDM uses bandwidth selectively and TDM cumulatively, with resulting different consequences in case of noise.

Since line degradation problems are usually frequency related and normally appear on the outer edges of the total line bandwidth, only two outer bands of an FDM signal would be affected. In a TDM transmission, all terminals would suffer equally and line degradation would require a decrease in modem speed.

One final, and perhaps not insignificant difference is that FDM cannot be implemented with a minicomputer which when used as a concentrator can eliminate many of the shortcomings of TDM or FDM multiplexers. In fact, it is the minicomputer and its dropping price tag which presents the greatest threat to the multiplexer industry. As minicomputer makers reach a bottom price level and microminiaturization receives greater emphasis, competition for all applications will intensify. At that time, software for multiplexing or appropriate firmware may be offered with minicomputers as standard.

Markets for Multiplexers

The specialized common carriers such as Datran and MCI Companies will eventually emerge as the largest customers for multiplexing equipment. They will make extensive use of multiplexers on local city loops in order to keep their operating costs to a minimum. These specialized carriers may lease a voice grade line to particular buildings or industrial park areas within a city, and multiplex several data communication clients from each such point.

End users of multiplexers today are primarily the time-sharing services and private corporate teleprocessing systems. At the end of 1971, there were approximately 200 remote computing service firms, of which about 50% offered their services in remote cities to which they are connected by some data links.

One indication of the potential market for multiplexers can be obtained by comparing the number of commercial time-sharing clients with the number of distant cities in which they provide toll-free dial-in access. From the table developed on the following page, we estimate that about 800 to 1,000 lines may be in use by time-sharing services today connecting computer centers to remote cities, which implies a market for 2,000 multiplexers.

This number must be offset by considering alternative communication methods available to time-sharing companies. These include dial-in WATS, foreign exchange lines and data concentrator systems which, under particular conditions, may offer advantages over the use of multiplexers.

TABLE XIX

CITIES WITH LOCAL DIAL-UP ACCESS TO REMOTE TIME-SHARING SERVICES

Time-Sharing Service	Estimated No. of Time-Sharing Computer Centers	Remote Cities with Local Dial-Up
Allen-Babcock	3	10
Applied Logic	1	14
Bolt, Beranek & Newman	1	4
Boeing Computer	4	10
Computer Sciences Infonet	5	90
Comshare	3	60
CDC Cybernet	7	25
Computer Network	3	10
General Electric	15	250
Honeywell Information	1	20
Interactive Data	1	10
ITT Data Services	10	20
International Timesharing	1	10
Keydata	1	10
Leasco Response	2	30
McDonnell Automation	1	5
NCR	1	20
National CSS	2	10
On-Line Systems	1	3
Rapidata	1	10
Remote Computing	2	5
Service Bureau (IBM)	6	50
Tymshare	4	25
University Computing	5	30
Other (approx. 170 firms)	200	75
Total	280	806

Except for the 24 major time sharing firms, most of the remaining are small local operations based on a single computer installation and serving the local area. All time sharing firms can be accessed from any telephone, using appropriate couplers, but the user is then responsible for the cost of the toll call required unless he is located in the same city as the time-sharing service.

While the time-sharing services and private communications systems are so far the primary markets for TDM multiplexers, new opportunities are emerging for additional sales of TDM equipment among the common carriers and several Government agencies which so far installed the vast majority of the existing FDM multiplexing units. Their plant, however, is now also being expanded through the use of TDM equipment, particularly, where data transmission ser-services are being developed.

The new specialized common carriers and data transmission services being planned by existing independent common carriers are considered one of the largest single markets for multiplexers in the immediate future. Unfortunately, these are primarily one-time markets which will build up during the next few years, as new services are constructed and brought into operation, but will peak out after 1976 when most new facilities are scheduled for completion.

Significant overseas markets for multiplexers will also develop as data communications is being introduced in foreign countries. But most of these will remain under the control of local national common carriers.

Price Stability of Multiplexer Products

Contrary to the severe price erosion in the modem markets, prices of typical multiplexer units of both types remained fairly stable during the last few years, although profit margins must have decreased as competition forced the introduction of products with **additional features and sophistication at relatively stable prices.**

There are some industry sources, however, who already point out sporadic price reductions in quantity sales which they believe signify a forthcoming price erosion in the years ahead. The majority of multiplexer manufacturers believe, nevertheless, that relative price stability will continue and feel competition within product sophistication will intensify. Some foresee inclusion of modems and extensive status indication and error checking features into the multiplexers.

In developing our annual multiplexer sales projections, we have extended forecasted multiplexer shipments by average price of $6,500 per unit. We believe this average price will fall only slightly until about 1976, when the demand for multiplexers by the new common carriers will subside and more competitive conditions will suddenly come into being. At that time, because of market saturation and LSI developments, we believe a much more rapid price erosion may develop.

In the second half of the seventies, the multiplexer of today will also be much more seriously threatened by the availability of very competitively priced programmable data concentrators offering more flexibility at lower prices, which will further justify the more rapid price erosion in this product line.

Multiplexer Market Forecast

Our forecast for multiplexer sales, which appears on the following page, is based on the fact that the existing ratio of terminals to multiplexers is in the order of 50:1 and is unlikely to decrease to less than 40:1 during the next decade. Since we have established the rationale for our terminal population growth elsewhere in this report, we are now applying the ratios in order to project the expected multiplexer installations and consequently annual shipments during the next few years. In this projection, we have considered that no significant replacement of multiplexers will be taking place.

We feel that the number of installed multiplexers will about triple to 30,000 - 37,000 units by 1975-1976, but that annual shipments will grow most rapidly during the 1974-1976 period in response to a surge in demand from the new specialized common carriers. Annual sales will then peak out at about $76 million and will later settle to a steady market of $50 million a year, while shipments will continue to increase slightly and replacement markets come into play. But erosion of prices will prevent further increases in sales revenues.

Not all the on-line computers will use multiplexers because a certain percentage will always operate locally without the need for such equipment. More important, however, is the fact that programmable data concentrators and sophisticated communications controllers will increasingly offer multiplexing functions as part of their own design and very competitive prices. Another factor is the possible availability of multiplexing hardware built into the

TABLE XX

MULTIPLEXER MARKET FORECAST (1970-1980)

Year	Estimated Number of Terminals	Terminal to Multiplexer Ratio	Cumulative Number of Multiplexers	Annual Shipments	Average Prices	Annual Sales ($ Millions)
1970	280,000	56	5,000	2,000	$6,500	13.0
1971 1972	384,000	50	7,700	2,700	6,500	17.5
1972	545,000	50	11,000	3,300	6,250	21.0
1973	720,000	48	15,000	4,000	6,000	24.0
1974	960,000	46	20,000	5,000	5,750	29.0
1975	1,250,000	46	27,000	7,000	5,500	38.0
1976	1,620,000	44	37,000	10,000	5,250	52.5
1977	2,120,000	41	52,000	15,000	5,000	75.0
1978	2,650,000	41	64,000	12,000	4,000	48.0
1979	3,300,000	42	78,000	14,000	3,500	49.0
1980	4,100,000	43	94,000	16,000	3,000	48.0

computing hardware designed for communications applications, which is very likely to develop as competition sharpens up. The most serious threat to independent multiplexer industry is, therefore, a combination of rapidly falling component prices and availability of very low priced minicomputers on an OEM basis, which can perform data concentration functions and offer additional flexibility to the user.

Market Shares of Multiplexer Manufacturers

According to our estimates, 15 multiplexer manufacturers control 85% of the total multiplexer market and of these, several are large, well established corporations such as Lenkurt, Data Products, Collins Radio, Singer Tele-Signal, and Ultronics, while a few are controlled or affiliated with larger firms. ADS, for example, is controlled by North American Rockwell, while Coherent Communications is affiliated with Victor Comptometer.

The leading supplier appears to be American Data Systems, who were the Time-Division multiplexer pioneers. Lenkurt, Collins Radio and Northern Radio are large FDM multiplexer suppliers to common carriers both domestically and overseas, while Timeplex and General DataComm Industries are the new entrants who captured a significant market share. Together, the top five suppliers probably account for about 50% of the multiplexers installed.

In our estimates, we have considered together the time-division and the frequency division multiplexers. Although some companies manufacture both types, many specialize in one or the other and often claim that they do not compete with suppliers of other types of multiplexers. This is only partially true, since many data communications systems may have mixed multiplexing equipment as optimal solutions to their data communications problems. This is particularly true with some time-sharing companies which need the multi-drop capability of FDM multiplexers as well as economies of TDM equipment for long distance transmission.

The market shares are therefore not always directly comparable

TABLE XXI

ESTIMATED MARKET SHARES OF MULTIPLEXER MANUFACTURERS AT END OF 1972

Manufacturer	Type of Multiplexer TDM	FDM	Estimated Cumulative Installations	Share of Market (%)
American Data Systems	x	x	1,500	13.6%
Lenkurt (GT&E)		x	1,500	13.6
Collins Radio		x	1,000	9.1
Northern Radio		x	800	7.3
Timeplex	x		700	6.4
General DataComm	x	x	600	5.5
RFL Industries	x	x	500	4.5
Tel-Tech	x		400	3.6
Coherent Communications		x	400	3.6
Rixon Electronics	x		350	3.2
Data Products		x	300	2.7
Databit	x		300	2.7
Infotron	x		300	2.7
Ultronics (GT&E)	x	x	250	2.3
Singer Tele-Signal	x	x	250	2.3
Codex	x		100	.9
Computer Transmission	x		100	.9
Others (about 20 suppliers)	x	x	1,650	15.0
Total			11,000	100.0

because each TDM installation usually represents multiplexing of 12 or more channels, while many FDM installations may only be a few channels each. Most FDM suppliers estimate their installations in terms of total channels rather than multiplexing units. For purposes of comparison, when this happened,we have assumed about 4 to 5 channels per FDM multiplexer.

Of the total multiplexer installations at end of 1971, about 3,000 to 4,000 units were Time Division multiplexers, while the rest are FDM devices. As previously argued, there is a need for either type of unit and this need is expected to continue for some time. The general concensus, however, seems to be that Time-Division Multiplexers will form an increasingly larger percentage of the total, particularly once the new common carriers start buying equipment to develop local loops for their transmission networks. Already estimates indicate that 70% of all current multiplexer sales are TDM units.

With present voice oriented tariffs, the telephone companies have very little interest in optimizing the use of their transmission facilities by providing multiplexing equipment, as it only reduces their revenues for data transmission without multiplexing. But even Bell is not completely unresponsive to the pressures of the data communications user,and provides a service which multiplexer user data streams into voice grade lines.

As with other AT&T services, the DATREX service, as it is known, can only be leased from the telephone company. For comparison purposes, the DATREX service provides up to 8 channels of

150 BPS data streams over a single voice-grade line and rents for $72 per month for basic 3 channels. Each additional channel rents for $15 monthly. This would suggest that a one-year rental of 8 DATREX channels is equivalent to an outright purchase of an FDM unit from an independent manufacturer.

It is difficult to predict at this juncture what the future of DATREX will be, particularly when Bell will bring the Digital Data System on stream which will not require user multiplexing. On the other hand, the service may be of value to those who will need to communicate from areas where DDS will not be available until a much later date.

Future Trends in Multiplexers

By comparison with the modem market, the multiplexer product lines exhibit much greater price stability. Because a multiplexer is a much more complicated device, not as many companies have the talent or the resources to develop the product. This is particularly true in the case of Time-Division multiplexers, where character or bit interleaving techniques are rather sophisticated and even some of the large system houses pulled out of the business after announcement that they were going to build TDM multiplexers.

All this contributes to stability of prices in the multiplexer business. Average prices are often measured in cost per channel, that can be derived and average between $250 to $300 per channel. Usually the units which feature character interleaving are about 10% more expensive because of additional electronics required to buffer complete characters as opposed to single bits in the bit-interleaving devices. Frequency Division multiplexers will continue to sell for up to 20 channels or, in situations where multi-drop arrangements must be made along a telephone line.

There is growing performance competition in the multiplexer market, however, which is expected to continue. Manufacturers are beginning to offer products which are more flexible and offer greater adaptability to a particular configuration of a user. Some of the TDM manufacturing are also considering units which are stripped of some of the more sophisticated features which they hope will appeal to the present user of the Frequency Division multiplexer.

Diagnostic and control features of multiplexers will become more common and will be available at little additional cost in the future. In the economics of communications, such features mean cost savings to the users who otherwise face time-consuming trouble shooting and maintenance procedures. We anticipate that rather than price,these features will be the basis of any competition in the multiplexer markets.

Rather than price or new technologies, a much greater threat to the future of the multiplexer market is the increasing use of minicomputers as communications controllers and data concentrators.

