Introduction to Teleprocessing

Student Text

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Preface

This reference publication is designed to provide non-technical personnel with a conceptual introduction to teleprocessing. It presents the concepts of teleprocessing with little emphasis on programming techniques. Following an historical survey is a review of the elements of a teleprocessing system, including a discussion of typical application areas and basic teleprocessing systems flow.

Equipment characteristics, communications terms and concepts are presented in detail, and summary chapters are devoted to a study of teleprocessing systems design and the concept of the total system.

The major objectives of this manual are to:

1. Define the elements of, and examine the information flow within, a teleprocessing system.

2. Introduce the basic functions and capabilities of the teleprocessing equipment in the IBM product line.

3. Provide a background for the study of teleprocessing systems design through a discussion of the elements of a teleprocessing system, including communications line considerations, network design, and programming support.

For titles of associated publications, see the bibliography at the end of this manual.

Minor revision (October 1973)

This edition includes minor editorial changes to the following pages, 35, 36, 37, 38, 39 and 40. The previous edition is not obsoleted.

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Contents

Introduction

A teleprocessing (TP) system may be defined as a data processing system plus communications. To the user of a data processing system, this definition implies that he is able to communicate with devices at a remote location from his central installation. These remote devices have access to the computer and vice versa, allowing the remote users to take full advantage of the computing facilities available at the central location. This gives the user the ability to transmit meaningful data from remote location(s) to a central computer, and utilizing central information files, to receive complete status information at any remote location.

The methods and equipment used to transfer information between the central and remote locations are discussed in subsequent chapters of this publication. The following section is devoted to a review of the evolution of TP systems and how they meet the requirements of today's expanding businesses.

Historical Review

The growth of teleprocessing systems is actually an evolutionary step in the development of computer systems. It is important to realize that present TP equipment and programming techniques are not innovations in the computer industry but logical extensions of the requirements of an economy which has changed drastically over the past three decades.

Developments in Teleprocessing

Although the majority of teleprocessing systems have been developed in recent years, the potential benefits of these systems were recognized by early computer users. In fact, the first use of TP equipment with a computer occurred before the advent of stored program systems. As early as 1940, scientific calculations were telegraphed several hundred miles to an electromechanical calculator and within minutes results were returned to the distant users.

In 1940 and 1941, production models of IBM data communications equipment were used by the U.S. Army Air Corps at Wright Field in an inventory control application. The IBM 57 converted the data on punched cards into paper tape for use as input into a teletypewriter network, and receiving stations utilized the IBM 40 to convert the paper tape output back into cards. Later, the IBM 65 and 66 Data Transceivers were developed to provide direct card-to-card transmission over telephone lines, thereby eliminating the intermediate steps for conversion.

Such pioneering demonstrations indicate that there was an early awareness of the convenience in using a powerful calculator and telephone lines from remote locations for centralized computations. These experiments were considered valuable enough at the time that a patent was issued on one such system.

Experimentors recognized that a calculator was fast enough to service several remote devices concurrently; and, although the terms had not been introduced as yet, the concept of sharing the central calculator was a predecessor of recent advances in multiprogramming (executing several interleaved programs concurrently) and time-sharing (distributing the resources of a computer system among a number of independent users).

During the early part of the decade following World War II, military planners realized that new approaches were needed to provide an adequate air-defense system. Vast amounts of data would have to be collected and processed with results being directed immediately to command personnel, who in turn, could interrogate the system and plan effective defensive action. Here, then, was a need for transmitting data from such remote sensing devices as radar stations to a central computer, processing the data rapidly enough to influence the environment being monitored (that is in "real-time"), and using a man-machine system to combine the judgment and experience of professional personnel with the rapid, accurate processing of a computer. The system which grew from these requirements was named Semi-Automatic Ground Environment (SAGE); and the equipment and techniques formulated for such systems as SAGE had a substantial influence on the evolution of similar systems for commercial applications.

The first commercial teleprocessing applications were developed for industries with requirements for real-time control or rapid access to large data files. By the late 1950's, computers had been installed for controlling both industrial processes and critical time-dependent business inventories, including a number of airline reservation systems. Initially these systems used special-purpose, fixed-program machines to maintain inventories of passenger seat availability for future flights. Later, general purpose systems were programmed to provide more general reservation-accounting functions; and the design of the largest of these, SABRE (for Semi-Automatic Business Research Environment), was stimulated, as the name implies, by the earlier military systems.

The design of these general purpose systems, however, involved extensive modifications to the commercially available equipment and required the attachment of several special devices: separate channels to attach the communications equipment, special remote units, modified processors to protect against inadvertent destruction of data, additional core storage and drums to hold transactions before processing, and large disk files for the reservation data. Specifically designed programs were developed to control and coordinate the equipment. The design and testing of these complex programs required highly competent, trained personnel, long development schedules, and extensive amounts of machine time for testing. Naturally, developers soon realized that the widespread, economical use of such systems in commercial applications would require the development of TP equipment and control programs to interface directly, without modification, with standard computing systems.

With the advent of System/360 in the early 1960's began a new phase in the evolution of teleprocessing systems.

Although the earliest application of computers was to the solution of scientific problems, the potential of TP systems in this area went relatively unnoticed for some time. Computer equipment had become more economical and, with the introduction of operating systems, more conventional and efficient. User access to scientific computers, however, had not improved. In fact, individual users were experiencing more inconvenience and longer turnaround time (the time interval between submitting a job and receiving results) to the point that it was limiting programmer productivity.

Several leading university computer centers, recognizing the impact of turnaround time on user productivity, developed the concept of providing many users with the ability to share the facilities of a central computer via numerous remote devices. According to their plans, experienced personnel could apply their knowledge and judgment directly to the formulation and solution of complex scientific problems; whereas, inexperienced users with less background in computer systems could code and debug programs.

Teleprocessing Today

Teleprocessing systems have evolved from data processing systems because of the need to respond to the requirements of expanding industries with faster and more accurate information. The following trends summarize the industrial growth patterns which established these requirements:

- All communication techniques have improved.
- Much faster transportation is available through automobile, bus, train, and jet travel; and radio, television, and satellite provide new communications media which are capable of reaching millions of people at once.
- Business competition has increased.
- More services are available to the consumer, so he is able to discriminate between the services offered to him.
- The economy in general is mobile and growing rapidly.
- Businesses have expanded geographically because of competition and consumer familiarity with products and services as well.

Communications expansion facilitates widespread advertising, and business has responded to the demands where the markets are available. As a result, the internal operations of business and industries alike have increased in speed to such an extent that volumes of data are accumulated daily, and there are many more users of the computer today than ever before.

Today's economy is vigorous and complex. It is vital to good management that a centralized source of information exist concerning all facets of operations, consumer services and activities in remote areas when and where it is needed for effective decision-making. Data processing systems, with their powerful logical ability and speed, reduce the variety of information to the facts required for decisions and control. This data, however, must be collected from its sources before it can be processed.

By capturing the data at its source, the time, effort and expense required to convert information into a form suitable for entry into a data processing system are substantially reduced. The rapid transferral of information from its source to the central processor increases system performance and can provide both accurate and timely reports for management decision-making.

Consequently, the capabilities of data processing systems have been expanded to include new equipment as well as new applications. Computers now incorporate teleprocessing features as standard equipment rather than as special attachments, and special-purpose control programs are being replaced by general purpose programming systems to service the teleprocessing environment.

Summary

The attachment of teleprocessing equipment to digital computers requires much more than establishing the appropriate electrical connections. It involves a merging of the separate technologies of communications and computing, which have different heritages and attendant differences in equipment requirements and technical terminology.

It is a significant factor that much communications equipment was developed long before the modern digital computer, and facilities that were designed for convenient or economical data communication are not always ideally suited to a computer system. Teleprocessing demands new techniques which are not required for the standard input/output devices associated with data processing (e.g., printer, card read/punch); and because data is often entered into a computer directly from a remote device, this direct man-machine communication requires data validation and programming procedures not encountered in off-line (conventional) systems.

It is not feasible to satisfy all the requirements of a teleprocessing environment with standard products and programming support. Many application requirements, however, can be satisfied by TP devices used in conjunction with standard computer equipment, and a large number of applications can be processed under available operating systems augmented by communications-oriented control programs.

Substantial new capabilities, not available with earlier computer systems, become practical in a teleprocessing environment. In order to capitalize on this potential, one must have a general understanding of TP devices and terminology and of associated computer equipment and programming techniques. The direct substitution of a TP system for a conventional computer system is no more sensible than the rigid conversion of a manual accounting application to a computer, because the best use of the new TP system is made not by doing the old job in the same manner on new equipment, but by rethinking the entire approach in consideration of the new capabilities available with teleprocessing.

Elements of a Teleprocessing System

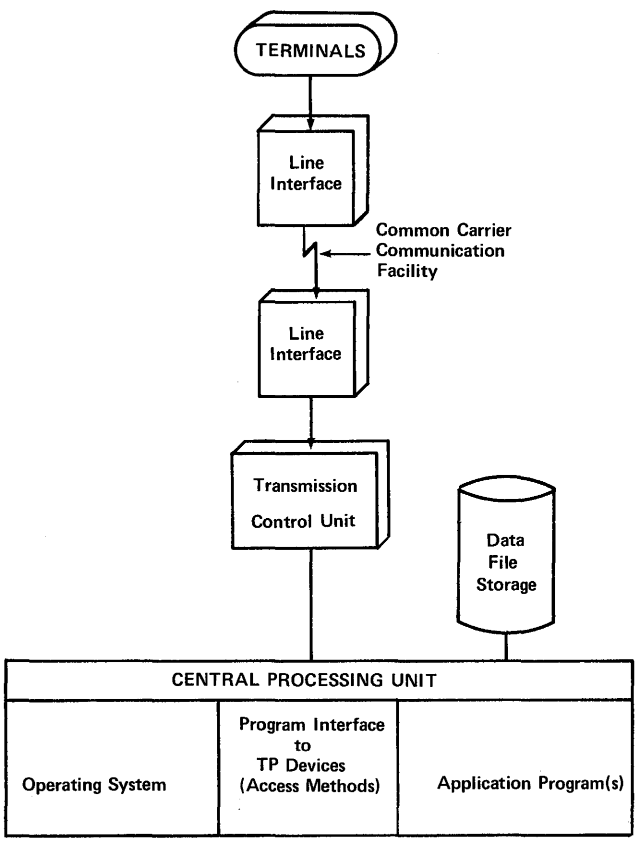

Figure 1. Relationship between terminal and other elements of a TP system.

The most meaningful approach to any study of the elements of a TP system is through an examination of the flow of information between these elements. The following section introduces the function of each of the basic elements of a TP system and establishes the relationship between them.

The flow of data in a TP system is initiated at a remote location from the central processing unit; data from this remote station is entered or received through a mechanical or electrical device called a terminal. One of the most familiar devices that can be used as a terminal is the common 12-key Touchtone* telephone, which provides both an input and output device capable of data transmission. Other common terminal types are the standard electric typewriter (incorporating the necessary communications interface, of course), and visual display devices, which employ a typewriter keyboard for input and a cathode ray screen (similar to a television screen) for input verification and output display. Figure 1 illustrates the relationship between the terminal and the other basic elements of a TP system and

*Trademark of Bell Telephone

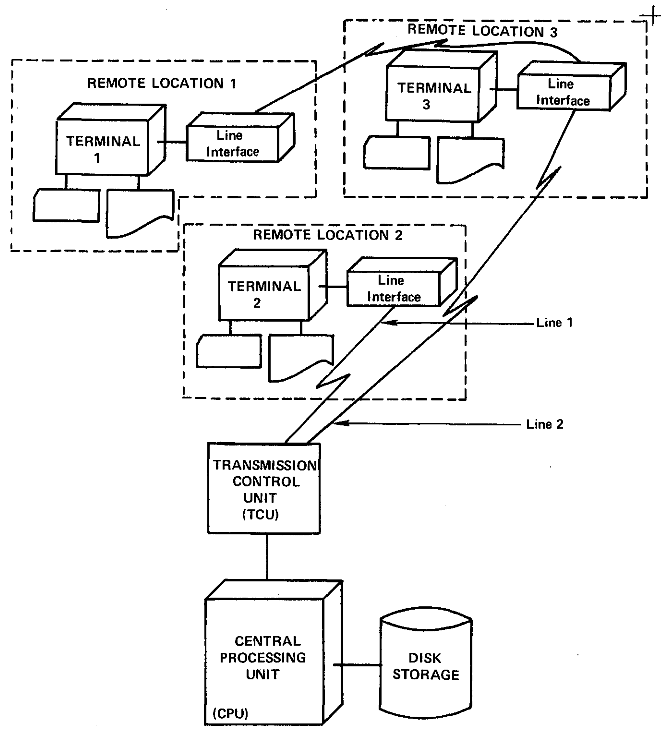

Figure 2. Example of a communication system and a teleprocessing system.

should provide a better understanding of the data flow. It is suggested that the reader examine this figure closely before proceeding to the next section.

The most basic definition of teleprocessing is data processing plus communications. Because this definition includes communication systems within the realm of teleprocessing, it becomes necessary to make some distinction between TP and the widely misused term "communication system".

A communication system is one in which a message is entered at one location and appears in exactly the same format at another location. Using the example in Figure 2, Terminal 1 can read in cards at remote location 1 and then, over a terminal-to-terminal communications facility, Terminal 3 can print the exact card formats in an 80/80 list at remote location 3. In other words, as a card is read in at Terminal 1, an exact copy is printed out at Terminal 3.

This type of terminal-to-terminal operation would normally be used to transmit source deck listings, for example, from one remote location to another. But what if remote location 1 wants to send computer assembled output listings to remote location 3? In this case, as cards are read in from Terminal 1, they are transmitted to the computer site itself via the TCU and stored temporarily on disk. The data processing system then executes the program to assemble the card-image disk records, and the results of the assembly are transmitted back over the communication line to remote location 3.

The object deck is punched at the punch station of Terminal 3, and the assembler listing is printed on the output printer.