A multiplexer is primarily a hardware device and although some units are quite flexible in terms of number of channels expansion and data codes, they have nowhere near the flexibility of a small computer which is programmable and therefore much more flexible than a hardwired device.

But there is no advantage of replacing a multiplexer with a programmable concentrator unless the user wishes to take advantage of the storage capability of the minicomputer. The most directly competing application is the data concentrator,which can have a higher concentration ratio for the same number of lines than a multiplexer because it polls all terminals in sequence,and if there is no input from some, that time slot is used up to continue transmission of the active terminals. A multiplexer, even a TDM unit, will actually waste the time slots on the transmission line in such a situation. By the same token, a concentrator can handle more terminals than total line capacity and, in cases of overflow, would simply store some of the messages for forwarding a little later. Multiplexers, which do not have a memory, are not able to exploit such situations.

On the other hand, concentrators and all programmable devices require software which adds an extra cost to the purchase and operation of these units. Therefore, for installations where dedication of the system is well defined and frequent changes not anticipated, multiplexers will prove to be the answer. The programmable data concentrator or front-end is, however, a very real and fast growing competitor in the more general purpose on-line data processing installation, which is handling many applications and is changing rapidly in configuration with addition of new types of terminals and devices.

VIII - COMMUNICATIONS PROCESSOR INDUSTRY AND MARKET

Summary

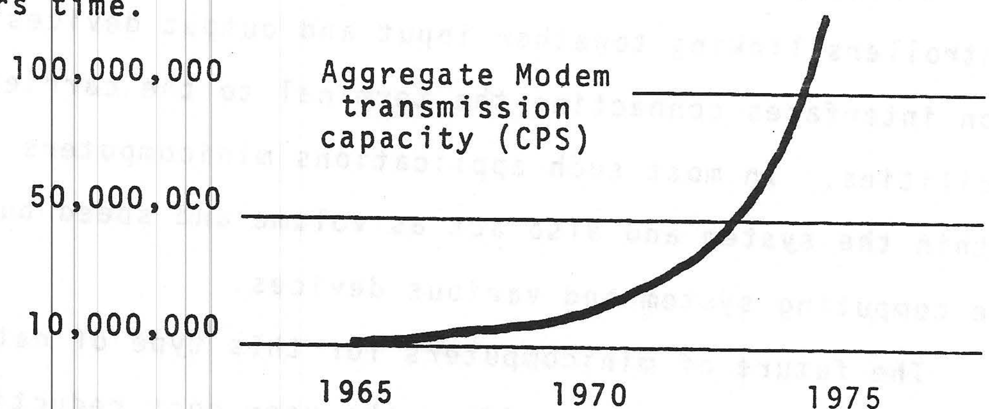
Communications processors are increasingly important elements of data communications systems. While some hardwired processors are specifically built for the data communications function, the trend is towards the use of programmable devices, often based on a small computer or minicomputer. A significant portion of the communications processor market, therefore, is also counted as part of the computer market, a fact which is not always made clear.

Several types of communications processors are in use today, such as front end controllers, message switches, data concentrators, store-and-forward units and remote data controllers. In more complex applications, there is considerable functional overlap between different types of devices, and it is only with difficulty that one can conceive of a typical or average communications processor.

There is also a very large price range for these devices, generally varying from $50,000 to $500,000 for a single installation, depending on the complexity of the application. In our projections, we consider primarily the markets for specialized communications processors hardware, not including the attendant software and consulting markets. Also excluded are large general purpose computers specially adapted to operate as message switches in complex data communications systems. Only hardware primarily designed for data communications functions is considered.

Need For Communications Processors

With increasing number of large computer systems operated in the communications mode the collective transmission capacity of all the modems connected to the Bell telephone network is growing exponentially. It is estimated to be about 10,000,000 characters per second (CPS) today and expected to have a capacity of 100,000,000 CPS by the end of 1975. This means it will increase tenfold in but a few years time.



Such rapid increase in overall data transmission rates means a much more efficient utilization of the available bandwidth over the carrier facilities with a resulting crowding of the lines and creation of communications control problems, particularly at sources and destinations of data. These of course are nothing else but computers and terminals themselves.

For meaningful message transmission to take place from one point to another, circuits must be provided and data links established. When messages arrive rapidly, at random and from numerous sources with different transmission codes, considerable communications control is called for. To establish and terminate such transmission in order, there are many functions that can only be performed by a computer, and this is where the communications processor which is programmable can really come into its own.

Communications processors came into general use the late sixties when time-sharing companies realized that their large computers were involved in many data editing functions, an activity wasteful of computer power in a competitive environment. The solution was mini-computers attached in front of the central processor to handle the low and medium-speed terminal input as well as some high speed trans-missions from multiplexers or remote data concentrators, which more often than not were also minicomputers in their own right.

Minicomputers are now most readily used as remote terminal controllers linking together input and output devices,with communica-tion interfaces connecting the terminal to the carrier network facilities. In most such applications minicomputers route the data within the system and also act as volume and speed buffers between the computing system and various devices.

The future of minicomputers for this type of data communications control is assured as it offers the user cost reductions and increased price/performance capability for his computer system. The program-mable mini-computer controller gives the user the flexibility to use various computers which may not be directly compatible.

The "front end" communications processor market, is not expected to last forever as large modern computers increasingly incorporate multiple processors as part of their basic configuration. This is likely to create a trend toward incorporation of the front end function into the basic mainframes. Until this happens, the communi-cations processor is a fast growing market in dollar volume,larger than the modem or the multiplexer markets by themselves.

Programmable communications processors were offered during the early 1960's by major computer manufacturers including General Electric Datanet 30, IBM 7740, CDC 8090/8050 and Collins Data Central. Primarily these were message switching systems and since that time the cost of such units has come down drastically,particularly with the advent of the minicomputer.

However the low hardware list price should not be taken by the prospective user at face value,because a complete data communication processor system requires interfaces and software, both of which may turn out to be considerably more costly than the minicomputer itself.

One of the most valuable features of a supplier is the ability to take full responsibility for service and operation of the externally controlled communications network,which is controlled by his processor. This leads, on the one hand, to the emergence of systems houses but at the same time rapid growth in the field created numerous suppliers, large and small, confronting the end user with the dilemma of who to turn to,for what,and how much to pay for it.

Functions of Communications Control

The functions associated with communications control range from the simple to most complex and are usually grouped into so-called low-level and high-level functions. The low-level functions are common to all communications systems. The high-level functions occur in specialized systems and depend predominantly on the main application of the computer system.

TYPICAL LOW-LEVEL CONTROL FUNCTIONS

1. Interface Signalling
2. Message status indication
3. Bit and character synchronization
4. Character assembly/dissassembly
5. Polling of terminals, selection
6. Connection control
7. Terminal control
8. Message assembly for processing
9. Message error control
10. Code conversion
11. Data editing and compression
12. Performance monitoring and analysis
13. Job routing
14. System testing

TYPICAL HIGH LEVEL CONTROL FUNCTIONS

1. Data buffering and Query
2. Address routing of messages
3. Priority assignment in contention
4. Hardware configuration control
5. Fail soft capability
6. Time and cost recording
7. Formatting control of data
8. File management
9. Diagnostic routines

Low-Level Control Functions

1. Message protocol is the simplest of communications functions and refers to handling of individual signals which arrive at random at the interface between the transmission facility and the computer system or terminal and must be dealt with in an organized manner. From just a few to a dozen individual control signals may exist in a single circuit.

2. Message Status Indication. Closely tied to recognition of interface signals it involves collection and interpretation of control characters which establish message status and programmed processors can immediately take appropriate action routing the message.

3. Bit and character synchronization. Messages are transmitted in form of bits and it is mandatory to discover the timing of the bit stream across a transmission facility boundary. Asynchronous transmission requires this activity at the receiving end; synchronous operation relies on transmission facility for bit-rate timing detection. In character synchronization the main task is to detect character boundaries in arriving data stream.

4. Character assembly and disassembly. Transmission facilities transmit signals serially while data processing machines involve parallel data processing. At the interfaces it is necessary to arrange for conversion of serial to parallel processing and vice versa when data is being sent to remote terminals.

5. Polling of terminals. In this process a series of terminals is addressed serially to determine if they are active and are ready to transmit data. Processors should be able to select those terminals which have immediate input and continue transmitting until another active terminal is encountered.

6. Automatic Dialing and answering. This activity controls the connection and performs dialing and answering either in an automatic or manual mode. Line switching operations may also be required in this function as well as ability to manually interfere with the calls.

7. Terminal Control will include a series of functions which may be required to activate specific terminals or exercise certain capabilities of these units such as cursors in a CRT displays.

8. Message Assembly for Processing. This procedure involves the accumulation of characters or records required to complete a message which is then verified and acted upon as specified.

9. Error Control. One of the most important functions in all data communications refers to detection of errors from routine and random sources and initiation recovery procedures or alternate action depending on complexity of the error detected. Generation of parity checks.

10. Code Conversion. This is a necessity in every data communication system because there are at least a dozen major transmission codes in use today. Code conversion software and function could present a very significant load on the central processor and is best handled by a front end type of device.

11. Editing and Compression. This function may include the deletion and insertion of redundant characters, words and changes in format for more efficient transmission. More sophisticated routines may also include validity checks.

12. Performance monitoring and analysis. This group of functions keep records of line usage, connection and traffic statistics and other information. These can be recorded on a per terminal or per line basis and utilized later in optimizing the system.

13. Job Routing of Messages. Once messages are identified and their purpose decoded, the messages must be routed to different parts of the system for execution. In this function the communications processor must be able to act as a message switching device.

14. System Testing and Diagnostic Routines. Ability to test performance of the remote terminals and various elements of the system allows the user to pin point trouble spots as soon as possible. These functions are of particular importance in complex or extensive networks with remote located terminals too far from the source of manual diagnosis.

Most of these low-level functions have not got much to do with the actual message transfer but are necessary in a chain of procedures which leads to that task. The activities are required in connecting the physical circuits of the appropriate parties that wish to communicate and also in establishing the appropriate links. The data links are the logical paths for communications since the circuit connection usually brings together several parties at the same time. Communications processors must be able to identify those parties that wish to communicate and those that have terminated communication and act to establish the appropriate data links to enable this activity to proceed in the most effective manner.

High-Level Control Functions

1. Data Buffering and Queing. In this function the unit must act as a "store and forward" processor arranging messages in transmission order according to priorities or known sequences which depend on transmission terminal, time of day or special code indicating a particular job function.

2. Address Routing of Messages. Is in fact the basis of message switching. It involves identifying the address of each message which may be coded in the message or stored in memory in form of tables or directories, After identification messages are dispatched, they are routed and stored accordingly and appropriate records are made.

3. Priority Assignment in Contention. Specific coding of messages may assign priority to certain types of messages and the system must be able to distinguish these codes and take appropriate action within the previously described queing function. The object is to allow important messages to get through immediately regardless of the loading of the system at any one time.

4. Fail Soft Capability. This feature is designed to increase overall reliability of the system. It means that remote terminals can continue transmitting and receiving limited response even when the main computer system is temporarily out of commission. While there are limits to this activity and certain functions cannot go on, the user is not completely cut-off and may even obtain status responses to his inquiries about the system. One of the first users of this capability were the time-sharing companies which experienced considerable down time in the initial stages of their operations and found that lack of "fail-soft" capability was a serious factor in that competitive environment.

6. Time and Cost Recording. This function is of first importance in time-sharing services operated for numerous clients who use it in a random fashion but it is just as vital in one-line systems which are operated in-house for a variety of departments. Precise records must be kept of the use of central processor time, duration of connection to the system and amount of storage used and maintained. The statistics are extended to present the user with a cost of the service and are also used to analyse the usage and eliminate unnecessary or wasteful operating features in the system. Time control and records are also vital in certain recovery procedures and in locating errors.

7. Formatting Control of Data. This function is for the use of remote terminal user to guide and control their actions in an interactive way. Software required may be quite extensive and usually takes the form of an interactive higher level language.

8. File Management. This primarily refers to ability to manipulate the extensive records of communications transactions that are kept in order to permit accurate updating, billing and disposal of files.

9. Diagnostic Routines This is usually a group of functions more sophisticated than the lower-level error control functions and are used on the more complex communication processing systems to check the performance of hardware as well as some of the software involved. These routines may be designed to perform preventive testing and monitoring of the system. They may be limited only to the communications processor because of the special communications-oriented instructions which may be added to the unit's repertoire but not elsewhere in the system.

Types of Communications Processors

Communications processors come in a variety of configurations and capabilities and in both cases can be hardwired or programmable. Therefore it appears best to classify the devices by the applications to which they are being put in a communications system.

Both hardwired and programmable processors perform similar functions today but industry experts are suggesting that if a system includes more than 17 terminals,a programmable processor becomes more cost effective. From our previous analysis of the computer population and associated terminals,it appears that on the average,on-line computers have more than 17 terminals and that this number is growing steadily although not without limit. It seems certain therefore,that before long,the hardwired communications processor may be completely replaced by programmable devices. Some of these may employ "firmware" using Read Only memory (ROM) techniques for greater reliability and efficiency,but while not as flexible as general purpose computers, these devices can be changed fairly simply without too much of cost. In addition many units will employ "firmware" for only part of their software which remains faily constant most of the time.

The basic applications of communications processors are listed below and each will be discussed in more detail in subsequent pages.

Front End Controllers

Data Concentrators

Message Switching Units

Store and Forward Systems

Remote Data Controllers

Front End Processors

In most cases the Front End processor replaces the hardwired communications controller as the interface between the transmission facility and the computer system. Front Ends are programmed to pre- and post-process the data in many ways in order to relieve the central computer from time consuming message formatting and control activities.

A typical Front End may relieve the main processor of as much as 40% to 50% of the work load,and in addition contains the communications software which would otherwise have to occupy from 10K to 20K bytes of memory in the main processing system.

A Front End unit is connected directly to one of the computer input/output channels or ports. It works in parallel with a central computer and contributes considerably to increased throughput of the overall system.

The Datanet devices of General Electric were at one time the only Front Ends to gain wide acceptance. Since the Honeywell acquisition,Datanet units have been discontinued and replaced by the Honeywell 515 communications minicomputer.

In purchasing a Front End Processor,the end user must decide first whether he will be satisfied with a relatively simple "plug-in" device which will not require additional software expenditure. Most common among these are the many units designed as replacements for IBM 2701 Data Adapter and IBM 2702 and 2703 Transmission Control Units. Such devices have the advantages of functioning with standard IBM 360 or 370 communications software.

When more complex Front End devices are contemplated,the turnkey approach is probably the best and is becoming popular among users. In this type of arrangement,the supplier takes on the responsibility to provide hardware, software and maintenance of the system.

The system is sold at a one time price and there is a monthly maintenance fee which varies from a few hundred dollars to a few thousand,depending on the complexity of the system and the range of responsibilities undertaken by the contractor. Sometimes the maintenance fee includes the cost of software and the updating and new developments. In other cases there may be a separate one time charge for software alone.

Some of the first Front End devices supplied by Collins, Marshall and Phillips were by-products of equipment developed for the Military Command and Control Systems,and while very comprehensive are out of reach for commercial applications because of their high cost.

While the Front End business is booming it already has casualties among suppliers of such equipment. One industry suggestion is that if a user wants a highly specialized front end system which is unlikely to be sold in quantity to other users, he should be prepared to buy the whole company to assure himself of the service and maintenance after delivery. Understandingly this applies to small, unseasoned companies which have recently entered the business.

Data Concentrators

Basic to the understanding of this application is the fact that data concentration is a process similar to multiplexing. But while a data concentrator usually can operate as a multiplexer the reverse is not true. Also the programmable aspect of communications processors in this particular application is less important than in any other uses.

Data concentrators allow the data streams entering or leaving the terminals to exceed the data rate of the communications channel. A processor can store input from several terminals and utilize the channel with greater efficiency than a multiplexer. This means that the transmission line must be only fast enough to handle the average data rate of the system and does not limit the system when input exceeds maximum line transmission rates. Programmable concentrators capable of doing this have been claimed to have obtained 4 times the data rates of hardwired devices in the same system mix.

Use of a data concentrator also permits direct connection of terminals to the unit which then transmits multiple signals through a high speed modem to an equivalent modem at the computer site. There another "deconcentrator unit" separates the signals into individual messages for processing. Each appears on an independent line through a separate interface and this method does not require additional software in the computer system.

Alternately concentrated data streams may be entering into a computer through a high speed interface but the unscrambling of messages must then be performed by the computer and requires special software for the purpose.

Used as data concentrators, communications processors are more expensive than hardwired multiplexers,but their storage capability and buffering allow higher overall concentration ratios to be obtained from the equipment.

DATA CONCENTRATORS (2)

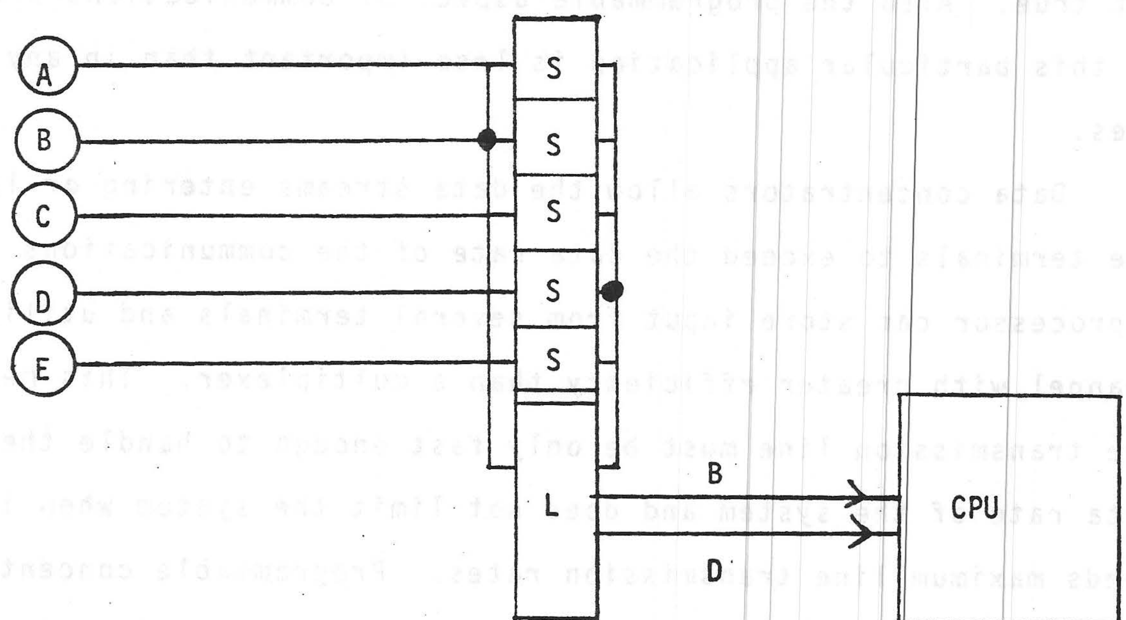


Diagram above shows a typical contention data concentrator with remote data terminals A, B, C, D, and E each transmitting into a buffer storage (S) on its own within the data concentrator. Under programmable logic (L) unit the concentrator can transmit data to the central computer facility (CPU) with which it is connected by only two channels. Terminals B and D are shown transmitting. All modems and interfaces have been omitted for clarity.

Minicomputers as Data Concentrators

A concentrator based on a minicomputer acts like a funnel which takes a number of low-speed data streams and puts them into one higher-speed stream for transmission to a processing computer. Since a data concentrator seldom performs any data storage functions it is very similar in this respect to a multiplexer.

But while a multiplexer can concentrate low-speed data streams it is primarily an inflexible hardware device with predetermined data input and output parameters. Data concentrators, on the other hand, can be programmed to decide where to send data, perform several validation functions and interact with the user in a sophisticated way to detect and correct transmission errors. If more than one data processing systems are involved data concentrators can also act as code converters.

So far the market for data concentrators was directly dependent on the growth of the time-sharing industry, but with increased use of computer networks within companies, agencies and businesses,the demand for minicomputers for data concentration role is increasing.

The competition is also becoming stiffer among minicomputer manufacturers for a share of the data communications applications market. As a result the user is getting improved cost/performance characteristics and there are attempts to combine the functions of remote terminals controllers and concentrators in a single product which is also likely to present additional savings to the end user.

Message Switching Units

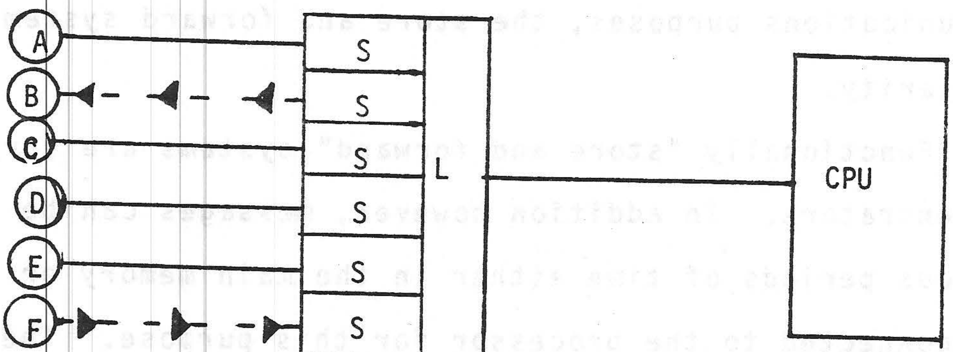
In this type of application the processor receives messages from remote terminals, analyses each to determine their ultimate destinations and then transmits to terminals or the computer.

The typical message switching processor is a "stand-alone" device, and because of its special purpose and high performance requirements it is usually protected from the disturbing influence of other data traffic. A message switching processor is therefore much more remotely related to the computing facility than the front end or other communications devices.

In performing the message switching function the processor may be called upon to do code conversion and to provide a certain amount of buffering. Then messages are temporarily stored on a disk, drum or tape for later transmission when the lines are free. For this reason communication processors with this capability are of the store and forward variety,and many units dedicated to message switching must have this capability.

The length of time during which messages are stored may range from seconds to days depending on priorities coded into them. But in any case little if any processing is performed on the message itself. The principal function is that of traffic direction and as such is one of the most common applications of communications processors.

MESSAGE SWITCHING UNITS (2)



A typical message switching communications processor can transmit messages between two remote terminals without the necessity of going through the central processor. This not only saves the central computer time and capacity but also dispenses with the need to transmit over the multiplexed line to the computer which results in additional savings in communication costs.

In the diagram above the terminal F transmits directly to its buffer storage (S) in the message switching processor whose logic (L) decodes the message and if necessary performs code conversion and routes it to terminal B by-passing the central computing facility (CPU).

Modems are omitted in the diagram for clarity.

Store and Forward Systems

These applications were already mentioned in describing the message switching application of communications processors. But with the advent of the minicomputer and its ready availability for data communications purposes, the store and forward systems are gaining in popularity.

Functionally "store and forward" systems are very similar to data concentrators. In addition however, messages can be stored for various periods of time either in the main memory or in the peripherals connected to the processor for this purpose. The "store and forward" systems are used by many time-sharing services in an attempt to optimize their data networks which must have national scope in many instances.

The market for "store and forward" devices is growing also among intracompany data communications users but it must be pointed out it does so at the expense of data concentrators and multiplexers. In fact various applications of the communications processors are overlapping one another and it is difficult to find two units performing precisely the same tasks. Much of the operations, of course, depends simply on availability of specific software, and communications processors will generally differ in precise functions as users differ among themselves.

But there are quite a few users who are not willing to combine the storing and concentrating functions because they feel a higher standard of reliability is needed in "store and forward" systems than in commercial data processing.