This latter operation from Terminal 1 to CPU to Terminal 3 adds the processing power of the computer to the simple data movement within a communication system. The CPU can edit, audit, add to, delete, and modify the incoming data and/or examine centrally stored data files to prepare output information. This type of data manipulation performed at the CPU site is a function of the application program design and may vary for different users, input formats, or locations.

Business machines (terminals) are not normally designed to produce output signals that may be transmitted directly over common carrier communication facilities (see Glossary of Terms). Because the common carriers operate their facility to accommodate voice transmission, business machines cannot be directly attached to the common carrier facility without some type of interface. These interfaces handle the conversion of business machine signals into frequencies suitable for transmission.

The line interfaces are normally separate boxes, composed of electronic circuits that are attached to the communication line and the terminal. The interface units may be purchased from the common carrier or IBM. If the interface is obtained from IBM, the communication lines are usually privately owned or leased from the common carrier. Switched (dial-up) lines will normally use common carrier line interfaces. The terminal is attached to the communication line facility via this line interface (frequently referred to as a data set, modem, line adapter, subset or data phone).

The communications lines necessary to transmit and receive data signals are offered in many different grades and speeds. Communications lines and the differences between leased and switched facilities will be covered in detail in the section entitled "Communications Terms and Concepts".

Since data is transmitted from the remote site over communications lines using a voice frequency range, the information transmitted must be converted back into business machine output at the receiving CPU location. This final data conversion requires another line interface located at the CPU site because the data signals, once converted by the line interface, are still not in a format acceptable to the computer. This interface is called a transmission control unit (TCU) and is used to prepare transmitted data for acceptable input into main storage of the computer. The functions of transmission control units will be discussed in detail in the section entitled "Transmission Control Units".

The major internal structure of the CPU consists of many blocks of user written logic, called programs. The most important series of programs to assist the user in overall computer operations is called an operating system. The received data transmitted from the terminal is first handled by portions of the operating system and then passed to user's application programs. Application programs are designed and implemented by the user to perform the necessary processing required in handling everyday business functions.

To aid the application programs in obtaining data from remote terminals, a series of logic modules has been developed called "Access Methods". The access methods for TP provide an interface between the TCU and the user's application program(s). By utilizing these access methods, the user is able to devote his company's programming efforts more toward solving its business requirements because many of the detailed steps necessary in hardware interface and code conversions need not be a concern of the programmer. Access methods for TP will be covered in more detail under "TP System Design".

These then are the basic elements of a TP system as discussed above: terminal, line interface, common carrier communication facility, TCU, CPU, operating systems, application programs, and access methods.

The following section presents a brief discussion of user application programs and their function within a TP system.

APPLICATION AREAS -- A BRIEF OVERVIEW

Recent surveys of TP applications indicate that approximately seventy-five percent of all installed and on-order TP systems may be separated into the following three categories:

- Data Entry
- Inquiry
- Record Update

Data Entry

The results of these surveys point out that only a small cost of processing an entire segment of data is at the CPU site itself. The larger percentage of cost actually occurs in preparing the data for computer processing because of the necessary error checking and audit trails required as data moves through the various personnel and locations from initial data creation to a format acceptable for CPU processing. Consequently, one of the first areas addressed in TP applications was the entry techniques employed in preparing CPU input data, and the application area in TP that directly addresses this problem is data entry.

Data entry allows the terminal operator to enter new data from its original source directly into the CPU. This technique provides both the verification of data at the remote location prior to input and reductions in user-to-user transfer steps in data submission. The creation and maintenance of a usable, current and accessible data base is an essential part of a TP system, and although data entry is not necessarily the first application examined or installed on a TP system, it is easily the most desirable. This is simply because data entry is frequently used in building the central data base of information that will be accessed either centrally or remotely to produce useful company reports.

A data entry approach which has been designed to utilize effectively all remote input stations will greatly reduce the expense involved in maintaining and creating this data base.

Inquiry

Once the data has been assembled on a central data base, it may be examined by remote terminals through a technique called inquiry. Many users have rather limited requirements and may need to inquire only into data pertaining to their own departments. It is possible, also, to access files of other departments or corporate data contained on the central data base. TP systems may be designed to allow or deny access to entire files, records within files, or data fields within records to specific individuals and/or specific terminals only.

Record Update

TP inquiry capabilities alone do not allow remote stations to alter stored file data. They provide only for an examination of this data; however, if inquiry is to be beneficial or accurate, the data records must be kept current. The necessity of keeping data current requires TP techniques to permit record alterations; i.e., record update.

Several questions regarding data bank considerations and program design philosophies must be answered prior to the implementation of a record update application in a TP environment. What happens when a program or the hardware (the physical units of a computer system) fails? What happens to the data being received or transmitted when the communication facility fails? What can be done if incorrect fields or records are accidentally updated? Obviously, some system design techniques must be implemented to permit accurate audit trails and effective program check and balance routines. This is an entire science in TP system design, however, and will be addressed in the "TP System Design" discussion.

Other Application Areas

Data entry, inquiry and record update are the predominant applications used in the currently installed and on-order TP system. The scope of TP will probably extend into fast growing areas outside of these three categories in the future. It is impossible to predict what dynamic changes will occur in the spectrum of TP applications, but some very interesting areas have already been implemented and should be discussed.

Remote Job Entry

One fast growing TP application area is Remote Job Entry (RJE), which allows a remote location to utilize the processing powers of the central CPU. The CPU may be a large processor that services many smaller CPU's or non-intelligent remote devices (if the remote device does not possess processing capabilities, it is classified as a non-intelligent terminal). By utilizing a large CPU to service many remote devices, RJE extends the processing power of the large CPU to each remote user.

RJE may be subdivided into the following two categories:

- Remote batch processing
- Conversational RJE

With the remote batch processing facility of RJE, the user prepares all the required logic and/or data for a job or a series of jobs and then submits this entire batch via communications lines to the host system for processing. Conversational Remote Job Entry (CRJE) allows the user to enter his problems line-by-line from the remote device rather than in a batch as specified above. Once the problem is entered in its entirety, the central processor executes the job and displays the results back to the terminal.

RJE permits the data processing installation to concentrate its personnel talent and development efforts. This normally results in instilling unity among the remote user(s) and the central staff personnel.

Message Switching

Another fast expanding area in TP is message switching. Message switching provides the ability to send messages from one remote site to one or more different remote locations via the CPU but without any requirement for CPU processing.

Two major problems in message switching applications were encountered in early TP systems:

- Manual intervention required at the terminal
- Uneconomical data storage facilities at the CPU

The technique used for message switching at the initiating location was to key the message(s) on a typewriter and simultaneously produce a duplicate copy on a punched paper tape. The tape was used to store the message temporarily, in order to avoid domination of the communication line as the operator keyed the data. Once the tape was completed, it was removed from the paper tape punch and placed into a tape transmitter. This tape movement required an undesirable manual step and involved excessive tape handling.

Terminals have been designed in recent years to include the same entry "buffering" capabilities provided by the paper tape but without involving manual intervention. These terminals are understandably called buffered terminals. The buffer normally employed is a matrix of magnetic core that allows storage of various message lengths and effectively eliminates any manual handling of tape prior to transmission. Once the data is keyed into the magnetic core matrix, the operator may then request the data to be transmitted by depressing a key on the typewriter.

The computer installation itself presented another problem in message switching because the central site was handling large amounts of paper tape for incoming and outgoing messages.

As magnetic disk storage became more and more economical to store data, the paper tape was removed from the central location, thereby providing the same advantages at the central site as the terminals were given at the remote site. Today, high speed, large capacity, magnetic disk storage is available to make message switching a very desirable application for TP systems.

Time Sharing

A major area that is making a strong move to become a leading TP application area is time-sharing. Time sharing can be defined as the servicing of many terminals concurrently from a central system, by allocating each terminal only a portion of the total available system time.

This definition can be better visualized by assuming, for purpose of illustration, that each terminal output message is one minute. As this message is being output at one terminal, the system may begin additional transmission to other terminals. The original terminal serviced will be given additional processing capabilities at the lapse of the one minute time slice. The actual internal speed of computers is measured in millionths of seconds. Within the assumed one minute time slice, therefore, many terminals could be provided service of input and output data. By allocating the computer resources in this way, the central processor is said to be operating in a time sliced mode. Most systems used in this manner allow only a few seconds per time slice rather than the one minute in our example.

Application Area Summary

To summarize, below are listed the categories of TP applications discussed so far:

Data Entry	Entry of data from a remote location into a central processor via a communication link
Inquiry	Examination of centrally stored data via a communication link from a remote site
Record Update	Alteration, deletion, or addition of data contained on existing data files and stored at the CPU site via a communication link from a remote location
Remote Job Entry	Entry of logic functions from a remote site to be executed at the central CPU location via a communication link
Message Switching	Ability to relay a message from one remote location to one or more additional remote location(s) via a CPU and a series of communication links
Time Sharing	The allocation of central processor computing resources to many different remote locations, so that each appears to have exclusive use of computer resources

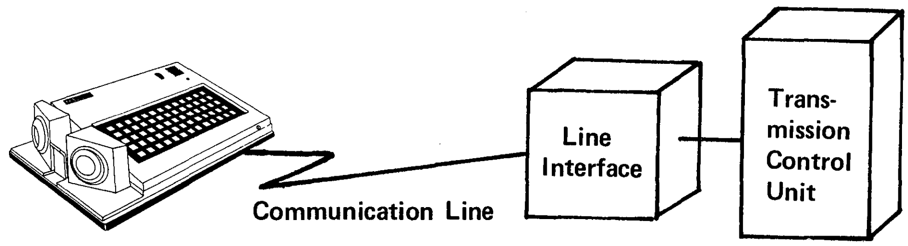

Figure 3. Major elements in the information flow of a TP system.

TP INFORMATION FLOW

Figure 3 illustrates the first three major elements to be covered in the information flow of a TP system: the terminal, the line interfaces (data sets) and the TCU. In this example, the IBM 2721 Portable Audio Terminal is the terminal specified.

Line Interface

Terminals and communication lines differ greatly with regard to their structural design. Communication lines are designed to operate with voice frequencies. Terminals, on the other hand, are designed to produce a direct current signal. This inherent difference between terminals and communication lines naturally restricts the terminal from transmitting its output directly over communication lines without some kind of signal conversion. This signal conversion from terminal-to-line, and line-to-terminal as well, is accomplished via the line interface.

Line interfaces, or data sets, are provided by the common carrier on a monthly-charge basis and are offered to the user in several grades of service, each of which can accommodate different speeds of data transmission. Examples of the grades of service available are voice, sub-voice, and broadband or micro wave. The common telephone operates on a voice grade facility, which is capable of transmitting message data as well as speech. For slower devices, sub-voice grade service would be used (see Glossary of Terms), and for higher speed devices, broadband facilities would be used. Broadband is a tariff offering which allows a wide frequency spectrum for high speed data transmission and can be visualized as a combination of several voice grade channels.

For in-house operations, the user may elect not to use the common carrier facilities available. He may install his own private communication lines and attach the terminals via an IBM line adapter or private vendor adapters.

Transmission Control Unit

The flow of voiced information over the line in a telephone conversation is very similar to the flow of data over communication lines in a TP environment. Certain functions must be performed for the parties at either end of each system to be able to understand each other, whether it be a standard telephone conversation involving just two people, or a TP system with a CPU and remote terminals. These functions are performed by the transmission control unit (TCU) in a teleprocessing system and the following analogy between a telephone conversation and a TP system is designed to emphasize these TCU functions in relationship to the entire system.

In a typical telephone conversation, one party (Mr. A) would first dial the desired telephone number, which would be routed through the various telephone companies' switching stations to the other party's (Mr. B) location. The first thing Mr. B must do is to recognize the ringing of his telephone. The TCU must also perform this function of recognizing a request to communicate. Next, Mr. B would perform the mechanical function of picking up the receiver. Similarly, the TCU must establish the connection.

Mr. B's next step is to determine who is calling. He says, "Hello". Mr. A then identifies himself by saying, "Hello", this is Mr. A". The TCU likewise must identify the calling terminal and ensure that the correct terminal is using the correct communication line. If Mr. B does not recognize Mr. A, he will most likely say, "Sorry, wrong number", and hang up. On the other hand, if he does recognize Mr. A, he will acknowledge him and ask him to proceed. Similarly, the TCU will await a message from the terminal.

When Mr. A is ready to talk, he might say, "How are you, Mr. B?" Suppose that Mr. B was only able to distinguish part of Mr. A's sentence. He would immediately detect an error and ask him to repeat it. The TCU must also recognize that the data transmitted from a remote device is received in the same image as it was transmitted. If the data is not received in the same image, an error condition must be acknowledged and passed to a program for necessary retransmission or correction.

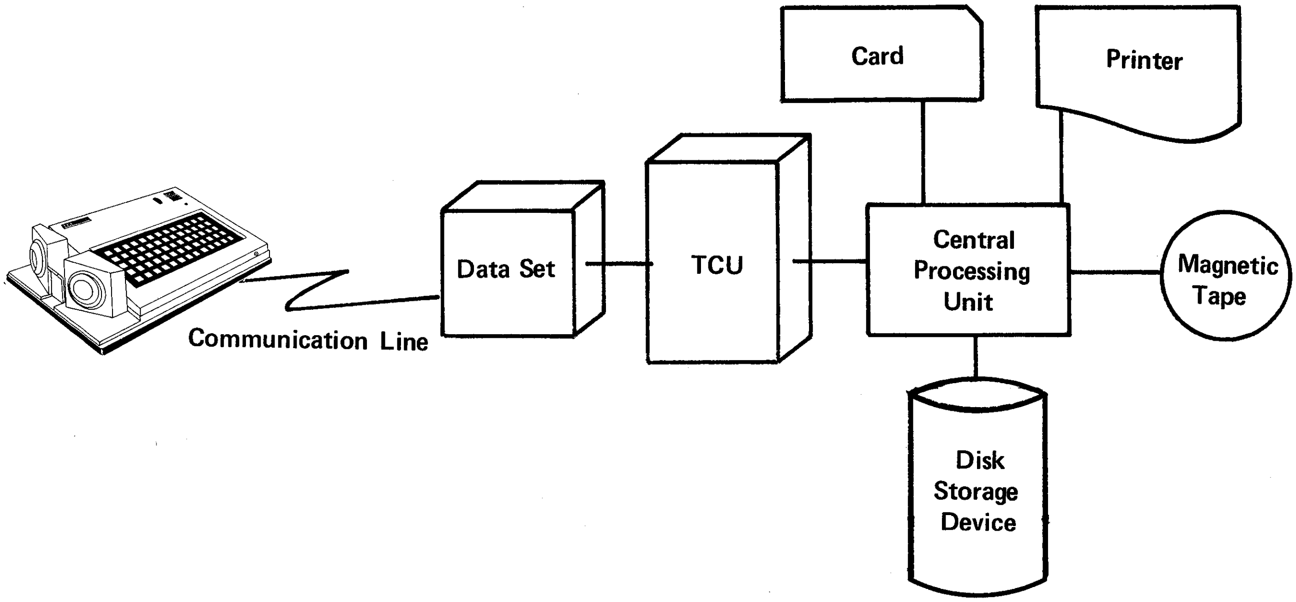

Figure 4. Expansion of Figure 3 to include elements of the central processor

Now that the necessary components to transmit data from the terminal to the TCU (i.e., the terminal, line interface, TCU) have been introduced, processing logic can be added to the data received at the CPU. Figure 4 expands Figure 3 to include the elements of the central processor.

The central processor must contain the necessary application programs to process the data received from the terminal(s), and it must be able to access various peripheral devices. The common data processing "hardware" elements at the CPU would be a card reader, printer, magnetic tape, and magnetic disk. Multiples of one or more of these devices will appear on many data processing systems.

The card reader/punch provides the central processor with the capability of punched card entry or punched card output.

The printer provides output printed data, at high speeds, from the processing programs. Printers at the central site are typically of the 1100 line per minute output speed and can print up to 132 characters per line. This permits data to be printed at approximately eleven pages each minute, with multiple copies available if desired.

The magnetic tape unit(s) provide mass data storage for the central site. Magnetic tape units, however, do not possess the necessary characteristics for data base storage in a TP environment because of their sequential access requirement. TP requires rapid access and fast response to file update or examination of stored data and would require excessive tape movement if tapes were used for data files.

It is not difficult to imagine the amount of movement and the time required if 100 users all requested different information at the same time from the same tape file. It would be quite a bit like 100 persons simultaneously requesting 100 different songs from the same stereo tape mounted on one tape player.

Magnetic disk storage is an essential element of all TP systems. These units are a series of magnetic disk surfaces, stacked about one inch apart, one on top of the other. The access to data is made by a series of read/write heads that move in and out between these surfaces. This movement is very rapid, allowing direct access to the data stored on one or more surfaces.

A typical disk unit (IBM 2314) can store 29.18 million characters of data, or approximately 24,000 pages. There is also a wide range of speeds and storage capacities available in magnetic disk storage to match the requirements of the installation.

Magnetic drums can be used equally well as magnetic disk for TP systems, although the magnetic drum provides generally less storage capacity. Magnetic drums do provide immediate access to all data stored because there is no mechanical movement of the read/write heads to obtain the data.

Sample Inquiry

Assume that a user wishes to make a remote telephone inquiry against an accounts receivable file stored on a disk volume. He would first dial the CPU on the telephone and enter a request for, say, the current balance information for customer number 44050. The audio response output data would be issued in voice answer-back and could have been initiated either by an IBM 7770 or IBM 7772 Audio Response Unit.

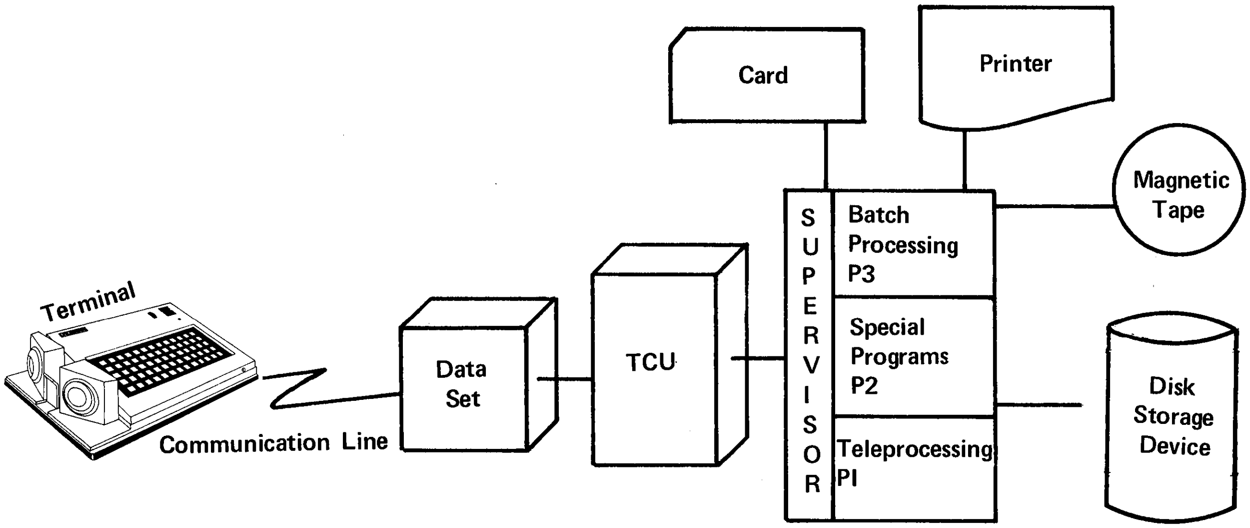

Figure 5. The processor divided into three partitions

Suppose that the unit chosen was the IBM 7770. This is a TCU which can operate with up to 48 communications lines, all transmitting and receiving data simultaneously. If 47 different individuals are simultaneously utilizing the A/R inquiry application, it is possible that they could be obtaining A/R status for 47 different customers. What would happen, however, if the 48th user to dial the CPU requested the year-to-date sales analysis information from the system. The only currently active TP application is the A/R inquiry. How can this sales analysis request be serviced?

It is feasible to telephone the requestor and ask that he redial the system later in the day, after the sales analysis application for TP inquiry has been activated. Another possibility is to disconnect the other 47 users and allow the requestor exclusive access to the computer. Either decision would result in a less than desirable attitude toward the system. This is one of the first problems that designers of TP systems have to face: how to control requests for multiple applications. In our example, the designers should plan for the possibility of 48 different requests from 48 different individuals, all of whom are capable of communication with the system.

Even more challenges must be met for systems which must support different types of terminals along with different types of applications. Most TP installations will find it advantageous to have several different on-line terminal types to solve the many different application requirements because terminals have been designed to satisfy a rather wide range of functions and capabilities. There is one consideration even more critical that must be examined before approaching a solution to the multiple application/multiple terminal design problem. Even with the 48 lines available in the above example, there will be a time when only one terminal is transmitting or receiving data. If this occurs on an intermediate size IBM System/360, approximately 30,000 instructions can be executed during each half second (also the time to audio-output one word). This implies that the system may be wasting the computer power of 30,000 instructions if the only job currently executing is the TP application. This idle computer power should be directed toward processing other operations not associated with TP through programming techniques called multiprogramming.

Multiprogramming permits the user to subdivide his available computer core storage into a series of areas called partitions. Each partition can operate an independent job or function without concern for the functions being performed in other partitions since the partitions are assigned certain system priorities. The partition assigned the highest priority (usually TP) will be given first use of the entire computer processing power. The partition assigned the next priority will be given second use of the system, and so on. This allocation of CPU resources, called task scheduling, is handled in a purely sequential order. The processors of today are very fast and this sequential processing occurs so rapidly that each partition seems to operate as a separate processor to the user.

Figure 5 illustrates the processor divided into three partitions. These partitions could be labeled P1, P2, and P3. P1 will represent the partition with the highest priority, P2 the next priority, and P3 the lowest priority. The supervisor (the control module) is shown spanning across all three partitions. The supervisor is responsible for the processor time allocated to each of these partitions and also handles many other functions for the system, such as:

- Job scheduling
- Physical handling of input and output data
- Error recovery routines
- Open and close routines (establishing contact and releasing contact for programs and physical device)
- Task scheduling (internal processing allocations)
- Initial program loading (system initial setup)
- Operator communication (messages between system and operator)
- Program termination
- Tables describing the system configuration and operational status

These functions play an important part in the total operation of a TP system because many functions handled by the supervisor would otherwise have to be programmed repeatedly by the user in each application program.

The following discussion examines the partition operation possible in the system described in Figure 5:

The batch area (P3) normally handles jobs that require execution in a job stream, for example, payroll, accounts receivable, stock status, etc., and certain input/output devices must be available to supply the requested data to the applications for processing. This batch area is not required for TP operations, but it does provide batch processing capabilities along with the TP operations for better system utilization.

The second partition (P2) is most frequently used to provide processing of special applications like stockholders' listings, high speed TP processing, or TP application test programs to be handled without interference from P3 or P1. If the user only utilized two partitions, he may find himself waiting upon the completion of all batch processing in P3 or having to cancel the P1 (TP) area.

The TP partition, however, should not be suspended to allow processing of any special jobs. The user must spend a considerable amount of time and money in establishing a usable data bank and keeping this data current. If the user cut all communications lines leading into his TP system, the data base would become virtually useless in a very short period of time.

The quickest way to simulate the cutting of the communications lines is to make the terminal operations difficult and unreliable. The terminal operator is the keystone of any successful TP system. Every effort should be made to make the terminal operations easy to learn, easy to use, and easy to correct. This is one very important, but often forgotten, reason why the TP partition must always remain active.

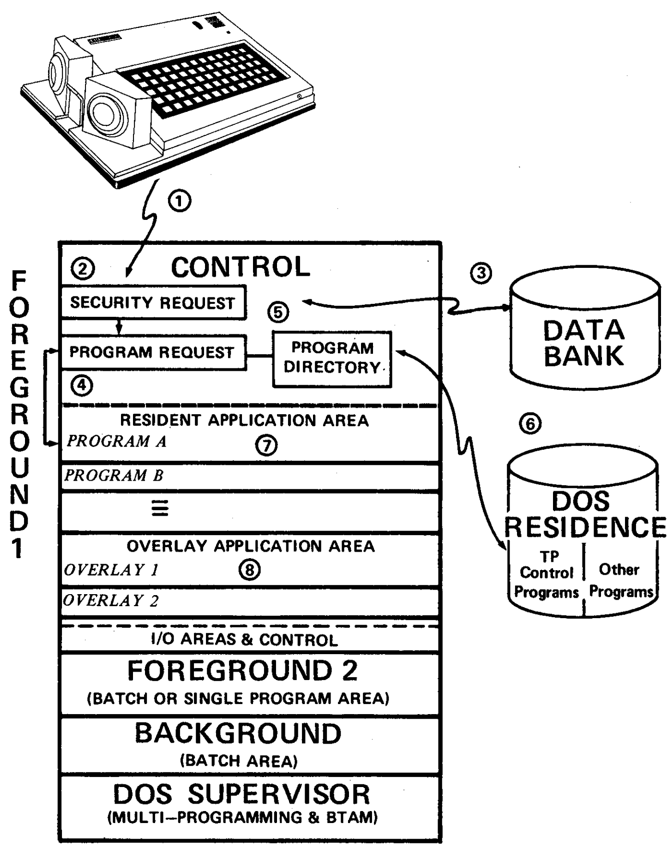

Figure 6. Breakdown of a TP partition

TP Control Program Design

Figure 6 illustrates the breakdown of a TP partition designed to satisfy the requirements for multiple terminals and multiple applications to be operating concurrently.

The following example is a step-by-step examination of the information flow from a remote terminal to the CPU in a multiple terminal/multiple application TP system. These steps are numbered on Figure 6 to correspond to the outline below:

(1) The remote user would first dial the CPU from the terminal via the communications line, appropriate line interfaces, and TCU. The function of the TCU is to place the data byte-by-byte (character-by-character) into main storage; when the entire record has been entered from the remote terminal, the TCU will alert the processor to begin processing of the entered data.

(2) The area that is alerted by the TCU is called the control area for all TP devices. The first processing by the control area is to request user identification, which could be in the form of a security code or other ID number. The user then enters his valid security information.

(3) The control area then decodes this information and retrieves a valid security list from the data bank. If the information entered is not valid, the user will be informed to re-enter a security code. If the code entered is valid, the user will be asked to identify his application or program request, which identifies the function to be performed. Let us say, for example, that the user wishes to make the previously described inquiry against accounts receivable data for customer number 44050. Each application on the system, including the A/R inquiry program, could be identifiable by a particular application code, which must be entered by the user in order to access it.

(4) The remote user now enters the program request code for the desired application. If this code is not found, the user will be instructed to enter a correct request. Once the user enters a valid program code, the system determines the program location.

(5) The program directory directs the terminal to the appropriate program. Each program contained in the system requires a certain amount of core storage and because computers are designed with a fixed amount of core storage (for example, 128,000 storage positions), an excessive amount of core storage could be required for the incorporation of all TP programs used.

One way to limit the core storage is to provide overlay areas. Program directories are somewhat like a table of contents for a book. The table of contents directs you to the appropriate page for a particular subject if it is in the current volume; if the subject is not available in the current volume, a reference is normally included to direct you to another volume. The program directory points to the resident application program area for the currently referenced volume; it points to the overlay application program area for the volume not currently in the system.

(6) If, for example, the A/R program is requested, and is not found in the resident area, the program directory searches a disk volume to locate the requested program. If the program is found, the directory instructs the system to place a copy of this program into one of the overlay areas. The input is then directed to this area by the control program. Any program that is placed into an overlay area eventually requests some form of input and/or output. This input and/or output operation always requires a significant amount of time to perform, relative to the internal processing speed of the computer. While this input/output is occurring, another program may replace the A/R program in this same overlay area. When the A/R program is ready for additional processing, the A/R application is again loaded into the overlay area from magnetic disk. Using a technique similar to this, an unlimited number of programs may be made active in the TP area upon request. This in effect provides several additional partitions to the system previously described.