STORE AND FORWARD UNITS (2)

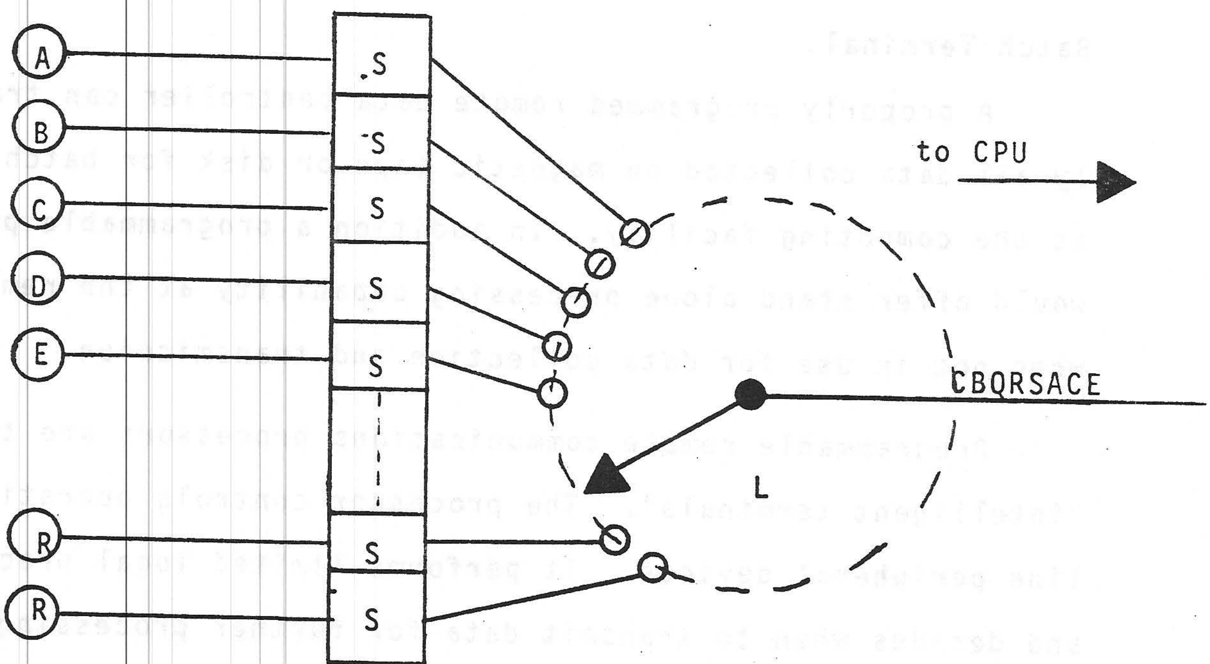


Diagram indicates a basic store and forward unit which can also serve as a data concentrator. Output of the unit is a function of message rates on the incoming lines from terminals A, B, D, D, E, ... R and Q. Each message can be stored in a buffer storage (S) until the line is free or according to other priority criteria that may be part of the message and are recognized by the logic of the unit (L).

Modems and interfaces required as well as the central processing facility (CPU) have been omitted for clarity.

Remote Data Controllers

This type of device acts as a replacement for data collection units and is often compared with a standard IBM 2780 Remote Job Entry Batch Terminal.

A properly programmed remote data controller can transmit directly all data collected on magnetic tape or disk for batch processing at the computing facility. In addition a programmable processor would offer stand alone processing capability at the remote location when not in use for data collection and transmission.

Programmable remote communications processors are the heart of "intelligent terminals". The processor controls operations of on-line peripheral devices. It performs limited local processing of data, and decides when to transmit data for further processing at the central computing facility.

"Intelligent terminals" usually upgrade ordinary remote batch terminals and make it possible to incorporate higher performance peripherals as well as faster transmission rates. In some studies of the communications processors, the "intelligent terminal" is not considered as part of routine communications processing. Because it increasingly involves considerable data communications capability, we feel it should be mentioned as one of major uses of communications processors.

Characteristics of Communications Processors

The table following this page lists almost 100 different models of communications processors which are being supplied by 53 different manufacturers. These include computer mainframe companies, minicomputer manufacturers, systems houses and software companies, as well as a few small consulting firms without a product available off the shelf. The basic characteristics are from published surveys and company literature, and price ranges, whenever quoted, refer to a basic operating unit.

It must be borne in mind that as data communications vary with almost every single application, basic prices will differ even for similar models of equipment, depending on such factors as number of lines served and functions performed. We believe, however, that in most cases, prices include the necessary data communications hardware such as line adapters and interfaces mandatory for operation as a communications processor.

In many instances, operating software is available only at an additional fee over and above the hardware cost. On top of both, there may also be a monthly maintenance and updating charge. Alternatively, suppliers of communications processors also offer monthly leasing plans for both hardware and software, an option with considerable amount of appeal to a less sophisticated data communications user.

Later in the study, we use data in the following tables to plot average price ranges against communications processor complexity, as defined by maximum number of lines capacity. This graph uncovers a significant trend to replace hardwired processors with programmable devices, particularly for more complex systems. It also provides a basis for estimation of average prices used in forecasting future sales of communications processors.

TABLE XXII

SUPPLIERS OF COMMUNICATIONS PROCESSORS AND THEIR PRODUCTS

Manufacturer	Model	Type	Maximum number of lines	Price range ($ 000's)
American Data Systems	950	P	128	76.5
Action Communication System	TELECONTROLER	P		80.0 to 400.0
Bolt, Beranek & Newman	IMP/TIP	H	63	120.0
Burroughs	DC 1200	H	65	60.0
	DC 1800	H	64	92.0
	B 5700		256	122.0
	B 6700/7700		256	135.0 to 250.0
Control Data	791		40	80.0 to 135.0
	SC 1700	P	512	
	M 1000	H,P	512	250.0 to 600.0
CHI Corporation	Mark II	P	128	60.0
Computer Automation	Alpha 8		32	3.0 to 10.0
	Alpha 16		64	3.5 to 20.0
Collins Radio	C System	H	256	135.0 to 250.0
Computer Communications	CC-70	H,P	240	47.0
	CC-71	H,P	240	37.5
	CCI-7000	H,P	960	280.0
Comtec Data Systems	CI/90	P	511	50.0 to 70.0
Computer Control Systems	DCS-5000	H,P	128	75.0
	Teleswitcher	H	32	
Comten(Previously Comcet)	Comten 20	H	128	60.0 to 150.0
	Comten 40	H	240	100.0 to 500.0
	Comten 60	H	240	200.0 to 800.0
	3670	H	384	94.0
Cybermatics	Tin Can 1	H	64	50.0
	Tin Can 2	H	300	70.0 to 200.0
Data General	Nova 1200		16/mux	6.0 to 50.0
	Nova 800		16/mux	7.0 to 75.0
	Supernova SC		16/mux	11.9 to 125.0
	Nova 1210		64/mux	4.4
	Nova 820		64/mux	6.4
Data Quote	DQ 100/200/300		64/300	20.0 to 400.0
Data Pathing	2102	H	4	40.0
	2104	H	10	50.0
Dataserv	System 770		128	
Datacraft	6024/1/3/5	P		

Notes:
Maximum number of lines refers to low speed lines. For higher speeds, smaller number of lines can be handled by the same unit.

Type H = Hardwired controller, P = Programmable processor.

TABLE XXII - Cont'd.

Manufacturer	Model	Type	Maximum number of lines	Price Range ($000's)
Digital Computer Controls	D-116	P	128	5.0 to 50.0
Digital Equipment	6801		128	12.0 to 60.0
	PDP 11/05		256	4.8 to 80.0
	PDP 11/20		256	11.0 to 120.0
	PDP 11/45		256	18.0 to 300.0
	DECComm 11D20	H	100	16.4
	DECComm 11D23	H	100	30.9
EMR Computer	DCS-16	H	250	180.0
	DCS-45	H	500	250.0
Four Phase Systems	IV/70	P		
General Electric	Diginet 1600	H	256	16.0 to 76.0
General Instrument	System 75	H,P	128	45.0
Honeywell	1621	P	68	29.0 to 42.0
	1622		132	47.0 to 83.0
	316-700		49	30.0 to 35.0
	Datanet 30		128	94.0 to 150.0
	Datanet 355	H	200	152.0
	Datanet 2000	H	120	87.9
	System 700/20	H	256	53.5
Informatics	ICS-IV-250	H	144	250.0
	ICS-IV/500	H	640	1,250.0
Infotronics	Mini/max		334	12.9
Intercomputer Communications	I-50	P	250	46.0
Interdata	Model 50	P	126	23.0
	Model 55	P	250	39.0
	270X	P	126	64.3
IBM	3705	P	352	72.4 to 92.9
Jacquard Systems	RTCS	H	64	25.0
Mark Computer Systems	System 70		16/mux	25.0 to 250.0
Microdata	1660	P	128	23.0
Memorex	1270		96	

Notes: as on previous page

TABLE XXII - Cont'd.

Manufacturer	Model	Type	Maximum number of lines	Price range ($ 000's)
Modular Computer Systems	Modcomp I	P	128	7.9 to 55.0
	Modcomp II	P	128	11.6 to 77.0
	Modcomp III	P	128	39.5
North American Phillips	DS 714	H	8000	1,900.0
Omnus Computer	Omnus 1/C	H	224	15.0 to 77.0
Prentice Electronics	P-3000	P	352	37.0 to 140.0
Programming Methods	FCF-R		128	120.0
	FCF-H		180	180.0
	FCF-T	H	256	700.0
Remote Computing	FRED	P	256	100.0
Raytheon	450-M3		26	50.0 to 100.0
	450-M4		3	50.0 to 100.0
	450-M70		3	50.0 to 100.0
	PTS-100		256	5.5 to 25.0
RCA (Univac)	1600		64	35.0 to 72.0
Sanders Data Systems	Sandac 200	H	128	60.0
Scantlin Electronics	801	H	384	68.0
Scidata	SCIDATA	H	38	93.0
Scientific Control	5000	P	1024	40.0
	SCC 4700	P	352	40.0 to 200.0
Telefile Computer	T-46-1	H	256	25.0 to 100.0
Teleprocessing Ind. (WU)	C 2000	H	256	110.0 to 180.0
Tempo (GT&E)	TEMPO I & II	H	768	50.0 to 250.0
	270T	H	255	50.0 to 250.0
Texas Instruments	980 EMS		127	69.0 to 250.0
	980 DCS	P	256	50.0
Univac	C/SP	P	128	80.0 to 175.0
UCC Communications	COPE	H	960	55.0 to 130.0
Varian Data Machines	620-DC	H	64	23.5
	620L		64	15.0 to 60.0
	620F		128	20.0 to 150.0

Notes: As on previous pages

IBM Blesses the Communications Processor Concept

IBM's entry into the communications processor market with its IBM 3705 controllers, March 1972, is regarded as a turning point in this industry. It was hailed as a blessing of the concept which Digital Equipment and other manufacturers have been using for years.

It is also not without some concern to the communication processor suppliers, because many of them have been thriving on the large percentage of IBM computers installed.

Of the total 162 communications processors models we have analyzed in our table, 84, or over 50%, are IBM compatible units. The new IBM unit which is only now beginning to be delivered comes in many configurations designed to handle most of IBM terminal equipment which is operating today. It ranges in purchase price from $57,000 to $449,000 which spans the whole price range offered by all the other suppliers. It is also available on lease, basically on 24-month contracts, after which the user has the option of unlimited one year contract extensions.

The entry of IBM into this market is not unexpected and it is a logical move by a company whose sales of mainframes were flattening out during the last three years with increasing number of independent manufacturers concentrating on supply of peripherals and communication devices. It is too soon to tell what effect this will have on the independents but it is expected that with the continuing downtrend in minicomputer prices, this move by IBM will not immediately affect the industry as comparable systems are available to users at lower cost. The independents are also offering systems which from the outset, accept a variety of terminal devices, while IBM processors are designed to handle IBM terminals only.

HOST COMPUTER COMPATIBILITY
OF COMMUNICATIONS PROCESSORS

Host Computer	Number of models of compatible communications processors	
IBM 360	48	xxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxx
IBM 370	36	xxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxx
UNIVAC (*)	35	xxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxx
CDC	13	xxxxxxxxxxxxx
BURROUGHS	10	xxxxxxxxxx
HIS	10	xxxxxxxxxx
XEROX	7	xxxxxxx
Others	3	xxx
Total	162	

(*) Includes RCA compatible units

The biggest percentage of communications processors which could be identified as to host compatibility is for IBM 360 and IBM 700 equipment. Of the 162 different models above,84 were IBM compatible processors,which only underscores IBM domination of the computer market as a whole. Interestingly,there are very many processors compatible with Univac also, while Burroughs, Control Data and Honeywell have all considerably smaller numbers. Honeywell has a big range of its own communications processing equipment which accounts for most of the HIS compatible models above. Xerox,although with a small market share in computers,has relatively many processors available which reflects Xerox Data Systems real-time hardware orientation.

Hardwired Versus Programmable Controllers

Most early communications processors were of the hardwired variety and some were even mechanically operated devices. Although hardwired units can be rewired by replacement of pertinent circuits boards it usually involves the manufacturer, considerable time, and is unlikely to prove convenient or economical.

The trend now is toward programmable communications processors which to a large extent is dictated by the increasingly complex computer networks. As the number of lines increases, hardwired controllers become more expensive because of the need for additional hardware, particularly if new terminals, not previously wired for, are connected to the system. In large systems, programmable processors become more economical because of their flexibility. As most of these processors are based on minicomputers whose prices are continuing to drop, the programmable communications processor may replace the hardwired unit completely in a very short time.

While programmable controllers offer the user considerable flexibility, they do so at a price in additional software and maintenance charges required. This cost may range from $130 to as high as $1,800 per month, or even more, and will depend on sophistication and the software required, but it assures the user of receiving the latest modifications and improvements without additional effort on his part. The average maintenance cost for these processors appears to be in the order of about $350 per month.