(7) Once the control area directs the input to the appropriate processing application, the application then handles all processing of the actual input and output data.

The above example is only one of many system design approaches which could be used to solve the multiple application/multiple terminals requirements of a TP system. There are several advantages in using this approach. First, the control area may be written to support the entire line of terminals offered by IBM, and it need only be developed and programmed once to handle all of these terminals. The control program is used to accept requests from the application programs and interface with one of the IBM-supplied TP access methods in order to handle TP input/output, analyze errors, and provide necessary error recovery, etc. Not only can the control program handle the interface function, but it can also perform other functions, such as the security and program directory activity previously described. The application programs, utilizing the functions provided by the control program, can also be coded with little concern for the specific terminal types. For example, an application would have to be coded somewhat differently for audio output than for typewriter output because an audio TCU cannot talk to a typewriter. Other devices, however (for example, the visual display and the typewriter), do have similar functional capabilities. Both devices have a keyboard and a line-by-line output device. Therefore, a single application program could be written to communicate, via the control program, to either or both of these terminals, simultaneously or separately.

This is not necessarily a recommended system design for every TP system, because there is no facility for message switching or I/O queuing of incoming messages. This system design would apply to a data entry, inquiry, and record update oriented TP system.

The important thing at this point is the overall system flow and design considerations in handling many applications and many terminals through the subdivision of one partition into many smaller areas, all related to TP. The control program may also be designed to allocate small time blocks to each application, and control these time blocks to restrict extensive usage by any single application. In short, no program should be allowed to dominate the computing system in the TP partition.

Terminal Considerations in Information Flow

The last character of a message to be entered by an operator from a remote terminal is a special end-of-message indicator or key. The transmission control unit recognizes this character as the end of input from the terminal and alerts the processor. The application program is then informed that all of the message has been placed in core storage and processing begins. This same logic applies to output data, except that the control program places the end-of-message indicator in the outgoing message. After processing is initiated, a message from another terminal can be accepted by the TCU, and the cycle is started all over again.

In the case where two typewriter oriented terminals are prepared to transmit a message at the same time, problems arise if both terminals are installed on the same communications line. Only one of these typewriter terminals can transmit data over the communications line at a time so that one of the two must wait for the use of the line. The same is true of output data. Typewriter output speed is approximately 148 words per minute, and if one terminal were to receive a particularly lengthy message, the other terminal could be kept waiting.

There are two solutions to the above dilemma. One is to attach each terminal to the processor on a separate communications line. This could become a rather expensive proposition, however, if the terminals are located long distances from the CPU, even though it would definitely provide a solution to the operator-communication line contention problem.

Another method used to solve this problem is to use buffered terminals with magnetic core, magnetic tape or magnetic disk. These buffers allow the operators to record data off-line into the buffers and when the message is complete, the operator requests transmission. The transmission and receipt of data back to the terminal is at a higher speed than without buffering and the communications line is only tied up during the data transmission, not while the operator keys or prints the data.

This section has addressed the TCU's and terminals in a general fashion. The next section will address the most common TCU's and terminals available in the standard IBM product line. Any or all of these TCU's and terminals could be interfaced to the control program design described in this section. The user should examine the functional ability of each terminal discussed to determine which terminal(s) best suits his application requirements.

INTRODUCTION

The first teleprocessing systems designed were specialized systems created to satisfy specific communications-oriented requirements. Today's teleprocessing systems ideally must operate in many diverse environments: they must be capable of supporting both batch processing and teleprocessing applications, and they must be able to communicate with various types of terminals.

There are actually two major differences between TP systems and the more familiar batch data processing systems. Input is scheduled in batch processing, but it is not scheduled in teleprocessing. In addition, batch processing is ordinarily sequential, while teleprocessing is random. Consequently, in order to develop a general-purpose system, it becomes necessary to service the unscheduled and random nature of the TP environment in a system in conjunction with batch processing.

Transmission control units (TCU) are the devices which were developed to make this merger of teleprocessing into the standard data processing system both possible and practical.

FUNCTIONS OF THE TCU

Just as the standard peripheral devices (for example, card read/punch or high-speed printer) require a control unit to interface to the computing system, devices that transmit over communications lines require a TCU to provide a similar system interface and to control the multiple inputs arriving in an unscheduled fashion from the remote terminals. The main functions of the TCU are as follows:

- Assembly: Characters are normally transmitted to a TCU from the remote devices serially by bit. That is, several segments of a character are transmitted down the line very much as dots and dashes are transmitted in a Morse Code character. These bits must be assembled into one character before the computer can recognize their existence.

- Checking: As a complete message is transmitted to, or from, the computer, a checking character is generated by the transmitting device. Next, as the message is received, the terminal or TCU in turn generates a character based on the message content. Finally, the last character transmitted from the terminal (the checking character) is compared with the centrally generated character; and a response is returned to the terminal indicating that either the message was correct or in error. See the topic "Error Detection" for a more detailed discussion of error checking.

- Inserting and Stripping: Terminals attached to a TCU have unique coding structures and control characters which are completely divorced from the actual message content, or text. They have no value from the standpoint of the application being processed, and, consequently, are stripped off on incoming data and inserted for outgoing data at the TCU. This function of the transmission control unit prevents the central processor from being tied up by such an operation.

- Buffering: Once a full character has been assembled by the TCU, it must be stored temporarily to prevent the next character(s) immediately following from being lost. It is possible, of course, for a program to gain control and issue instructions to bring a single character at a time into main storage. This technique, however, requires repetitive programming on the part of the programmer, additional core storage for the instructions, interruption of the computer's processing, and time to transfer each character to main storage. Clearly, this is poor utilization of computer time, valuable core storage, and programming effort.

  With System/360-370, this is accomplished by hardware. After assembly and stripping, a character is held in a line buffer of the TCU until the processor signals that it is free to receive the character into main storage. This method of transferring characters is known as cycle stealing or interleaving of processor time with the transfer of characters. The processor controls the buffer, making maximum use of the processor time and taking full advantage of the system's processing resources. Cycle stealing does not interfere with the program operation and, therefore, provides for much better utilization of the central processor power.

The actual capabilities of the specific transmission units in relation to line speeds, line availability, and terminal support are discussed in the section entitled TRANSMISSION CONTROL UNITS. The following section addresses the functions and capabilities of the various TP terminals.

TELEPROCESSING TERMINALS

The concept of a terminal as presented in ELEMENTS OF A TP SYSTEM builds the terminal within the framework of a computer system, with particular emphasis upon the relationship between the terminal, TCU and central processor. This section removes the terminal from this basic context of TP systems flow to examine the functions and capabilities of many typical IBM terminals both by class and by terminal type.

Terminal Classes

The diversification and expansion of today's industries and businesses have generated requirements for so many different TP applications that it is unreasonable to expect any one terminal to satisfy all of them. On the other hand, many terminals do have inherent similarities in design, and they may be classified accordingly:

- By application
- By purpose

These classifications are by no means exhaustive and, in fact, involve some overlap from one to the other out of necessity. They do provide, however, an effective structure by which to examine the terminal functions and capabilities available.

Applications-Oriented Terminals

- Transaction (conversational) Terminals: Transaction terminals are characterized by the transmission of a single transaction: data entered from the terminal elicits a one-time response from the computer to complete the transaction. For each set of input data received from the terminal, an acknowledgement or guidance response is issued by the system to the terminal. The user is for all practical purposes in a "conversational" mode with the central processor.

- Batch Terminals: Batch terminals are characterized by the transmission of a group, or batch, of transactions, rather than one transmission at a time as with transaction terminals. In actual practice, the data is frequently transmitted on a scheduled basis; for example, a record of the shipments made from a factory in a single day could be reported in one batch transmission to the company headquarters upon completion of the daily activities.

- Retrieval Terminals: Retrieval terminals provide the ability to inquire into certain data files and to receive current status information of this data in response.

Examples of other application-oriented terminals are those used for the specific support of dedicated programming systems as time-sharing, computer-assisted instruction, administrative correspondence, and problem-solving.

Special Purpose Terminals

Special purpose terminals are quite similar in approach to the application-oriented terminals, because both types relate to the job to be done. The special purpose terminals involve a somewhat different perspective; they are industry-oriented rather than application-oriented. The terminal units used in the airlines or motel reservation systems are excellent examples of special purpose terminals; and industry-oriented devices have also been developed for financial and banking as well as scientific and administrative terminal systems. The section entitled CUSTOM SYSTEMS examines special purpose devices in greater detail and presents some of the custom terminals developed for particular industries or individual customers.

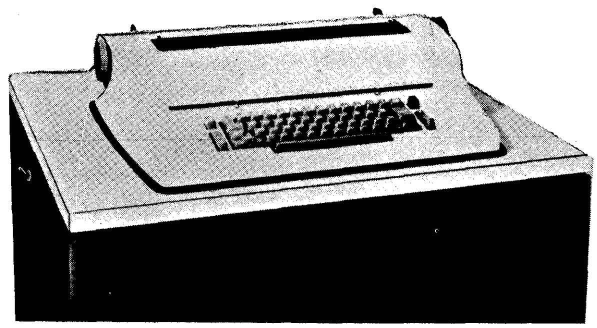

Figure 7. IBM 2741 Communication Terminal

IBM Terminals

2741 Communication Terminal

The IBM 2741 Communication Terminal (Figure 7) is a modified SELECTRIC® typewriter provided with electronic controls that enable it to operate as a remote conversational terminal, thus permitting direct access to the computer system. When it is not being used for communication, the 2741 may be used for normal office typewriting.

The features available on the 2741 Communication Terminal are as follows:

- Familiar, conventional keyboard and SELECTRIC printing element

- Output typing rate of approximately 148 words per minute

- 13-inch printing line; 10 or 12 characters per inch

The 2741 has only one control key and one switch. Therefore from the operator's viewpoint, it is identical to the standard SELECTRIC typewriter in all other respects and requires a minimum of operator training.

Intended primarily for text processing and scientific applications, the 2741 Communication Terminal permits users at remote locations to use the problem solving capability of System/360 on a time-sharing basis.

Some of the application areas for the 2741 are:

- On-line scientific computation
- On-line computer programming
- Text processing (technical writing, proposal writing, text editing)
- Information retrieval
- Procedure documentation
- Maintenance of price lists, sales catalogs, cost tables, budgets
- Preparation of contracts and other legal documents

One central processing unit can service many 2741's; however, 2741's cannot communicate directly with each other and only one 2741 terminal can be attached to a single communications line. The computer services one terminal at a time, and each terminal controls the computer intermittently. The computer can service many terminals and perform the requested processing without any noticeable delay at any terminal. In effect, each terminal user is able to feel as though he has full-time control of the computer.

2740 Communication Terminal

The 2740 Communication Terminal (Figure 8) combines the typing advantages and ease of use of the standard IBM SELECTRIC typewriter with the flexibility and speed of a printer-keyboard communications terminal. The 2740 can function alternately as:

- A document writing device in a normal typing operation ("off-line" or "local" mode)
- A data sending and receiving device over communications lines to another 2740 terminal or to a computer ("on-line" or "communicate" mode)

The keyboard design and basic features of the conventional office typewriter are retained in the 2740 so that the terminal can be operated by any typist with a minimum of additional training.

The 2740 is available in two models: 2740 Model 1 and 2740 Model 2. The Model 1 is equipped with a keyboard printer to provide on-line transmission from one 2740 to another, or directly to a central computer system. The Model 2 incorporates a core buffer feature to allow for off-line entry of data or information which can be edited and modified in this off-line mode. When the complete message has been verified, it can then be transmitted from the core buffer to the central system for processing.

Figure 8. IBM 2740 Communication Terminal

The 2740 Model 1 provides the following features:

- Typewriter keyboard input.
- SELECTRIC printer output.
- Ability to print each character on the SELECTRIC printer unit as it is keyed and as it is transmitted to another terminal or to the central system.
- Response speed from the system of approximately 15 characters per second (the typing speed of the SELECTRIC type element).
- 13-inch writing line (130 characters per line) for great versatility in the design of documents or forms.

The 2740 Model 1 is a versatile device and it is well suited to the requirements of a business which generates a substantial amount of correspondence. Internal communication between company departments can be expedited and an effective two-way communication between executive offices and sales or manufacturing locations can be maintained easily using the Model 1. It also provides remote inquiry capabilities (e.g., stock and customer sales status) with hard copy for both input and output, thereby documenting all activities from the terminal involved. In addition, 2740's could be installed in the purchasing departments of major customers as a sales aid for the company's administration and to expedite the processing of customer orders.

The 2740 Model 2 provides maximum efficiency in the use of the communications line because of the off-line keying of information into the magnetic core buffer. Each character is transmitted as it is keyed on the 2740 Model 1; whereas, the Model 2 stores each character in the buffer until the message is complete. Then, and only then, would the communications line be used to transmit the message to the central system. The return system response is transmitted directly to the SELECTRIC printer.

The following features are available on the 2740 Model 2:

- Typewriter keyboard input into a magnetic core buffer for off-line preparation of entry data.
- SELECTRIC printer output.
- Three core buffer sizes: 120, 248, or 440 characters. The size of the buffer selected would depend upon the normal message lengths encountered in the particular application used and, where longer messages would occur, multiple buffer loads could be utilized.
- On-line transmission rates up to approximately 67 characters per second, 105 characters per second with a special feature.
- Off-line printing of the contents of the buffer at 15 characters per second (speed of the SELECTRIC type element). The buffer contents can be "dumped" to the printer prior to transmission for verificiation purposes; or, if a special feature is available, the system response can be transmitted to the buffer before it is directed to the output printer.

Application areas for both models of the 2740 are quite similar; however, the 2740 Model 2 provides the ability for several terminals to share one communications line and yet operate at full line speed. The operator enters data into the buffer in an off-line operation, thereby making the communications line available for the transmission of data by other terminals on the same line. With the 2740 Model 1, or other unbuffered devices, the communications line cannot be shared with other terminals while the operator is keying data. Therefore, the use of several 2740 Model 2's on the same line can reduce line costs significantly.

The buffer storage on the Model 2 provides for improved operation through:

- Faster transmission to and from the central system (increased line speeds)
- Visual verification before transmission (the buffer may be printed out for verification purposes prior to actual transmission)
- Easier correction of keyed errors (errors may be backspaced over and rekeyed while in the buffer and before transmission)

This storage makes the Model 2 particularly well suited for remote inquiry, update, and reply operations including: payment entry, journal entry, administrative messages, file updating, and record renewal.

Figures 7 and 8 show that the 2740 and 2741 are quite similar in appearance. Both terminal types are equipped with a standard SELECTRIC typewriter keyboard and printer to operate on-line with a computer system and off-line in a normal office typing environment.

They do differ, however, in function and application usage as outlined below:

- Only one 2741 may be attached to a communications line, whereas many 2740's may share the same line for processing and transmission.
- It is possible for 2740's to communicate directly with each other in a two-way environment without using the resources of the central system for processing or transmission. This local message switching facility is not available with 2741's.
- 2741's are not equipped with the terminal error checking capabilities available with the 2740. The 2741 is primarily a text and information processing machine, whereas the 2740 is used for those applications which require validity checks to be made on the data that is transmitted and received.

Consult the IBM 2740/2741 Operator's Guide (Form GA27-3001) for a more detailed description of the functions and capabilities of the two terminals.

2760 Optical Image Unit

The IBM 2760 Optical Image Unit (Figure 9) is designed to provide a new approach in the entry of data to a central computing system from a remote location. Data that relates to the application being processed is projected from a 16 mm filmstrip onto the 2760 viewing screen and by touching the sense probe to the segment of the

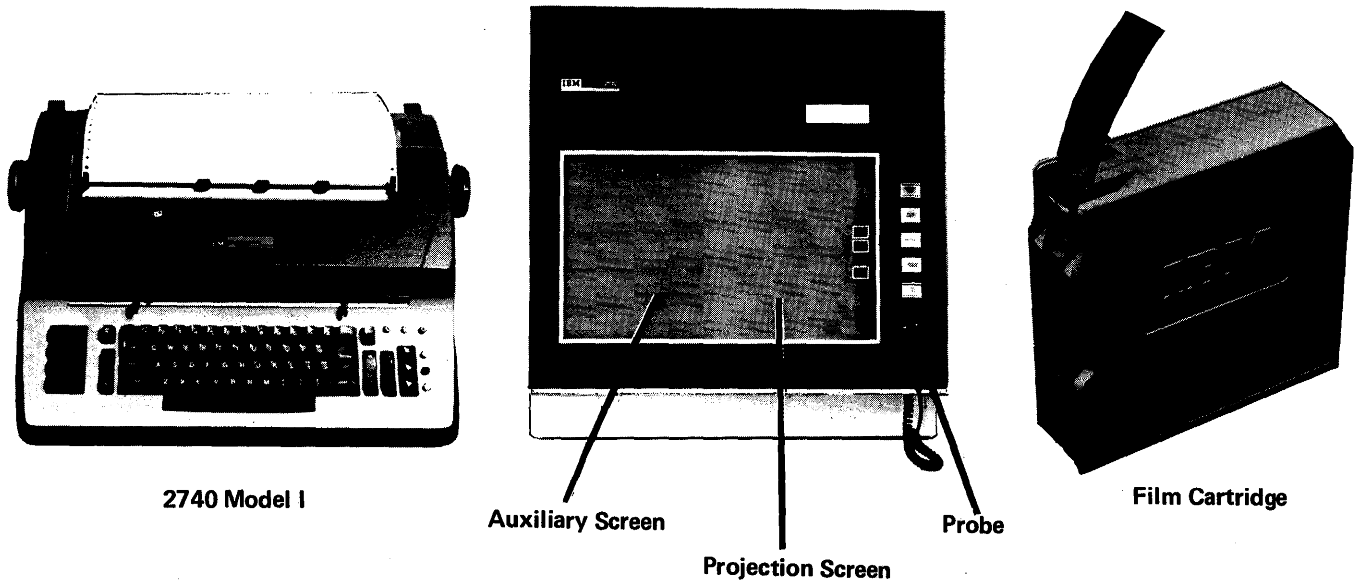

Figure 9. Components of IBM 2760 Optical Image Unit

screen where pertinent information appears, the selected data will be transmitted to the computer.

The integral elements of the 2760 Optical Image System are as follows:

- Viewing screen
- Radio frequency probe for identifying particular responses
- 2740 Model 1 Communication Terminal to provide additional input flexibility to the central system and hard copy printed response when required

The viewing screen of the 2760 is divided into two sections (the projection screen and the auxiliary screen) and provides 240 response points for the selection of displayed data. The data displayed on the auxiliary screen (or the left side of the viewing screen) identifies relatively permanent information that is constant for a particular application or job. It is used with application-oriented overlays that may be easily changed to provide the desired flexibility.

The data designated to appear on the projection screen (or the right side of the viewing screen) is rear-projected from 16 mm filmstrips contained in individual cartridges. The terminal operator inserts the appropriate cartridge into the 2760 according to the application to be processed. Filmstrips can be in either black and white or color, and may contain up to 128 frames or images. They are individually indexed so that they may be displayed on the projection screen in any order which is logical to assist the operator.

Specific responses from either the auxiliary screen or projection screen may be selected by the terminal operator simply by touching the appropriate response with the radio frequency probe. Each response point probed creates a transmission of a pair of display image coordinates which can be interpreted by the application program as a single or multi-digit number, a word, a phrase, a sentence, a name, or other meaningful information. The program's interpretation of the probe may then direct the next image to be displayed or, possibly, direct output messages to the associated 2740.

Terminal output is in the form of images selected for display on the projection screen, or hard copy printed output created by the 2740 Communication Terminal. When the 2760 is not being used for data entry, the 2740 can be operated separately as an inquiry terminal, a communicating terminal, or a standard SELECTRIC typewriter.

A significant feature of the 2760 Optical Image Unit is simplicity of operation, since no formal training is required to use it productively. The operator needs only to recognize words, phrases, or sentences in his own language or any nomenclature relevant to the work being processed. The filmstrip may be written in English, or any other language as desired, and data shown on the viewing screen can be set up to include pictures or diagrams of pertinent objects as well as written instructions to lead the operator through an application in a logical manner.

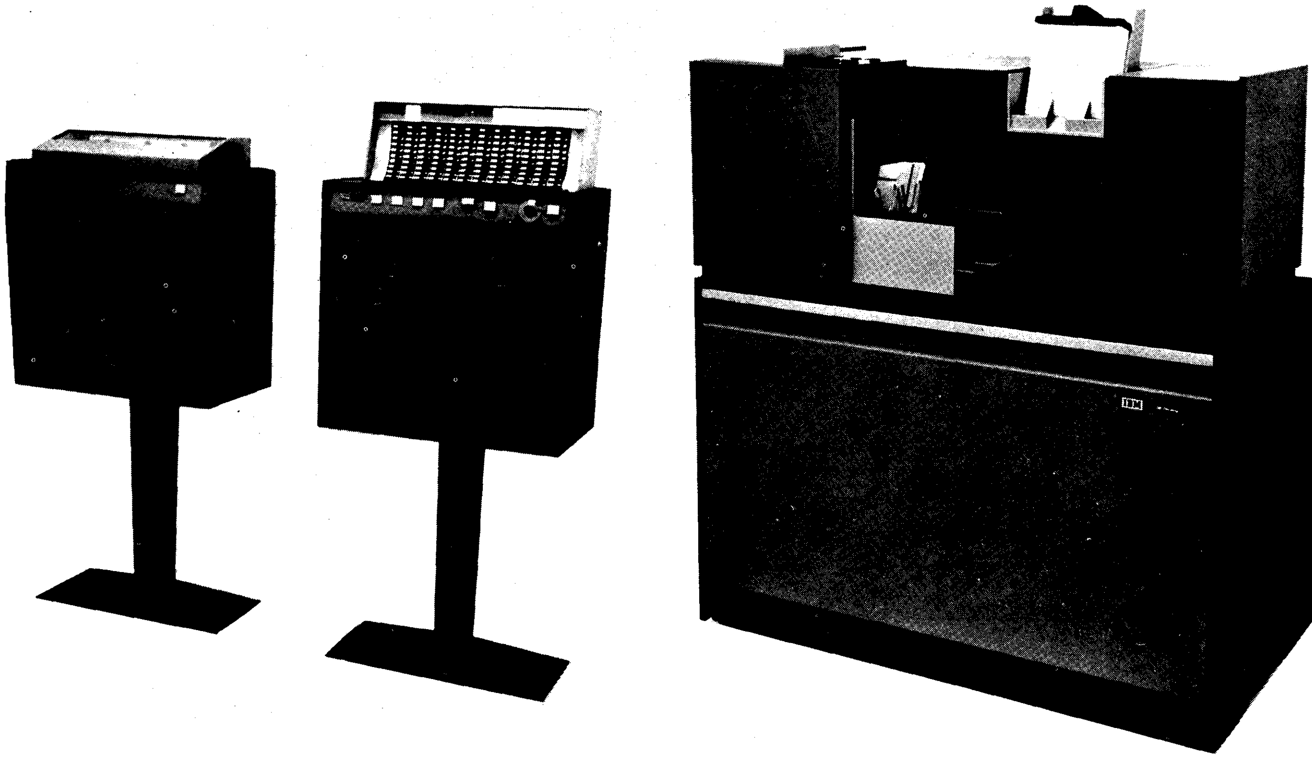

Figure 10. IBM 1030 Data Collection System

Because of the 2760's extreme ease of operation, the unit can be used by a broad range of professional and vocational personnel in a wide variety of application areas. These areas include:

- Medical: data required for patient entry into a hospital; hospital information systems; automated patient history; records of diagnostic procedures
- Insurance: generation of new policy data; claims processing
- Manufacturing and process industries: cost estimation; order entry; manufacturing planning
- Scientific: design simulation using computer techniques

Through the use of the 2760 Optical Image Unit, the simple probing of pertinent information may take the place of many multi-step operations generally associated with data entry.

1030 Data Collection System

The IBM 1030 Data Collection System (Figure 10) provides a rapid, accurate method for collecting data from remote locations. Information is collected from diverse reporting stations and transmitted at 60 characters per second to a central computer system for recording, processing and analysis. The 1030 is a versatile system and can be used for the following types of data collection functions:

- Recording of receipt or shipment of goods at a loading/shipping dock
- Production reporting in a plant
- Control of customer policy files in an insurance company
- Recording of the receipt and disbursement of certain documents as from a technical library in a research organization
- Issues of plans or drawings for a manufacturing concern
- Attendance reporting
- Labor distribution and performance
- Scheduling and dispatching of jobs for a particular production cycle in plant operations
- Inventory update and maintenance

The 1030 system can be an effective management tool to reduce the time between data origination and the time that data becomes available for machine processing. The specific units of the 1030 Data Collection System are:

- IBM 1031 Input Station
- IBM 1032 Digital Time Unit
- IBM 1033 Printer (on-line systems only)
- IBM 1034 Card Punch (off-line systems only)
- IBM 1035 Badge Reader

The IBM 1031 Input Station enables the 1030 system to accept data in various forms: prepunched plastic badges and the standard 80-column cards, manual entry units, and data cartridges. The punched card could be used as a job identification card or as a card attached to a particular book or document for identification purposes.

A badge might be used to identify a particular individual or station (for example, the student at a university who has checked out a document from the library, or the particular station that completed a step in a production process).

Variable information may be entered through a data cartridge or manual entry slide and might include such items as the quantity shipped, time required to complete a specific job, or the anticipated return date for a book or document being loaned.

The data cartridge may be preset with up to 12 characters of numeric information and then entered through the 1031 with additional data from a badge or punched card. The manual slide provides for the same variable entry function but must be set at the terminal by positioning each of the 12 slides for the specific information to be entered.

One consideration in selecting the data cartridge over the manual slide, or vice versa, would be the number of transactions expected to be entered at a specific terminal. The positioning of the slides with variable data frequently takes from 5 to 20 seconds. The 1031 station is effectively tied up while this information is being selected at the control station. The data cartridge, however, can be set prior to the employee arriving at the control station, thereby taking less time at the station for the entry of variable information.

The IBM 1032 Digital Time Unit provides the time of day and can be used to record the time that each transaction enters the system.

The IBM 1033 Printer provides on-line 1030 systems with SELECTRIC printer output at locations remote from the central computer system. In combination with the 1031 Input Station, 1033 printers offer full on-line inquiry and response capabilities and can provide hard copy documentation of certain exception information (for example, rerouting of a job on the production floor or notification of an appropriate fine for overdue books).

The IBM 1034 Card Punch is the transmission control and output unit for off-line 1030 systems. It coordinates transmission from the remote stations and punches standard 80-column cards as output records.

Badge identification can be entered through the IBM 1035 Badge Reader as well as the 1031 Input Station. The 1035 reads numeric data only from a 22-column badge and is available for use with both on-line and off-line 1030 systems. It provides for badge input only, however, and would be used where attendance recording is a major application.

For manufacturing areas, machine shops, warehouses, and other important sources of production data, strategically located 1031 Input Stations can accept and transmit fixed data such as man number or job number from a card or badge and certain variable information from a data cartridge or manual slide. Incorporation of the 1033 Printer provides the additional facility for printing up-to-the-minute information right in the factory. Consequently, the versatile 1030 Data Collection System offers plant management the means to eliminate the time-consuming methods currently used in transporting and converting source data prior to processing.