Programmable controllers can early be adapted to accept input from a variety of terminals operating with different codes while hardwired devices would be restricted to initial designs. In the case of changing computer system configuration,programmable controllers have an obvious advantage. Fail safe capability is also only practical with programmable units under program control. More elaborate and effective error control is possible,and only a computer is a practical means to effect housekeeping functions such as storage of statistical data and performance analysis.

Minicomputers as Communications Processors

What makes a minicomputer a communications processor is first and foremost, the dedicated data communications software. Thus minicomputer suppliers are eminently suited to become the main source of communications processing devices for all the applications described. Any of the minicomputers on the market is capable to be the basis of a communications processor.

However, so far, few minicomputers have been integrated with line multiplexers, interface units, or channel adapters to serve as complete communications processor products. Software is often not sufficient to make a minicomputer stand apart as a communications processor.

A minicomputer, for example can be easily put to use as a time division multiplexer and will handle up to 64 lines, but as such, it will not present any special advantages over the hardwired unit.

One development being used extensively by Interdata is to provide "firmware" (ROM) programmed packages consisting of hardwired sets of functions for use in Interdata minicomputers. Such programs are virtually non-destructible and offer execution up to 20 times faster than conventional methods.

Because of a relatively high dropout rate among the minicomputer firms, the user of mini-based communications processors must make sure he is dealing with a vendor who is likely to be in business for the life span of the system.

Markets for Communications Processors

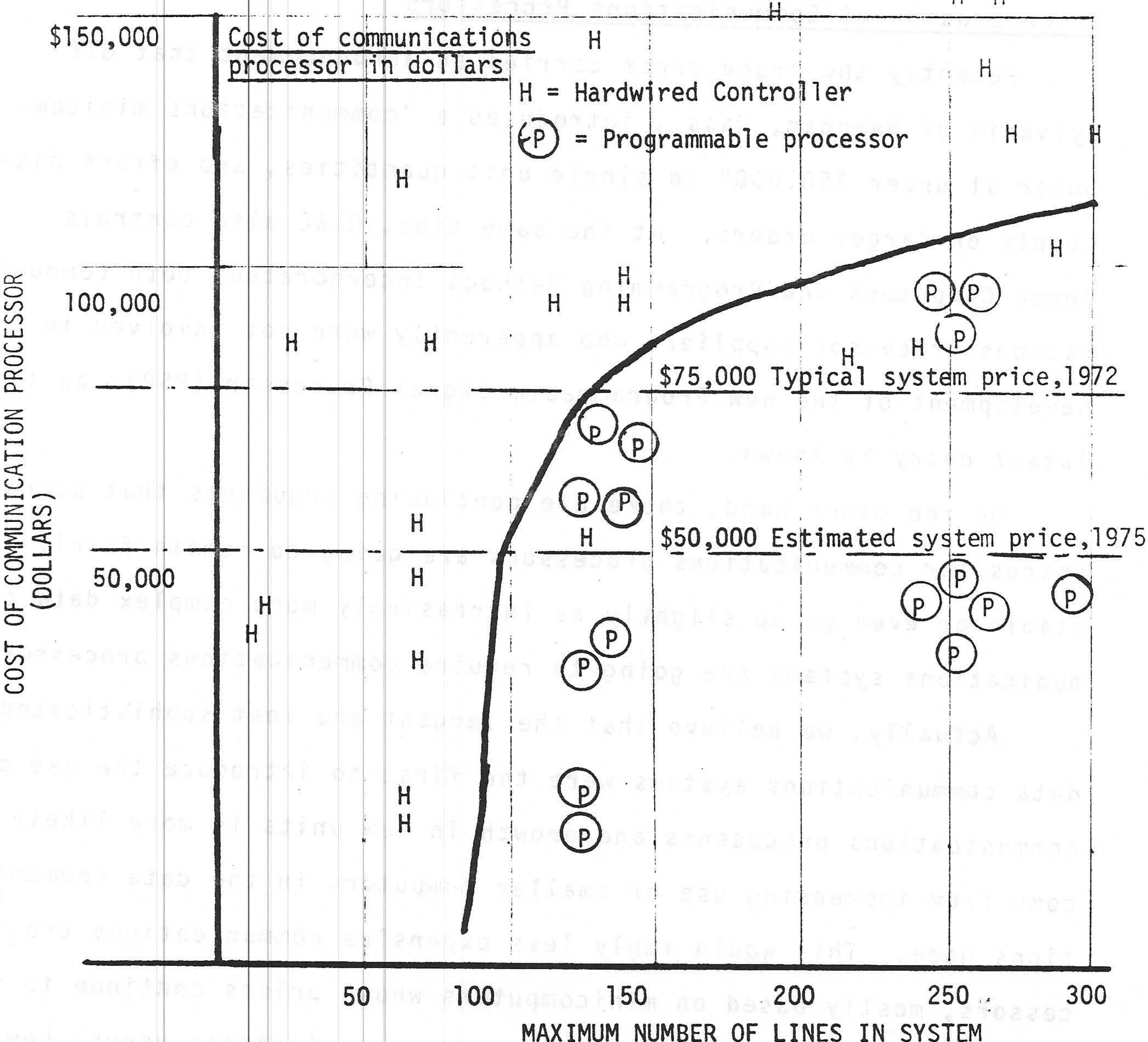
Of the almost 90 different models identified in our tables, approximately 50% represent communications controllers of the hard-wired variety. Plotting the basic prices for communications processors against their maximum line handling capacity, it becomes quite obvious that the programmable (P) units become more economical with larger number of lines to be serviced. (See Figure VIII.)

From our graph, it appears that hardwired controllers to handle 128 or more lines, already are considerably more expensive than comparable programmable units. Because earlier systems were not so numerous and did not send more than 24 to 60 lines, there are many processors on the market for this type of system, but they are being replaced by programmable controllers which can handle twice as many lines at comparable cost with additional advantages.

The graph also serves the purpose of providing a guide for choosing an average price for all communications processors. The present level of about $100,000 per unit will probably erode slowly to a $50,000 to $75,000 per unit level in the next few years. Much of this decline will be due to a rapidly falling cost of minicomputers as well as modems, both of which can form the elements of a communications processor.

FIGURE VIII

COMMUNICATIONS PROCESSOR
PRICE - COMPLEXITY RELATIONSHIP



Typical hardware prices for about 40 hardwired and programmable processors were plotted against number of lines that can be handled by each, which is considered a measure of complexity. The graph shows how programmable CP devices are displacing hardwired controllers in systems with larger line requirements. The prices are hardware prices only and do not include the monthly maintenance and software cost in the case of programmable processors. But the trend is obvious.

Price Erosion of Communications Processors

Recently the trade press carried an announcement that GTE Sylvania of Needham, Mass., introduced a "communications minicomputer at under $50,000" in single unit quantities, and offers discounts on larger orders. At the same time, GT&E also controls Tempo Computers and Programming Methods Incorporated, both communications processor suppliers who apparently were not involved in development of the new Programmable Signal Processor (PSP), as the latest entry is known.

On the other hand, there are continuing arguments that average prices for communications processors are going to remain fairly stable or even go up slightly as increasingly more complex data communications systems are going to require communications processors.

Actually, we believe that the largest and most sophisticated data communications systems were the first to introduce the use of communications processors and growth in new units is more likely to come from increasing use of smaller computers in the data communications mode. This would imply less expensive communications processors, mostly based on minicomputers whose prices continue to fall. The present core of sophisticated data communications users, however, present a replacement market, but again, for the more flexible programmable processors, often based on one or more minicomputers. It would be unlikely that those users would switch to use of more expensive processors. Rather, they are interested in cutting operating costs on their present systems.

The market is therefore significantly influenced by rapidly falling prices for components resulting in cheaper minicomputers, modems and multiplexers. We have accounted for this expectation in our forecast by applying a price erosion factor of 10% to 15% per year until the mid-seventies, while developing our forecast. We differ in this respect from other forecasts, which we feel are not considering the same price erosion factors.

Communication Processor Market Forecast

Year	Number of on-line computers	Cumulative Number of Communication processors	% growth	Annual Shipments	Average unit-price	Annual sales ($ millions)
1970	12,250	2,000	100%	1,000	$100,000	100.0
1971	16,700	4,000	100%	2,000	85,000	170.0
1972	22,750	7,000	75%	3,000	75,000	225.0
1973	30,100	11,000	57%	4,000	65,000	260.0
1974	38,700	16,000	46%	5,000	55,000	275.0
1975	50,000	23,000	38%	6,000	50,000	300.0
1976	62,400	30,000	30%	7,000	50,000	350.0
1977	75,700	37,000	25%	7,000	48,000	335.0
1978	88,000	44,000	20%	7,000	47,000	330.0
1979	100,000	51,000	15%	7,000	46,000	320.0
1980	114,000	58,000	15%	7,000	45,000	315.0

Source: Frost & Sullivan estimates, 1972.

Market Shares by Types of Communications Processors

The reader should keep in mind that our forecast reflects the total communications processor hardware market, including all types of devices. Actually, the three major types of communications processors account for different market shares and show varying rates of growth.

Estimated Market Shares by Type of Processor

Type of Processor	1972	1975-1980
Front-End Processor	40%	60%
Data Concentrators (local and remote)	20%	20%
Message Switching Devices	40%	20%
	100%	100%

At present, front-end controllers and message switches constitute about 40% of the total market each, but sales of front-end processors are expected to grow much faster, to account for about 60% of the total market during the 1975-1980 period.

During the same period of time, sales of message switches will drop to only 20% of the market and will become equal to the market share of the data concentrators, which is expected to remain constant as competitive pressures from hardwired and LSI multiplexing equipment and specialized common carriers continue. More precise market shares by type of communications processor are quite difficult to project, due to unpredictable degree of overlap which will continue to exist between the various types of devices.

Major User Areas of Communications Processors

While we project the total annual sales of communications processors to double from $170 million in 1971 to $350 million in 1976, the market for communications processors will develop the fastest in banking, credit checking and retail sales, areas which already account for 30% of all such use. This is so because of continued increase in credit card sales and billings and expected massive introduction of Point of Sale systems during the next few years.

TABLE XXIII

DISTRIBUTION OF COMMUNICATION SALES BY END USER

User Area	1972	1976
Banking, Financial information services,, credit checking	20%	27%
Government (local, state, federal)	15	7
Manufacturing	20	17
Process control industries	10	8
Retail Trade	10	17
Transportation (Air, Rail, Road)	20	16
Utilities (Power, Gas, Water)	5	5
	100%	100%

Percentage drop in sales in some user areas indicates that these industries have previously made the investment in data communications equipment, and although sales in all sectors will continue to increase, these will account for a smaller share of the total communications processor markets. Consumer service applications appear to be on their way to surpass industrial users as immediate future largest markets.

Market Shares of Communications Processor Suppliers

We previously identified 53 different suppliers of communications processors and we estimate they have a cumulative installed base of about 5,500 units through mid-1972. This is expected to reach 7,000 by the end of 1972. At current average prices, this constitutes a current annual market of $225 million, growing to a peak of $350 million by 1976.

Among the 53 suppliers, 15 are major factors in the market, accounting for 90% of all communications processor sales. These include several mainframe manufacturers and minicomputer firms and also four independent non-computer suppliers.

The market shares estimates on the following page are based on total 1972 sales of $225 million. We expect that IBM will quickly increase its market share beyond its present 17%. This will partly be due to the fact that IBM controls 70% of the computer installations around the world, and so far has not been a supplier of communications processors to any significant degree. Now, with the introduction of the IBM 3705 processor, the situation has changed radically, and the company will undoubtedly obtain a significant share of the market from its own computer installation base. The above will contribute to an increase in IBM market share at a faster rate than other suppliers, when measured in volume of sales. Another reason for fast market share growth of IBM is its relatively higher average unit price than that of the many minicomputer manufacturers. While this situation will present a continuing opportunity to the minicomputer manufacturers, it will also allow IBM to obtain a leading position in this market, due to the beneficial combination of its vast installation base and higher prices.

TABLE XXIV

ESTIMATES OF MAJOR SUPPLIERS' MARKET SHARES FOR 1972 COMMUNICATIONS PROCESSOR SALES

Supplier	Estimated Market Shares (% of Sales)
IBM Corporation	17%
Digital Equipment (1)	17
Honeywell Information Systems	11
Univac (2)	9
Collins Radio	7
Control Data	5
Tempo (GT&E)	4
Data General	3
Data Pathing	3
Burroughs Corporation	3
Comten (formerly Comcet)	3
Communications Systems (Harris-Intertype)	2
EMR Computer	2
Varian Data Machines (3)	3
Interdata	2
Total	90%
All other suppliers	10%

(1) DEC makes significant OEM sales of PDP 8 and PDP 11 computers to systems houses and software companies for inclusion in their communications processor systems, and thus there is danger of double counting when direct comparisons are being made with total annual sales of all suppliers.