2790 Data Communication System

The IBM 2790 Data Communication System is a high speed communications and production reporting system designed specifically to handle a large volume of short messages to and from many in-house locations. The 2790 is a versatile terminal system and can be readily adapted to a wide variety of application requirements for the larger data collection user. The application areas are quite similar to that of the 1030; however, the 2790 is a growth step away from the 1030 Data Collection System and provides expanded functions for use by manufacturing plants, shipyards, process industries, meat packing houses, hospitals, libraries, etc.

The 2715 Transmission Control Unit provides all of the terminal and line control required for transmission to the system. For local operation, the 2715 may be attached directly to the multiplexor channel; in a remote environment, however, the 2715 must include a binary synchronous communications adapter.

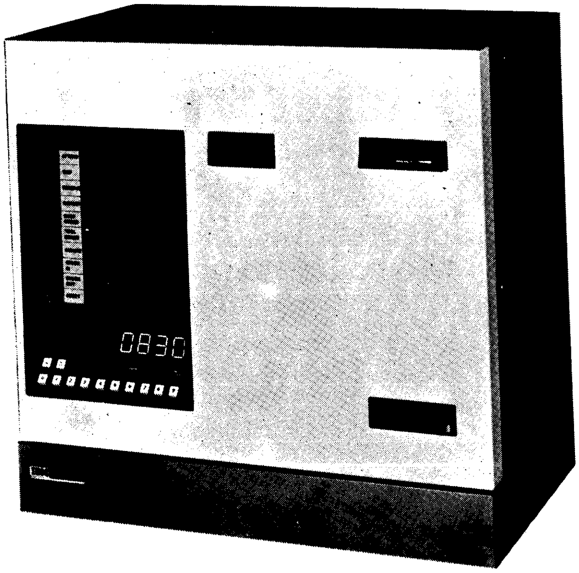

Figure 11. IBM 2791 Area Station

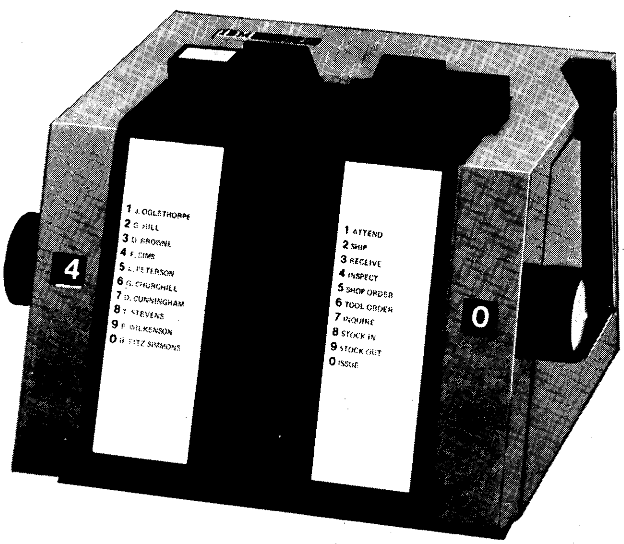

Figure 12. IBM 2796 Data Entry Unit

The other components of the 2790 Data Communication System are listed below:

- IBM 2791 Area Station (Figure 11) – provides data entry via punched card, employee badge and key entry. Additional facilities include a program-controlled display panel to guide the operator in data entry, attendance reporting at "walk-by" rates, and a visual display to show time and to permit verification of keyed data prior to transmission.

  As many as 100 area stations can be attached to a single 2715 control unit.

- IBM 2795 and 2796 Data Entry Units (Figures 12 and 13) – are compact inexpensive terminals designed for reporting job and machine status and production information by production employees at their work location.

  Up to 32 data entry units may be attached to one 2791 area station.

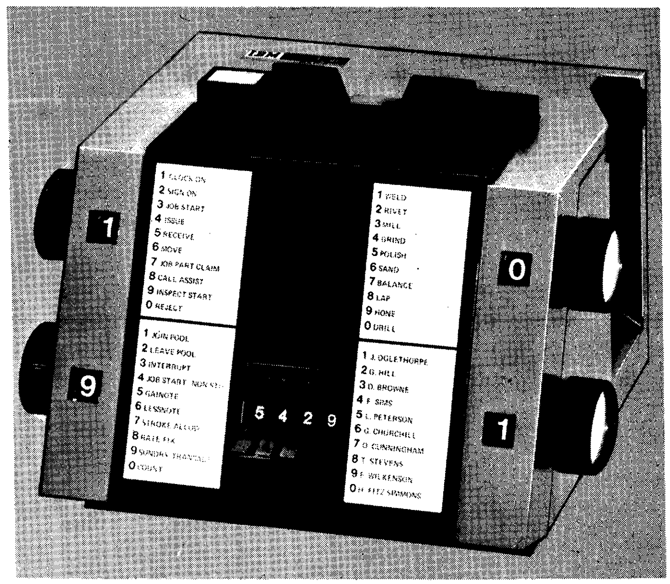

Figure 13. IBM 2795 Data Entry Unit

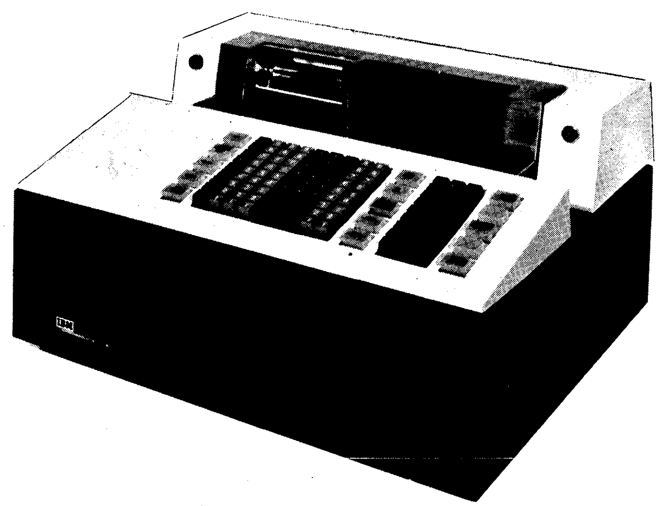

Figure 14. IBM 1060 Data Communication System

1060 Data Communication System

The IBM 1060 Data Communication System (Figure 14) is designed to improve services in such financial institutions as savings and loan associations, savings banks and commercial banks. It permits the tellers to handle customer accounts faster and more accurately by making available, on a real-time basis, all account records. The teller at any window, whether it be at the bank's main office or at one of its widely scattered branches, can access and update all the necessary customer records and, as the daily transactions proceed, the 1060 system can provide each customer with an accurate and current record of his account. The system also provides each teller with this same account information and continuously maintains his own balance on hand.

The 1060 Data Communication System is comprised of two units:

- IBM 1061 Control Unit: contains all the communications line control, code translators, and balance accumulators for the 1060 system.

- IBM 1062 Teller Terminal: (the "work unit" of the 1060 system) contains the printer, entry keyboard, document feed, terminal-record tape, and keys for two tellers.

Using the 1062 Teller Terminal, a teller can key transaction information directly from his window to a remotely located computer system. After the system has examined the transmitted data for accuracy and updated the associated records, the teller terminal prints on the customer's passbook any unposted interest, the current transaction amount, and the new balance. A complete audit record of both the transmitted and received data are also printed on the teller's terminal record tape; and if any exception conditions occur, such as uncollected funds or an account tied up in estate, the teller is informed immediately.

The following features are available on the 1062:

- Split platen – allows for the independent movement of the terminal record tape and a document, such as a passbook or ledger card.

- Document feed – includes automatic spacing of a passbook (after initial positioning by the teller), skipping of the centerfold and recognition of the last printing line.

- Keyboard – permits the entry of 9 columns of numeric data (such as account number, amount, etc.) and 27 transaction code keys identified by descriptive titles for an easy indication of the type of entry being processed.

- Functional control keys – identify an entry such as old balance or new account number and indicate the teller making the entry.

- Three individual locks– allow operation of the 1062 by 2 tellers and by a supervisor or auditor.

- Indicator lights – inform the teller of the status of each transaction being processed and of certain exception conditions as end of passbook page.

These features provide both on-line and off-line processing for complete control of all customer account numbers, no-book transactions, dormant accounts, uncollected funds, hold conditions, interest posting, passbook balances, teller's cash control, and sound audit security.

If communications cannot be maintained between the 1060 system and the central computer system, the 1060 can continue to operate in an off-line mode. A punched program control tape instructs the 1061 Control Unit to perform the arithmetic functions necessary to process transactions and develop new balances, and all customer transactions proceed normally without reference to the central system. When communications between the two systems are restored, the off-line transactions are entered into the TP system for updating via a batch run of the data processing system.

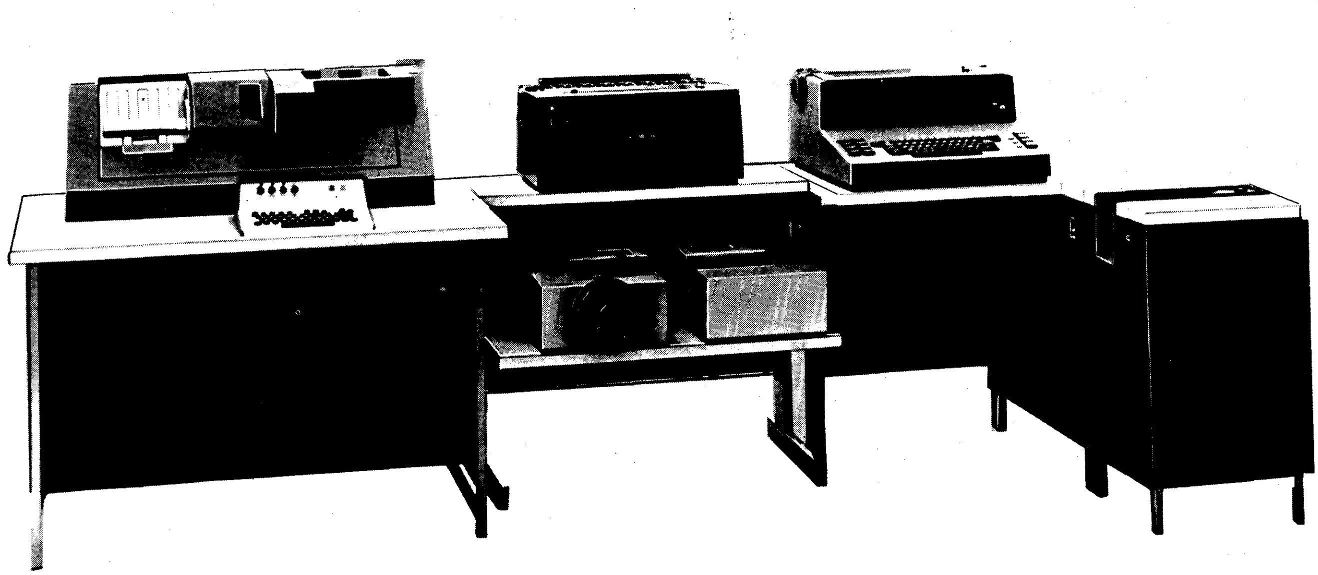

Figure 15. IBM 1050 Data Communication System

1050 Data Communication System

The IBM 1050 Data Communication System (Figure 15) is a multi-purpose office-oriented teleprocessing system designed for a large span of applications from conversational inquiries to batch entry.

The versatility of this system is made possible by the various input/output media available and the numerous system configurations. These range from a receive-only printer to the most complete configuration, including devices for:

- Manual keyboard entry
- Hard copy SELECTRIC printer output
- Punched card input and output
- Paper tape input and output
- Edge punched document input and output
- Programmed keyboard entry

The IBM 1051 Control Unit is required in all configurations and contains the power supply, code translators, and control circuitry for the entire 1050 system. The number of control switches, keys, and lights varies with the model of the system and with the number of features and components. The other components available on a 1050 system are listed below:

- IBM 1052 Printer-Keyboard
- IBM 1053 Printer
- IBM 1054 Paper-Tape Reader
- IBM 1055 Paper-Tape Punch
- IBM 1056 Card Reader
- IBM 1057/1058 Card Punch or Printing Card Punch
- IBM 1092 and 1093 Programmed Keyboards

Consult the IBM 1050 System Summary (Form GA24-3471) for detailed descriptions of the above components.

Two different modes of operation are provided by the control unit: off-line (or "home loop") and on-line (or "line loop"). Using any combination of input/output media in the home loop, the 1050 can create data, write documents, convert codes, and serve as an automatic typist. In the on-line mode, the 1050 can transmit or receive over communications lines at the rate of 15 cps.

An extensive list of special features to perform specialized functions, minimize operator intervention and increase throughput is available for the 1050 system. Examples are: pinfeed-platen and accelerated carrier-return for the printer, high-speed skip for the card reader, vertical forms control, and card reader program tape. Another special feature called "dual-circuitry" provides for simultaneous off-line recording of data (into paper tape or cards) and on-line file updating, where any combination of the input/output components of the system, not being used for on-line transmission, is available for independent off-line (or "home loop") operation.

A major use of the 1050 Data Communication System is in the off-line recording of data for subsequent batch transmission and on-line file updating. In an order entry application, for example, home loop operations would be used to generate orders in the form of paper tape or decks of cards which would later be transmitted in batch mode to a central computer system for updating of customer files and confirmation of shipping dates.

In addition to order entry, the 1050 system is well suited to the processing of the following applications:

- Document writing: of sales orders, purchase orders, insurance policies, payrolls, etc.
- Direct entry: for file updating and storage
- Inquiry and response: for immediate status reporting in a real-time operation
- Remote printing: of business records and invoices to supply full documentation of business transactions to remote locations
- Exception reporting: of information about credit ratings, inventory adjustments, work orders, etc.
- Intra-company correspondence: to provide rapid disbursement of memoranda, directives, administrative reports, etc.