(2) Includes sales of some Univac general purpose computers which are popular as message switching devices, i.e., 418 systems.

(3) Includes also significant OEM sales to Burroughs, etc.

Installations of Communications Processors

In order to provide additional insights into the structure of this relatively new and emerging industry, we have obtained, wherever possible, estimates of the cumulative number of installations by as many suppliers as was possible. These include the independent systems houses and software companies, as well as computer and minicomputer manufacturers, but we have kept the two types of suppliers separate in order to indicate the importance and significance of the two different types. Most of the following information comes from a variety of sources, including most recently published surveys in the trade press, but it is not complete. It does, however, provide sufficient information to indicate the relative magnitudes of installed bases of the major independent suppliers, as well as the computer manufacturers.

Of a total of 36 independent suppliers identified, 15 claim to have installed 10 or more systems, while there are still 20 additional firms which can only account for a few systems each. Many of the independent suppliers are OEM buyers of minicomputers which form the basis of their products. Several suppliers build their own specialized equipment, and some, like Collins Radio, Data Pathing and Communications Systems, are also among the top 15 suppliers, as measured by percentage of total annual communications processor sales.

It must be kept in mind, however, that because of great differences in prices between different units, the cumulative number of installations are not alone indicative of the relative market shares, and are provided here only as a guide to further study and analysis.

TABLE XXV

ESTIMATED CUMULATIVE NUMBERS OF COMMUNICATIONS PROCESSORS SUPPLIED BY NON-COMPUTER SUPPLIERS AS OF JUNE 1972

Independent Suppliers	Cumulative No. of Units Installed
Data Pathing	100
Collins Radio	50
Communications Systems (COPE units)	50
Modular Computer Systems	50
North American Phillips	45
Bolt, Beranek & Newman	27
Computer Communications	18
Programming Methods (GT&E)	17
Informatics	16
Teleprocessing Industries (Western Union)	12
Intercomputer Communications	10
General Instruments	10
Computer Control Systems	10
Comtec Data Systems	10
Telefile Computer Products	10
15 Major Non-Computer Suppliers	395
Additional 20 Non-Computer Suppliers	150
Total Non-Computer Supplier Installations	545

Communications Processors Installed by Computer Manufacturers

It appears that despite a proliferation of independent data communications systems houses and consulting organizations, the majority of communications processors are supplied by computer and minicomputer manufacturers directly to the users.

The table on the following page presents our estimates of the cumulative numbers of communications processors which we believe were sold and installed primarily by the hardware manufacturers for data communication applications. In some cases, we were able to obtain actual figures of such installations; in others, we derived approximations from sales volumes and average prices. In the case of several minicomputer suppliers, we have accepted the general industry estimate that at least 15% of minicomputer hardware is supplied for data communications applications and extended total minicomputer shipments to date of these companies by this factor to obtain our estimates.

No doubt there is some double counting in such figures due to previously mentioned extensive OEM arrangements between some manufacturers. But the total count which we have developed of about 5,000 communications processors plus an additional 500 installed by the independent non-computer suppliers, appears to be in line with our previous forecast. This will mean a total of 5,500 communications processors by mid-1972, installed by all the manufacturers and suppliers, and it will very likely reach the 7,000 units by year end, as stated in our projections.

Our estimates pertain primarily to domestic or rather North American markets and do not include projections of foreign demand. Some sources now claim these already are significant, but due to

TABLE XXVI

ESTIMATED CUMULATIVE NUMBERS OF COMMUNICATIONS PROCESSORS SUPPLIED BY COMPUTER AND MINICOMPUTER MANUFACTURERS AS OF JUNE 1972

Hardware Manufacturers	Cumulative No. of Units Installed
Digital Equipment	2,000
Honeywell Information Systems	500
IBM Corporation	500
Control Data Corporation	400
Varian Data Machines	340+
Data General	300+
Univac	250
Interdata	250
Datacraft Corporation	83
Raytheon Company	79
Burroughs Corporation	75+
Tempo (GT&E)	75
Digital Computer Controls	27
Scientific Computer Controls	20
EMR Computer	16
Texas Instruments	12
16 Manufacturers	4,927
Others (about 30 hardware manufacturers)	150
Total (Cumulative Communications Processors)	5,077

relatively poor state of communications facilities outside North America, we do not feel those markets are going to grow as fast as those of the United States and Canada.

Future Trends in Communications Processors

The general trend is towards more distributed functional processing which is being implemented by dedicated hardware. The object is always to obtain higher efficiencies from central processors operating in random access communications environments.

More communications processors will be designed as independent front end units providing "fail-soft" capabilities to large multi-client systems. This feature becomes very valuable in competitive environments such as will exist in several information services of the future.

"Intelligent" or "smart" terminals are a part of the trend to perform as much preprocessing as possible at remote sites before using the main computer facility.

As new terminal devices and more communication lines are used in each system, front end units will become more flexible to accommodate these changes.

Julius Marcus, product manager of Digital Equipment's PDP-11 Communications Products line estimated at a seminar conducted in May 1972 that technology has been pushing the costs of communications processors down at the rate of 30% annually, while at the same time increasing the performance "some 50%" every year. Increasing modularity and trend towards the use of MSI-LSI components are characteristic of changes in this type of product.

DATA COMMUNICATIONS EQUIPMENT
INDUSTRY STRUCTURE

Major Competitors

AT&T dominates the market for modem equipment but only leases the units and thereby creates a situation, which since the Carterfone Decision, allows independent manufacturers to come in under the Bell lease cost with flexible purchase and lease options on their devices. Significantly AT&T does not supply multiplexing equipment to the end user for voice-grade line applications, although Bell uses multiplexing with wideband facilities when their cost is included in the price of the facilities.

AT&T accounts for 70% of low-speed modem units but various industry estimates predict that this may drop to "bout 50% during the 1975 to 1980 period.

AT&T also supplies the Teletype terminals, which because of low cost and universally available service, are the most popular terminals in use. Teletype Corporation is a subsidiary of Western Electric, the manufacturing arm of AT&T. At one time as many as 6,000 units were manufactured every month, although due to a variety of alternative devices and poorer business conditions in recent years, this rate of production was significantly reduced. This supply of terminals is an indicator of the need for modems and multiplexers for use in general remote computing applications.

The recent lease rate reductions and introduction of a $100 per month 4,800 BPS modem by AT&T indicates that Bell is taking the independent competition quite seriously and the move shows how vulnerable the independent manufacturers really are. Some will find it very trying to try and meet AT&T's $100 lease in this modem range.

Paradoxically, while the independents have sprung up hoping to benefit the end user who was dissatisfied with AT&T, these objectives may be realized by influencing AT&T to offer better and more flexible services or products, but not necessarily benefitting the independents except in a few highly specialized areas.

A most significant competitor although not appearing as such because of its fragmented approach to the market through various subsidiaries is GENERAL TELEPHONE & ELECTRONICS, the largest independent telephone company. GT&E which has revenues in the order of $2.0 billion a year derives 50% of its income from manufacturing. A very large portion of that is from its consumer electronics subsidiary Sylvania, which also owns ULTRONICS and TEMPO, the latter recently acquired communications processor manufacturer that started out in life as a minicomputer manufacturer.

GT&E also owns PROGRAMMING METHODS INC. which has a programmable communications processor as one of its products not unexpectedly based on TEMPO equipment. Curiously SYLVANIA's Electronic System Group in Needham recently also announced a communications minicomputer product known as the Programmable Signal Processor (PSI) for under $50,000 per unit. This unit appears to have a built-in modem. This product is not based on the TEMPO devices.

AUTOMATIC ELECTRIC is, of course, GT&E's manufacturing firm, supplying communications and telephone switching equipment to the 30 operating telephone companies within the GT&E empire. Another wholly owned subsidiary is LENKURT ELECTRIC of San Carlos, California which supplies microwave radio and multiplexer transmission equipment to GT&E as well as the military and industrial end users. Of the total revenues, we estimate about $5 million to come from sale of multiplexers including the PCM type devices on which the company realized substantial business.

ULTRONICS presents a special case because the company's main business is to supply stock quotation services competing with Bunker-Ramo and Scantlin Electronics. However it is estimated that as much as $12 million of ULTRONICS revenues comes from sales of data communications equipment, and it supplies TDM and FDM multiplexers as well as a whole range of modem devices.

In addition to equipment manufacture, GT&E subsidiaries offer specialized software services as well as data processing services, and as a whole, GT&E contains a group of companies with impressive capability within data communications and great breadth of expertise. It remains to be seen if all those talents and capabilities as well as numerous clients of the various companies could be fully integrated to present a viable independent all around data communications company. All the elements of success exist within this group of companies backed by the size and resources of GT&E, which also has international and far flung operations and manufacturing facilities in Canada, Europe, Latin America and the Far East.

WESTERN UNION, also a common carrier and supplier of Bell compatible modems is not a major factor in this market. However it has recently created a new subsidiary called TELEPROCESSING INDUSTRIES, which is both a user of data communications equipment and a supplier of message switching services to the industry at large. This company has the capabilities and the necessary sponsorship to become a more important factor in data communication in the future.

Another growing threat to the independent manufacturers is the IBM Corporation, which also dominates the origins of the markets for data communications equipment by virtue of controlling 70% of all the computers installed.

IBM is also probably the second largest supplier of data terminals after Teletype, as well as remote batch units and other of various types which require modems to operate in remote configurations. Only in the banking field does NCR and Burroughs hold an edge with specialized units. IBM also provides modems and FDM and TDM multiplexing devices, but so far has not been a significant factor in these specific market segments.

Since December 1971, however, when IBM announced new medium and high speed modems and more recent announcement of the IBM 3705 communications processor, the independents have been given much to think about. Suddenly the market place is being dominated by two giants rather than one, and independent maneuvering becomes even more difficult. Actually IBM developed and marketed successfully some years ago a message switching unit to end users and others who had to develop their own data communication software.

IBM poses a very big question in the minds of independent manufacturers and is being watched very carefully as of late, in order to assess its longer range marketing policies. Generally the belief is that IBM is still testing the market reception for its new data communications products such as the IBM 3705 controller, optional integrated modems and data adapters. If IBM succeeds to entice enough users to pay higher prices for its service and integrated supplier approach, then it will undoubtedly become a leading supplier of data communications equipment.

Up to now the IBM communication controller was supplied by several non-IBM manufacturers, whose devices improved the cost/ effectiveness performance of the IBM 2703 series of controllers. They also provide more flexibility in handling a variety of non-IBM terminals as well as more efficient software or firmware. INTERDATA and TEMPO specialized in designing the 270X products specifically to replace the IBM line.

In answering a recent Frost & Sullivan questionnaire about future IBM market position within the remote computing industry, several points came up which are pertinent to this discussion. IBM is regarded as having an even chance of becoming a dominant factor in the front-end communications devices market although respondents did not feel that IBM will ever become a major modem supplier (by 88% to 12%). The last point may not be significant in view of IBM's obvious moves to provide integrated modems in some of its devices, and a general trend to do so by all terminal manufacturers.

MILGO ELECTRONICS is the undisputed leader among independent modem manufacturers accounting for a minimum of 25% of the total modem market and as much as 50% of the medium to high speed market. MILGO sales are currently running at the $11 to $12 million per year although 20% of its revenues come from overseas where its products are sold through a 50% owned subsidiary RACAL-MILGO, headquartered in England.

The company was formed in 1956, and until 1964 was building modems for NASA, NAVY and the AIR FORCE when it decided to enter the commercial highspeed modem sector. During 1969 commercial sales exceeded government sales which during 1971 accounted for less than 10% of all revenues. The company is phasing out all government business and last year ceased bidding on government contracts.

MILGO sells and leases its modems to end users although it also does some OEM work for Western Union and University Computing. During 1971 the lease to sales ratio was about 35%. The company recognizes the importance of service and maintenance and provides extensive field support to its clients. Service offices are located in major cities supported by contract service representatives in more than 200 cities. As a rapid response feature, MILGO stores modems at key airports throughout the country for immediate delivery dispatch.

Although MILGO established a new interconnect division only last November, and is marketing PABX equipment, the company decided not to enter the multiplexer business which is closely related to the modem market. The company surveyed the multiplexer market particularly the Frequency Division sector, because such units can be looked upon as collections of different frequency modems, but even though it concluded it could capture a $2 to $3 million market share MILGO decided not to enter this market. Because the company is a well established independent manufacturer in this business, its decision more than that of others, must be considered indicative of the trends and opportunities in data communications.