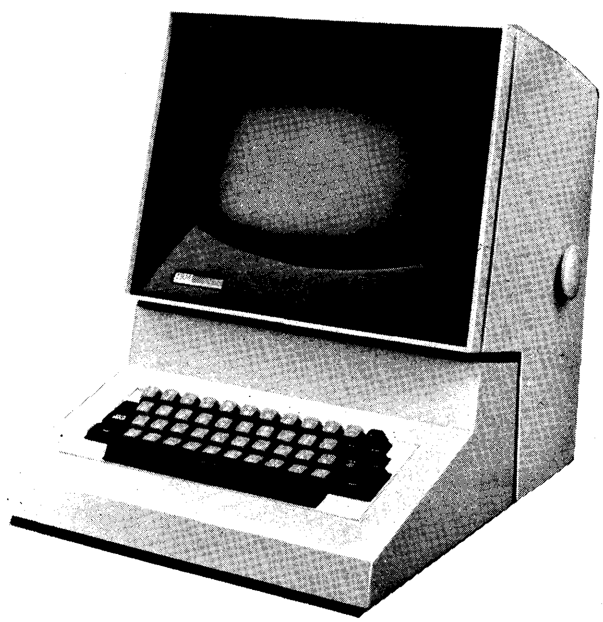

Figure 16. IBM 2260 Display Station

2260 Display Station

The IBM 2260 Display Station (Figure 16) is a high-speed inquiry display device that provides immediate visual access to stored data. A standard electric typewriter input keyboard allows easy entry of alphanumeric information, and the output cathode ray tube can display up to 12 lines (up to 80 characters on each line) of response. The inquiry is displayed as it is keyed to permit visual verification; and the system response to inquiry will remain displayed on the screen until it is erased, either by the terminal operator or by the computer under program control. The 2260 also provides an efficient means for updating central files without the multi-step operations normally associated with data entry. The user can analyze the displayed response and, if he wishes, update it immediately and return it to the computer for additional processing.

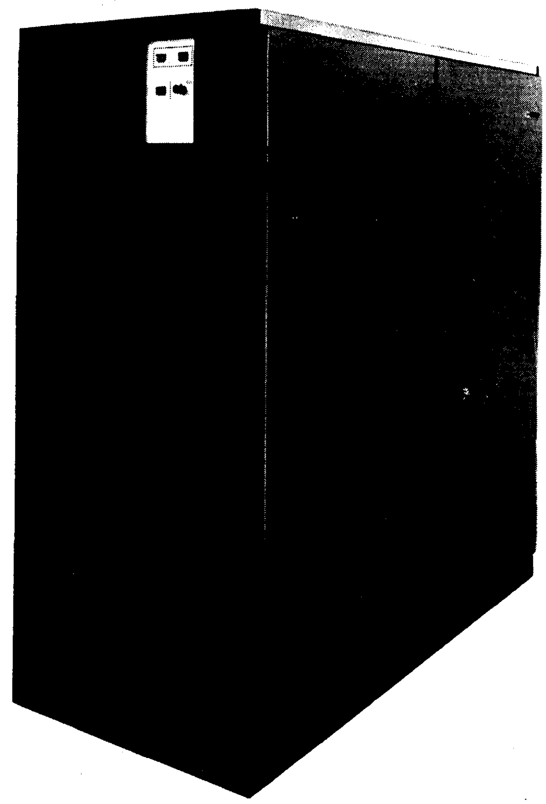

Figure 17. IBM 2848 Display Control

The 2260 Display Station operates under the control of the 2848 Display Control Unit (Figure 17) which is used to permit a number of 2260's to operate in an economical configuration. The 2848 provides most of the logic, buffering, and line control for the 2260, thereby significantly reducing the time the central processing unit must be committed to servicing the terminals. In addition, a 1053 Printer, Model 4 (Figure 18), may be attached to the 2848 display control for the selective printing of the data displayed on any of the 2260 terminals attached to the 2848.

Several models of the 2848 Display Control are available. Model 1 can control up to 24 Display Stations, each having the ability to display up to 240 characters per screen. Model 2 can control up to 16 terminals and produce up to 480 characters in each display and Model 3 can control up to 8 terminals of 960 characters each.

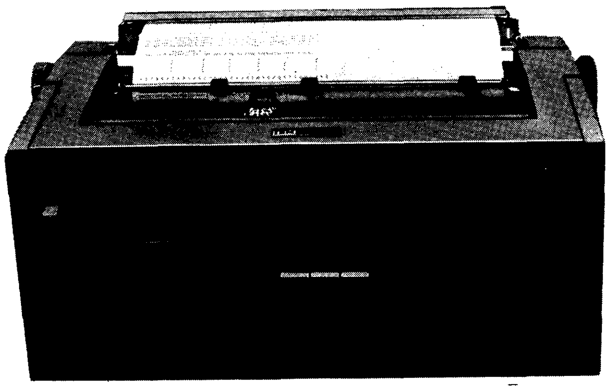

Figure 18. IBM 1053 Printer, Model 4

The 2848 Models 21 and 22 provide additional features related to high volume data entry, which involves the replacement of normal keypunch and key verification operations with the use of 2260's for on-line data entry. These additional features include an expanded buffering capability to allow experienced operators to key data simultaneously at high speed. An optional feature of the 2260 is a data entry keyboard which is similar in design to that of the 029 Card Punch and greatly simplifies the transition of a keypunch operator from the card punch to the 2260 for data entry.

Table 1 summarizes the capabilities of the various models of the 2848 Display Control:

2848 Model	Maximum # of 2260's/2848	Maximum # of Characters/2260
1	24	240
2	16	480
3	8	960
21	24	240
22	16	480

Table 1

All models of the 2848 provide for the operation of 2260 visual display stations at distances up to 2,000 feet from the associated 2848. The display control may be attached directly to the channel of the computer system and is considered to operate in "local mode". Local operation permits the placement of 2260 Display Stations at strategic locations throughout an office building or industrial complex, thus providing access to central data files at locations removed from the actual computer installation. In some cases, there may be a requirement for 2260's located in branch offices and other remote locations many miles from the computer site. For these distances greater than 2,000 feet, the 2848 may be attached via telephone lines and, as such, is referred to as a "remote" system.

The 2848 is designed for remote attachment to the central computing system through an IBM 2701 Data Adapter Unit, the transmission control unit which must be located at the central complex. Further details describing the 2701 appear in the section entitled TRANSMISSION CONTROL UNITS.

Possible 2260/2848 configurations for both local and remote environments are shown in Figure 19.

In a local environment, data is transferred at the maximum rate of 2560 characters per second. In a remote system, the speed of data transfer is limited by the type of telephone lines and line interfaces used and would be at 120 or 240 characters per second. Because of the high volume of data anticipated, the 2848 data entry models (21 and 22) may only be attached directly to the system channel for local operation.

Displaying data on a 2260 screen is, therefore, much faster than printing the same data on a terminal printer such as the 1050. The user has the ability to scan a page and, by entering new keywords, either receive another page or obtain more detailed information on topics currently displayed. The 2260 is ideally suited to applications in which a considerable volume of information must be visually scanned, and a new page of several hundred characters can be transmitted from the computer to the terminal in just a few seconds.

The 2260 Display Station provides new flexibility for rapid access to data stored at a central computer. In retrieving information from a large centralized data file, a user is often more interested in examining a substantial amount of data than in obtaining direct responses to specific inquiries. Consequently, there is a requirement for considerably faster output than in standard inquiry responses, and the 2260 Display Station is often used for such retrieval applications. The user enters a key word or a series of terms describing an area of interest from the

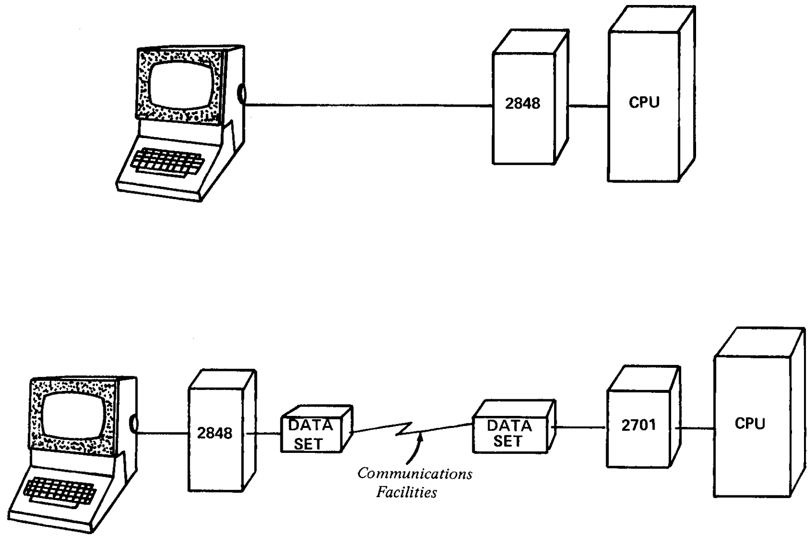

Figure 19. Possible 2260/2848 configurations for local and remote environments.

Figure 20. IBM 2265 Display Station with IBM 2845 Display Control

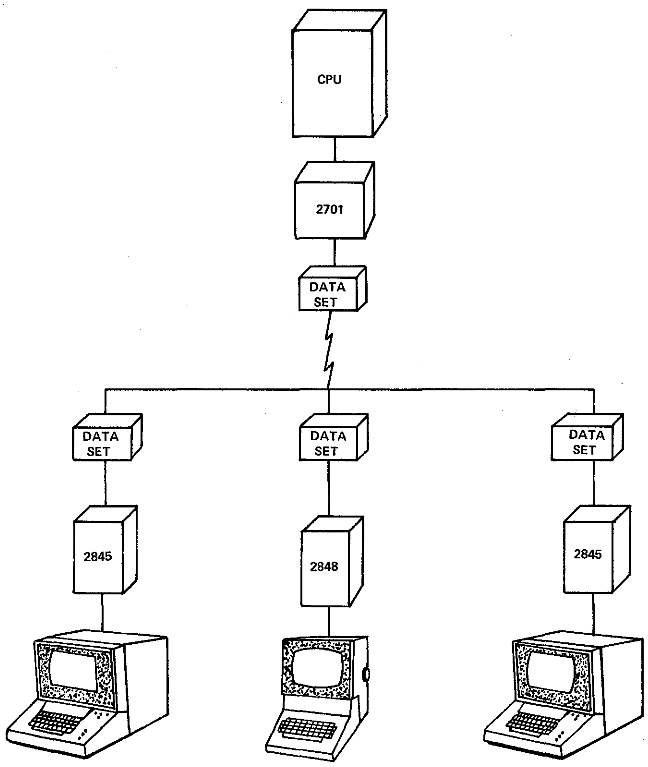

Figure 21. Typical 2265/2845 configuration.

keyboard; and, after this input is analyzed, the system retrieves abstracts of related information and returns them to the display screen.

In today's competitive environment this is a necessary requirement for the efficient handling of customer inquiries, services requests and specialized reports, because decision-making must be based on current information. Through the use of the 2260, a series of records (for example, a multi-page report) can be searched visually a page at a time. The displays can then be examined for pertinent information, updated and/or documented via the 1053 printer, thus providing man-machine communication for all levels of management and operating personnel.

2265 Display Station

The 2265 Display Station (Figure 20) is similar both in design and application to the 2260 Display Station. It provides rapid visual display of data stored in the computer system and immediate updating of critical records from many locations. However, it is strictly a remote device and does not operate in "local mode".

The 2845 Display Control, which provides the line buffering and terminal interface for the 2265, is a much more compact transmission control unit than the 2848, and is capable of controlling only one 2265 Display Station and an optional SELECTRIC printer for hard copy output.

The 2265 is equipped with an alphanumeric keyboard which can be located up to five feet from the display screen. As many as 960 characters can be displayed on the 2265 screen at a time in either one of two formats: 15 rows of 64 characters or 12 rows of 80 characters.

The 2265 operates over a communications line at a transmission rate of 120 or 240 characters per second, depending on the type of line used, and up to sixteen 2265/2845 units can be attached to one line. The 2845 is designed for remote attachment to the central computing system through an IBM 2701 Data Adapter Unit, the transmission control unit which must be located at the central complex. The 2701 is described in greater detail in the section entitled TRANSMISSION CONTROL UNITS.

A typical 2265/2845 configuration is shown in Figure 21.

Note that a 2260/2848 display complex is indicated in the above figure on the same line as the two 2265/2845 display complexes. The 2265/2845 system is fully compatible with the 2260/2848 system, and it is possible for both system types to operate through the same 2701 Data Adapter Unit, using the same application. The 2265 Display Station is, therefore, ideally suited for those systems with existing 2260/2848 complexes which require only one or two additional display devices for expansion.

The 2265 Display Station is designed specifically to meet the requirements of customers whose facilities are widespread and who need only a small number of display terminals at each location. Through the use of the 2265, the need to maintain duplicate files in both the central and remote locations could be eliminated.

The remote 2265/2845 system can be an invaluable tool for management. It can provide instant access to timely information and the ability to update central files. Typical applications are:

- Rapid response to customer inquiries
- Direct processing of customer orders in a conversational mode of operation
- Instant retrieval of customer account information
- Complete display of policy information
- Access to customer service records

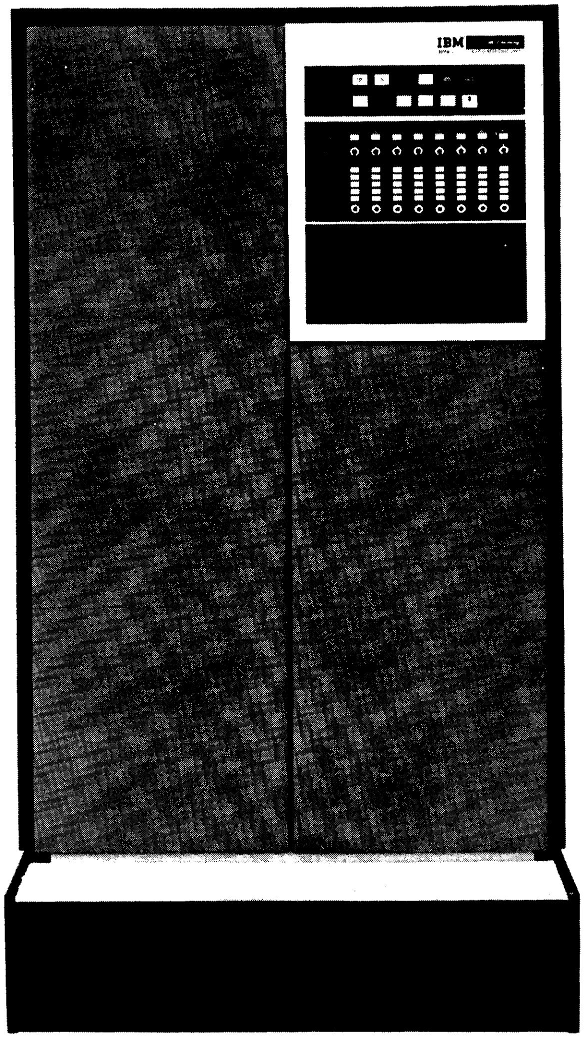

Figure 22. IBM 7770 Audio Response Unit

7770 Audio Response Unit

The primary function of the IBM 7770 Audio Response Unit (Figure 22) is to create prompt and accurate voice replies to inquiries initiated from a standard 12-key Touchtone telephone, or IBM 2721 Portable Audio Terminal.