DATA PRODUCTS became a major entrant into the data communications equipment market by acquisition of STELMA of Stamford, Conn. in November 1968, and are renaming it the Telecommunications Division. In fiscal 1969 STELMA had revenues of $16 million which contributed 44% of total sales to the combined company. For fiscal 1972 DATA PRODUCTS revenues were $50.8 million and 31% of the total came from telecommunications products which means a slight decrease in sales of data products since 1969.

DATA PRODUCTS' modems, multiplexers and other devices are sold to government agencies as well as Bell System companies and computer manufacturers.

A rather interesting situation is developing with regard to RIXON ELECTRONICS which was acquired by UNITED UTILITIES in 1968, recently renamed UNITED TELECOMMUNICATIONS, INC. RIXON is a leading supplier of modems and multiplexers and, at the time of acquisition, was a $6 million sales company with about $3.3M of the total coming from the military markets.

Considered a long time loss by the new parent, RIXON was recently allowed to resume direct marketing of its products and promptly made a deal with Honeywell to install and maintain its equipment which perhaps stresses the importance of a prime service organization. Later in August, Sangamo Electric picked up 60% of RIXON to form a new company by combining its own and RIXON data communications activities. This is perhaps the first big merger of the leaders in this industry.

AMERICAN DATA SYSTEMS is still a private company which was incorporated in January 1967 and experienced rapid growth as an early supplier of the Time Division Multiplexers. Sales increased rapidly from about $750,000 in 1969 to almost $5 million, by end of 1970, reflecting the demand at that time for this type of equipment. The time-sharing industry was the biggest market and ADS claimed 75% of multiplexers were sold in that market.

Presently at $6 million annual sales level, the company is a major independent supplier of TDM and FDM multiplexers, modems in all speed ranges, communications processors and data terminals, achieving its original goal to become a total telecommunications systems house.

The ADS-950 Front End is basically developed for the IBM 360/370 computers but easily interfaces with other cpu's. One feature claimed is handling of any type terminals without additional software or hardware. Interestingly ADS introduced its new low-speed modem (0 to 300 baud) to its line of products only recently which, however, is relatively high priced at $551 per unit.

Much of the technology of ADS products comes from Autonetics Division of North American Rockwell, which is also the largest stock-holder of ADS. Availability of this technology already used and tested in aerospace applications, allowed ADS to enter the market rapidly at an opportune moment. While both modem and multiplexer technology was made available, ADS shrewdly chose TDM multiplexers as its first product to gain attention and not to compete immediately with Milgo, which also brought its high speed modem technology from original government work.

Enjoying an excellent product acceptance and rapid growth, the company is facing a natural problem of service expansion and increasing need for maintenance facilities, as its product line gets larger and more units are placed in the field. It should continue to present an opportunity for additional financing or a public underwriting.

Because North American Rockwell controls ADS by virtue of its stock position, an interesting development is the acquisition by NAR of COLLINS RADIO, until then a strong competitor of ADS.

This common ownership may be exploited to consolidate the activities of the two companies in data communications product lines. On the other hand COLLINS RADIO may be looked upon as more of a supplier of military markets while ADS serves primarily the commercial data communication deeds. Even so COLLINS RADIO sold multiplexers and modems to airlines and independent telephone companies.

COLLINS RADIO is a large and well established company which a while ago was chased by University Computing, which eventually abandoned a takeover attempt. Main revenues of about $287M (FY 71) come from radio communications equipment and air navigational devices, and the company markets a total of almost 1,000 products. Only 20% of sales is estimated to come from communications markets, and we estimate that modems and multiplexers account for perhaps $2 million while communications processors probably contribute as much as $10 million per year, mainly due to their large message switching capabilities. COLLINS RADIO is well established in message switching and also manufactures printed circuits and MOS integrated circuits.

In September, 1971, North American Rockwell acquired controlling interest of the company for $35 million and now has 7 of its own directors on the board.

SANGAMO ELECTRIC is considered a leading modem manufacturer, but, even so, its modem sales are but a small fraction of the overall corporate sales which reached $82.5 million in 1971. Main business of the company is power equipment, various communications products, electronic systems and components. In the data communications areas, besides modems, the company manufactures line conditioners and equalizers, inductors, filters and communication systems subassemblies. It is therefore well poised to gain considerably by exploiting Rixons complementary line of multiplexers and additional modem product.

A different picture is presented by RCA which manufactures a modem as well as a multiplexer and which is a huge corporation of $3.5 billion in revenues for 1971. The modem and multiplexer sales within such a giant are negligible but may be complementary to many other company product lines.

RCA has specific strength because of its RCA Service Company. While divesting itself of computer products, RCA Service Company was not affected and continues to expand its third party maintenance program for computers and other data processing equipment. This organization may be of interest to smaller manufacturers of data communication equipment looking for maintenance and support for their products.

Availability of nationwide service and existence of RCA Global Telecommunications, which is an international common carrier, present some interesting possibilities but the company has not taken any significant steps to exploit the situation. If any of RCA modem and multiplexer sales were previously associated with the 1,000 odd RCA computer installations, which were sold to Univac, there may no longer exist the incentive to manufacture these products.

ANDERSON-JACOBSON is a relative newcomer and a very small company with annual sales running at the $4.8 million level, of which 40% is estimated to come from the modem market. While a small company, it is already publicly held and considered a major supplier of the low-speed acoustic coupler market.

The company obtained a license to manufacture the acoustic couplers from Stanford Research Institute which gave A-J a head start on competition, when it was founded in 1967. Although totally dedicated to data communications, the greater part of company sales come from sale and leasing of terminals. ANDERSON-JACOBSON modifies standard Teletype and IBM Selectronic units, and includes its own built-in modems into those terminals making them popular where probability of the unit is of importance.

The company has 170 employees and offers service in 14 cities. Its research and development program indicates that A-J is trying to expand by becoming a manufacturer and supplier of minipheripherals. Two small companies, TELUX and DATUM financed for these purposes were acquired in 1971.

Another newcomer into the data communications game, although otherwise well established in the computer field, is UNIVAC. While there are no units installed as yet, Univac 3760 devices will allow IBM users to connect with various terminals. Deliveries of the new units are scheduled for January 1973 and they are being manufactured in Univac's Salt Lake City division. UNIVAC's device will apparently be priced competitively at $54,500 to start, with one to three years lease plans available.

A major independent modem and multiplexer suppliers with a good chance of staying in this business is CODEX. The company was formed in 1962, supplying equipment to the government, and in 1967 demonstrated to the industry the feasibility of high-speed modems transmitting at 9,600 BPS over voice-grade lines.

In 1968, CODEX also introduced its time division multiplexers, and is now offering several medium and high-speed modems and three models of TDM multiplexers as well as a digital communications terminal device, which may in the future become a communications processor. CODEX certainly has the capability and is long established in the marketplace, with service arrangements, to undertake an integrated approach to supply data communications equipment.

TEL-TECH and TIMEPLEX are small companies, but fully dedicated to the sale of modems and multiplexers in the case of TEL-TECH, and multiplexers only, by TIMEPLEX. This puts them among major suppliers and TIMEPLEX already obtained contracts to supply multiplexing equipment for the new common carrier service provided by MCI Communications for Chicago and St. Louis transmission.

AMBAC INDUSTRIES is a large corporation with $135 million in sales for 1971, and its TELEDYNAMICS division supplies telemetry components and systems to the government. It is among the top 15 modem suppliers but compared to its total parent company sales, this business is small.

A rather interesting entry into data communications is EMR COMPUTER a subsidiary of SCHLUMBERGER LIMITED, a large corporation with $700 million in sales during 1971. The company is an international supplier of oilfield equipment and wireline systems, and with increasing use of remote computers in these areas may have a greater stake in data communications in the future. Telemetry, computers, components and photoelectric devices are also manufactured by the company.

Another supplier of modems as well as TDM and FDM multiplexers, perhaps growing in importance because of its well established parent, is TELESIGNAL operation of the KEAFOTT DIVISION of the SINGER COMPANY. Singer which is now a $2 billion corporation, designs and manufactures many industrial products, computers, defense and military systems, as well as sewing machines, and calls itself an integrated technology company. With a good line of modems and multiplexers and the small computer hardware, SINGER is well positioned to round off its offering in data communications with a communications processor or could possibly pick up one of the smaller existing competitors. It has the potential and financing as well as technology to become a significantly more important supplier of this market.

UNIVERSITY COMPUTING could have been regarded as a major factor in this market because of its COPE terminals which fall into the intelligent terminal and controller class, and of which 50 are installed already. However, the company recently sold this subsidiary to HARRIS-INTERTYPE in order to raise capital for the construction of its projected DATRAN digital communications network. As it is, HARRIS-INTERTYPE should now be included as supplier of this type of equipment. It is however, more properly remote batch terminal hardware rather than communications processing equipment.

GENERAL DATACOMM is a newcomer which began operations in 1969 and provides a large selection of modems and multiplexers. The company obtained $2 million initial financing from Loeb, Rhodes. It is carving out a place for itself among the more aggressive new data communications equipment companies.

OMNITEC is regarded as a leading supplier of acoustic couplers both to the end user and to the OEM buyer. The company is reported to have as many as 12,000 to 15,000 units sold and is a subsidiary of NYTRONICS corporation which is publicly held.

Among other suppliers of modems and multiplexers which are well known,but remain small companies in the order of $1 to $2 million in sales per year, are PENRIL DATA COMMUNICATIONS, NOVATION, INTERTEL, which was started by three employees who left CODEX in 1969, and FORD INDUSTRIES CORPS, PENRIL DATA COMMUNICATIONS, was also an off-shoot of Rixon and was started in 1968 while PRENTICE ELECTRONICS has been in business since 1963, and supplies signal conditioners, amplifiers and amplifiers as well as modems.

COMPUTER COMMUNICATIONS of California occupies a special place in this collection of data communications firms because it is a relatively new company and started out in 1968 as a total systems house providing terminal devices and associated equipment. This led the company to the manufacture of communications front-end devices, and it has about 20 units of processors installed which can interface with any computer due to the availability of interfaces manufactured by the company. CCI must be considered as wholly dedicated to computer oriented communications, but it is more of a systems house than a manufacturer of hardware.

Industry Information Matrix & Analysis

All of the companies that are suppliers of modems, multiplexers or communications processors, have been arranged in rough alphabetical order in the industry information matrix on the following pages.

The purpose is to give a quick overview of company product lines relative to each other, and indicate the range of data communication products handled. These product lines are indicated by an (x) under the appropriate column. The columns are each labeled by a single letter in order to simplify the tables. The key to the meaning of each letter is presented below.

Column heading	Significance
A	Company manufactures acoustic couple
L	Low-speed modems up to 300 BPS units
M	Medium-speed modems to 4,800 BPS
H	High-speed modems of over 4,800 BPS
F	Frequency Modulation Multiplexers
T	Time Division Multiplexers
C	Supplier of Communication Processors
S	Denotes a small company with sales under $5 million
P	Indicates a publicly held corporation n = New York Stock Exchange a = American Stock Exchange o = Traded over-the-counter

The industry information Matrix provided a basis for certain industry analyses that can be performed. Of the 156 companies identified by our matrix as suppliers of modems, multiplexers or communications processors, 107 are small firms many only recently established. Almost an equal number, actually 97 firms, manufacture acoustic couplers as part of their product lines, and 47 firms manufacture acoustic couplers as their only product in data communications.

There is an equal number of companies with low-speed and medium speed modem product lines (57 and 53), which probably reflects the demand for this type of modem. It may also reflect the fact that the 300 BPS low-speed modem limit may be arbitrary, and if extended to about 1,800 BPS, would change the mix of the companies in this product line. In effect this would greatly increase the number of entrants in the low-speed modem area which is quite crowded as it is.

Only 19 companies manufacture high-speed modems and a similar number is in the business of manufacturing Frequency Division multiplexers (20) and Time Division multiplexers (19). A total of 55 firms are in the business of supplying communications processors.

What is probably most significant, very few firms supply the complete product line including modems, multiplexers and communications processors. In fact there are only three such companies today, which include IBM, Collins Radio and American Data Systems.

In all, there are 97 companies which supply some kind of a modem, but only 22 which supply both modem and multiplexers. Suppliers of communications processors are mostly not engaged in the manufacture of either modem or multiplexers.

INDUSTRY INFORMATION MATRIX

Manufacturer	Location	A	L	M	H	F	T	C	S	P
Databit	Happauge, New York						X		X	
Datamax	Ann Arbor, Mich.			X					X	
Design Elements	Columbus, Ohio	X	X						X	
Digital Techniques	Royal Oak, Mich.	X	X						X	
Direct Access	Southfield, Mich.	X	X						X	
Data Products	Stamford, Ct.	X	X	X	X	X				a
Dataserv	Burlingame, Ca.		X					X	X	
Datastat	Sunnyvale, Ca.	X							X	
Da-Tel Research	Montrose, Colo.		X						X	
Digital Communications	Rockville, Md.		X						X	
Digidata	Bladensburg, Md.	X							X	
Dorado Systems	Hayward, Ca.		X						X	
Datron Systems	Mountain Lakes, N. J.		X						X	
Dynatronics (GD)	Orlando, Fla.		X	X						n
Dynelec	Glen Rock, N. J.						X		X	
Data General	Southboro, Mass.							X	X	o
Data Quote								X	X	
Data Pathing	Sunnyvale, Ca.							X	X	
Datacraft	Fort Lauderdale, Fla.							X	X	
Digital Comp. Controls	Fairfield, N. J.							X		o
Digital Equipment	Maynard, Mass.							X		n
ESE (Canada) Ltd.	Rexdale, Ontario			X					X	
ESL Incorporated	Sunnyvale, Ca.			X					X	
EMR Computer	Minneapolis, Minn.							X		
ESSCO Communication	Camden, N. J.	X							X	
Four-Phase System	Cupertino, Ca.							X	X	
Ford Industries	Portland, Ore.	X							X	
General Electric	Lynchburg, Va.	X	X	X	X			X		n
General DataComm	Norwalk, Conn.		X	X		X	X		X	
General Dynamics	Orlando, Fla.				X		X			n
General Instrument	Hicksville, N. Y.							X		n
Hallicrafters	Rolling Meadows, Ill.			X	X					
Honeywell (HIS)	Waltham, Mass.			X	X			X		n
Hughes Aircraft	Culver City, Ca.		X	X	X					
Infotron	Pennsauken, N. J.						X		X	
Infotronics	Austin, Texas							X	X	
IBM Corporation	White Plains, N. Y.			X	X		X	X		n

TABLE XXVI

INDUSTRY INFORMATION MATRIX

Manufacturer	Location	A	L	M	H	F	T	C	S	P
Ambac Industries	Ft. Washington, Pa.		x	x		x				n
Action Communications								x	x	
American Data Systems	Canoga Park, Ca.		x	x	x	x	x	x	x	
Anderson Jacobson	Sunnyvale, Ca.	x							x	o
Applied Digital Data Systems	Happauge, New York	x							x	o
Applied Communications	Belmont, Ca.	x							x	
Aquidata	Silver Springs, Md.					x			x	
Automatic Electric (GT&E)	Northlake, Ill.		x	x						n
Astrocom	Minnetonka, Minn.	x	x	x	x		x		x	
AT&T	Bell System		x	x	x					n
Bendix Corporation	Baltimore, Md.						x			n
Bolt, Beranek & Newman	Cambridge, Mass.							x		o
Bonnar-Vawter	Keene, N. H.		x						x	
Bowmar/ALI	Acton, Mass.		x	x					x	a
Betatronics	Evaston, Ill.	x							x	
Burroughs	Detroit, Mich.		x	x				x		n
Beckes Communications	Chicago, Ill.	x							x	
Carterfone Communications	Dallas, Texas	x							x	o
Codex	Watertown, Mass.		x	x	x		x		x	o
Coherent Communications	Central Islip, N. Y.	x	x	x		x			x	
Comtec Data Systems	Hawthorne, Ca.							x	x	
Collins Radio	Dallas, Texas	x	x	x	x	x		x		n
Comten (previously Comcet)	St. Paul, Minn.							x	x	o
ComData	Niles, Ill.	x				x			x	
Cybermatics	Englewood Cliffs							x		o
Computer Complex	Houston, Texas	x	x	x			x		x	o
Computer Conversions	Northport, N. Y.	x							x	
Computer Transmission	Los Angeles, Ca.				x		x		x	
Computer Control Systems	Dallas, Texas							x	x	
Credex	Huntsville, Ala.	x	x						x	
Computer Terminals	San Antonio, Tex.	x							x	o
Computer Conversion	East Northport, N. Y.		x	x					x	
Communications Technology						x			x	
CHI Corporation	Cleveland, Ohio							x	x	
Computer Communications	Culver City, Ca.							x	x	o
Control Data	Minneapolis, Minn.		x	x				x		n
Computer Automation	Newport Beach, Ca.							x	x	o

INDUSTRY INFORMATION MATRIX

Manufacturer	Location	A	L	M	H	F	T	C	S	P
Informatics	River Edge, N. J.							x	x	o
Info-Max	Sunnyvale, Ca.	x							x	
Intercomputer Communica.	Phoenix, Ariz.							x	x	
ICC (Milgo)	Miami, Fla.			x	x					a
Itel Corporation	Palo Alto, Calif.	x								
ITT Corporation	Rutherford, N. J.			x						n
Interdata	Oceanport, N. J.							x	x	o
Intertel	Burlington, Mass.		x	x					x	
ITL Electronics	Clifton, N. J.	x	x	x					x	
II Communications	Willow Grove, Pa.			x						
Information Exchange Sys.	Minneapolis, Minn.		x						x	
International Data Term.	Ft. Lauderdale, Fla.		x						x	
Jacquard Systems	Santa Monica, Ca.							x	x	
Livermore Data Sys.	Livermore, Ca.	x	x							
Lenkurt Electric (GT&E)	San Carlos, Calif.		x	x	x					n
Lynch Communications	San Francisco, Ca.		x	x					x	n
Mark Computer Sys.	Garden City, N. Y.							x	x	
Modex	Costa Mesa, Ca.			x					x	
Multitech	Monterey Park, Ca.	x	x	x					x	o
Modular Computer Sys.	Ft. Lauderdale, Fla.							x	x	
Mohawk Data Sciences	Herkimer, N. Y.			x						n
Memorex	Santa Clara, Ca.		x	x				x		n
Metroprocessing	White Plains, N. Y.	x							x	
Magnavox Research	Torrance, Ca.			x	x					n
Microdata	Santa Ana, Calif.							x	x	o
Northern Radio	Melbourne, Fla.					x			x	
National Midco	Trenton, N. J.	x							x	
Novation	Tarzana, Calif.	x							x	
North American Phillips	Mahwah, N. J.							x		n
Novar	Mountain View, Ca.	x							x	
Omitec (Nytronics)	Phoenix, Ariz.	x							x	a
On-Line Computer	Stamford, Conn.							x	x	
Omnus Computer	Santa Ana, Calif.							x	x	
Princeton Applied Res.	Princeton, N. J.						x		x	
Paradyne	Clearwater, Fla.			x					x	
Penril Data Communica.	Rockville, Md.	x	x	x	x				x	o
Philco-Ford	Willow Grove, Pa.			x	x			x		n
Prentice Electronics	Palo Alto, Calif.	x	x	x				x	x	
Phoneplex	Jericho, N. Y.		x						x	
Phonocopy	Stamford, Conn.		x						x	

INDUSTRY INFORMATION MATRIX

Manufacturer	Location	A	L	M	H	F	T	C	S	P
Pulse Communications	Alexandria, Va.	x							x	
Programming Methods (GT&E)	New York, N. Y.							x		n
PHI Computer Services	Arlington, Mass.							x	x	
Quindar Electronics	Springfield, N. Y.	x	x			x			x	o
Remote Computing	Los Angeles, Calif.							x	x	
RCA	Camden, N. J.					x				n
RFL Industries	Boonton, N. J.	x	x	x		x			x	
Rixon Electronics (UBC)	Silver Springs, Md.			x	x	x	x		x	
Raytheon Data Systems	Norwood, Mass.							x		n
Sycor	Ann Arbor, Mich.			x					x	
Sanders Associates	Nashua, N. H.							x		n
Sangamo Electric	Springfield, Ill.		x	x						n
Siemens	Iselin, N. J.		x	x						
Singer Tele-Signal	Woodbury, N. Y.		x	x		x	x			n
Scidata	Atlanta, Ga.							x	x	
Sonex	Philadelphia, Pa.	x	x			x			x	o
Scientific Control	Carrolton, Texas							x	x	o
Stromberg Carlson (GD)	Rochester, N. Y.		x							
Scantlin Electronics	Los Angeles, Calif.					x		x	x	o
Telefile	Irvine, Calif.							x	x	
Timeplex	Washington, D. C.						x		x	
Tel-Tech	Rockville, Md.		x	x			x		x	
TTS Div.Remote Data Term.	Santa Monica	x							x	
Tuck Electronics	New Cumberland, Pa.	x	x	x		x			x	
Texas Instruments	Dallas, Texas							x		n
Tycom Systems	Pompton Lakes, N. J.	x	x						x	
Tymshare	Palo Alto, Calif.	x							x	o
Technitrend	Pennsauken, N. J.					x			x	o
Tempo Computers (GT&E)	Fullerton, Calif.							x		n
Ultronics (GT&E)	Mt. Laurel, N. J.	x	x	x		x	x			n
Universal Data Systems	Huntsville, Ala.		x	x					x	
Univac (Sperry Rand)	Blue Bell, Pa.							x		n
UCC Communications	Dallas, Texas							x		n
Vadic	Palo Alto, Calif.	x	x	x					x	
Varian Data Machines	Irvine, Calif.							x		n
Vernitron	Farmingdale, N. Y.	x	x						x	a
Westinghouse	Newark, N. J.		x							n
Western Telematic	Arcadia, Calif.		x	x					x	
Western Union (Teleprocess)	Mahwah, N. J.							x		n
Xerox Data Systems	El Segundo, Calif.						x			n

Modem, multiplexer and communications processors suppliers

Company	Total sales ($millions)	Contribution to sales from data communication equipment
AT&T	21,000.00	Modems are leased only
American Data Systems	10.00	75% to 85% of total
AMBAC Industries	135.00	Small, Teledynamics Div.
Anderson Jacobson	4.80	40% of the total sales
Bolt, Beranek and Newman	16.00	Communication processors 20%
Bendix		Very small
Computer Communications		Significant
Codex	2.00	100% of total sales
Collins Radio	287.00	About $12 million of total
Data Products	50.80	31% telecommunications products
Data Pathing	5.00	100% processors
EMR Computer (Schumberger)	700.00	Very small with potential
General Data Comm	3.00	100% of total sales
General Electric	9,500.00	Very small
GT&E	1,925.00	Fragmented small with potential
IBM Corporation	8,000.00	Small with significant potential
Informatics	17.50	About 10% of total sales
Milgo	12.00	Almost 95% of total sales
Omnitec	2.00	Large acoustic coupler supplier
Penril Data Communications	1.00	100% of the total
Philco-Ford (Ford)	16,400.00	Very insignificant
RCA	3,500.00	Very small percentage
RFL Industries	1.60	100% of sales
Rixon Electronics	5.00	90% of total sales
Sangamo Electric	82.50	Small but potential, ab.$2 mil.
Tel-Tech	2.00	100% of total sales
Singer (Telesignal)	2,000.00	Very small but potential big
Timplex	1.50	100% in multiplexers
University Computing	127.00	COPE terminals sold to Harris-Intr.

Companies in the above table we believe supply 85% of all the multiplexing equipment and as much as 90% of all the modems. They also include some of the major suppliers of communications processors but no minicomputer manufacturers are included who could perhaps be regarded as the prime beneficiaries from sales of communication processors.

NO dialup modem startups!-

Important!

Problems of Staying in Business

Taking into consideration all the factors derived in this study which affect the data communication equipment market, the overriding one is the large number of small new companies which are all scrambling for a share of about a $250 to $300 million market today. At best, that gives an average $2 million annual sales per company today. Many of the small firms do not yet have that sales volume, but it is the growth of this volume in the next few years which is of particular concern.

Because of rapidly falling unit prices, particularly in the modem and communication processor (minicomputer) product lines, the short range forecast we have developed suggests the market to peak out at $450 to $475 million per year in the 1975-1976 period. If the number of competing firms remains constant (about 256 today), this will yield an average annual market in 1976 of about $3 million per company, only a 50% increase from the present level. Beyond that point, we believe that price erosion will keep the sales level relatively constant with smaller growth available for the small companies.

If there are to emerge a few fast growing firms that could show sales of $20 to $50 million a year, there does not seem to be any room for more than about 10 to 20 such companies.

The key to staying in business during the next few years may well be consolidation of resources with other partners in the market with complementary product lines. Only three firms today supply modems, multiplexers and communications processors. These are IBM, Collins Radio and American Data Systems. The first two are well established, and data communications is but a small percentage of their revenues. American Data Systems is well backed by North American Rockwell and other financial interests, and their marketing philosophy should not be ignored.

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