Input from the telephone is in the form of digital tone signals which are generated by the keys on the terminal device and transmitted over communications lines to the Audio Response Unit. Each key generates a unique tone signal that can be interpreted by the 7770 for presentations to the central processor and translated into a meaningful message for input to the application program.

Response from the system is in the form of spoken words composed from an American English vocabulary prerecorded (in a male or female voice) on a magnetic drum within the 7770. Each word in the prerecorded vocabulary has a specific address on the drum, which can accommodate from 32 up to a maximum of 128 different words. The response generated by the central processor is actually a series of addresses which are transferred to the 7770 for transmission back over a specified communications line.

The prerecorded vocabulary is specified by the user according to his message requirements. The vocabulary may be changed by field engineers at the user location by removing the magnetic drum and replacing it with another having a different vocabulary.

It takes approximately 1/2 second to "speak" any single word from the vocabulary in output transmission. Lengthy words, therefore, must be divided in two and will count as two words. For example, the word "operation" will exist as the two words "opera" and "tion" and both addresses must be specified to generate the full word "operation".

The basic 7770 Audio Response Unit can control 4 communications lines. This capacity can be expanded to 48 lines, all of which can be used simultaneously. In other words, up to 48 telephones can communicate with the central computer system at one time –– either in making an inquiry, updating data files or receiving a response –– and with no noticeable delay in audio output response to any user. The 7770 is a transmission control unit both by function and capability and is always located at the central computer installation rather than at the remote site.

The telephone is a low cost terminal that can provide inexpensive retrieval and updating capabilities to remote locations. In addition, the caller deals directly with the computer rather than through another person. This saves considerable time in the retrieval of information by reducing both the need for manual search of voluminous files and the possibility of errors because of misunderstanding.

IBM 2721 Portable Audio Terminal

The 2721 (Figure 23) uses a standard telephone to access a System/360-370 computer data base. Designed for use with the IBM 7770 Audio Response Unit Model 3, the 2721 can be used for data collection, data entry and inquiry. The basic 60-position keyboard provides 26 alphabetic, 10 numeric and 13 special characters, as well as a variety of function and control keys. The standard key designations can also be adapted for highly individualized applications through use of customized keyboard overlays.

Some of the highlights of this terminal are:

- Sturdy, luggage-style carrying case with detachable cover.

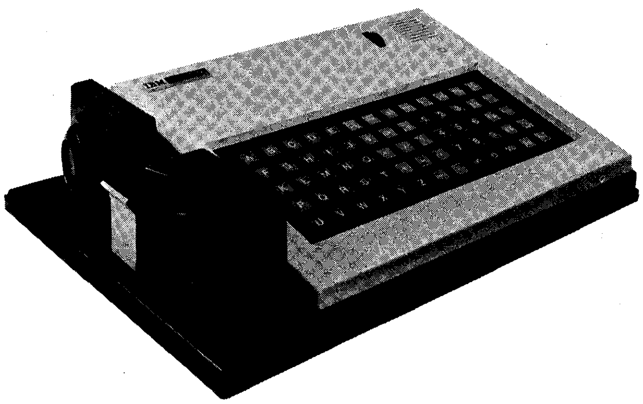

Figure 23. IBM 2721 Portable Audio Terminal

- Dimensions: 16 inches wide, 9 inches deep, 4 inches high.
- Weight: less than 10 pounds.
- Storage space for power cord, auxiliary earphone, extra keyboard overlays, and acoustic coupler.
- Operates on self-contained nickel cadmium batteries or 110 volt AC.
- Earphone for private listening.
- Built-in speaker for group listening.
- Individual terminal identification code to provide protection against unauthorized access to the data stored in computer files.

2780 Data Transmission Terminal

The IBM 2780 Data Transmission Terminal (Figure 24) is designed to accommodate large volumes of data over its communications lines. Input is in the form of punched cards only; output is either punched cards or printed documents, or both.

The 2780, which is available in 4 models, permits a variety of configurations in order to match individual system requirements more precisely. The 4 models are:

- Model 1 - card reader/printer
- Model 2 - card reader/card punch/printer
- Model 3 - printer (receiving terminal only)
- Model 4 - card reader/card punch

Inherent in the design of the 2780 is an advanced circuitry that offers improved efficiency through a new method of communications line control: Binary Synchronous Communications. The technological development is merely one type of synchronous transmission (see Communications Terms and Concepts) providing for the attachment of multiple terminal devices to the same line, resulting in substantial savings in line costs. It also enables a specialized Binary Synchronous Adapter, which is the interface between the 2780 and the communications line, to control the flow of data over the communications lines and maintain synchronization between the transmitting and receiving devices. Consult Binary Synchronous Communications – General Information (Form GA27-3004) for a more detailed discussion of Binary Synchronous Communications as it functions with the 2780 and other devices.

The actual performance of the 2780 is a function of the size of the messages being transmitted, the code used and the type of communications lines being used. At full operational capacity, the 2780 is capable of:

- Transmitting and receiving up to 400 characters per second
- Printing up to 300 lines per minute
- Reading up to 400 cards per minute
- Punching up to 270 cards per minute

The 2780 Data Transmission Terminal incorporates a number of significant features:

- Double Buffer: To achieve greater throughput and efficiency, the 2780 makes use of 2 buffers.

  The line buffer stores data received or to be transmitted to the communications line in 2-record blocks and thereby minimizes turnaround time.

  The input/output buffer accepts input data from the card reader for transferral to the line buffer and directs output data from the line buffer to the card punch or printer.

- Code Choice: Three transmission codes are available with the 2780 system:

  EBCDIC (Extended Binary Coded Decimal Interchange Code – 8 bit)

  USASCII (United States of America Standard Code for Information Interchange – 8 bit)

  6-bit Transcode

  Naturally, the choice of code depends upon the application. The use of 6-bit Transcode provides for maximum efficiency in transmission because less net data is being transmitted per message.

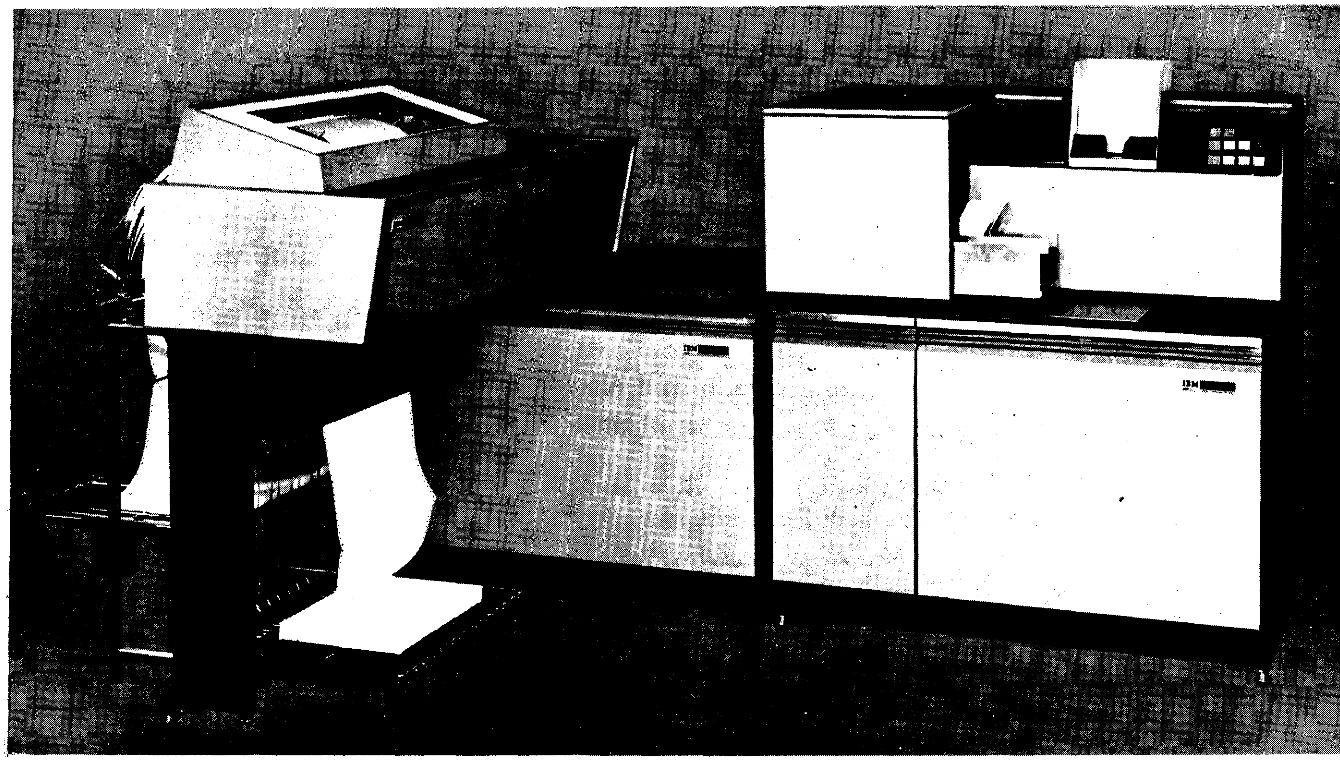

Figure 24. IBM 2780 Data Transmission Terminal

- Audible Alarm: If a situation occurs during transmission that requires some kind of manual intervention (for example, running out of paper on the printer or completion of transmission for the current job), the audible alarm alerts the operator so that necessary action can be taken.

- Component Selection: The modularity of the 2780 provides a configuration that can include both printer and card punch for output. With the component selection feature, certain control characters may be used by the programmer to select either the printer or card punch automatically during transmission.

- Off-line Listing: The 2780 can also be used in an off-line mode to list cards on the printer.

The 2780 also makes available a number of special features that contribute further to system efficiency:

- Multiple Record Transmission: With this special feature, up to 7 messages may be combined into one for a single transmission, thereby achieving greater efficiency on the communications line.

- Printer Horizontal Format Control: This feature provides what is in effect an electronic tab for the 2780 printer. Normally, the spacing of information from one field to the next (or the requirement for blank areas to appear in a specific section of a form) would require the transmission of space characters over the communications line. With the horizontal format feature, the electronic tab signal allows the unit to space over areas where no information is to be printed, thereby reducing the total amount of information necessary for transmission.

- Auto Turnaround: Auto turnaround is utilized when card transmission to the central computer system requires output response in the form of punched cards. Through the use of this feature, the 2780 can switch automatically from reading cards (in a transmit mode) to punching cards (in a receive mode) – all without operator intervention.

- Code Transparency: Code transparency is associated with EBCDIC only. It allows the 2780 to send and receive any type of EBCDIC bit configuration. This feature would be particularly desirable for the transmission of information that included computer program decks.

Some of the considerations in selecting the 2780 over other terminals are the workload, turnaround time, and the availability of operating personnel. Obviously, high volumes of work to be transmitted require a higher speed terminal such as the 2780, rather than a lower speed device like the 1050 Data Communications System described earlier.

Turnaround time can also be a significant factor. If the data must be transmitted to a central point for processing and a response received back by a specific time, the volume may not be as critical as the timeliness of getting the information to the processing center.

With lower speed devices such as the 2740 or other keyboard entry terminals, the operator is most likely committed full time to servicing the terminal, either in transmitting information or receiving responses back from the central point. With the use of the 2780 and some of the special features described above, the operator could be assigned primarily to other functions and only attend the 2780 when specific operator intervention is required.

The 2780 is a high performance terminal and is especially suited to those operations which require branch offices, plants, warehouses or other remotely located sites to prepare and/or receive high volume work on a continual schedule. An example of this is a daily multi-page printed report or large card decks for program processing. In such installations, the 2780 is capable of transmitting and receiving the same punched cards and printed reports over communications lines that previously had to be mailed to or from the central computer location. Therefore, what could have taken days in mailing procedures can now be accomplished in a few minutes. The burden of all the internal processing is assumed by the central system, thus relieving the remote locations of the responsibility of maintaining processing systems and technically trained staffs.

A typical application using the 2780 Data Transmission Terminal is that of order entry and invoice preparation. Order cards indicating customer numbers, stock numbers, and quantities could be transmitted to the central system in a batch through the 2780 card reader. After processing the orders and updating the appropriate customer files and stock inventory, the system would then transmit prepared invoices back to the 2780 printer at the remote location. It is also possible to indicate exception conditions (such as invalid customer number or insufficient quantity on hand for a particular stock item) in the form of punched card output, which could be listed later in an off-line, card-to-printer operation.

2770 Data Communication System

The IBM 2770 Data Communication System (Figure 25) is a multi-purpose terminal system which satisfies the function, volume and media requirements of a variety of applications. The 2770 can transmit either batched data or inquiry/response information, or a combination of both, to such devices as another 2770, a System/360, or other binary synchronous terminals (such as 2780, 1130).

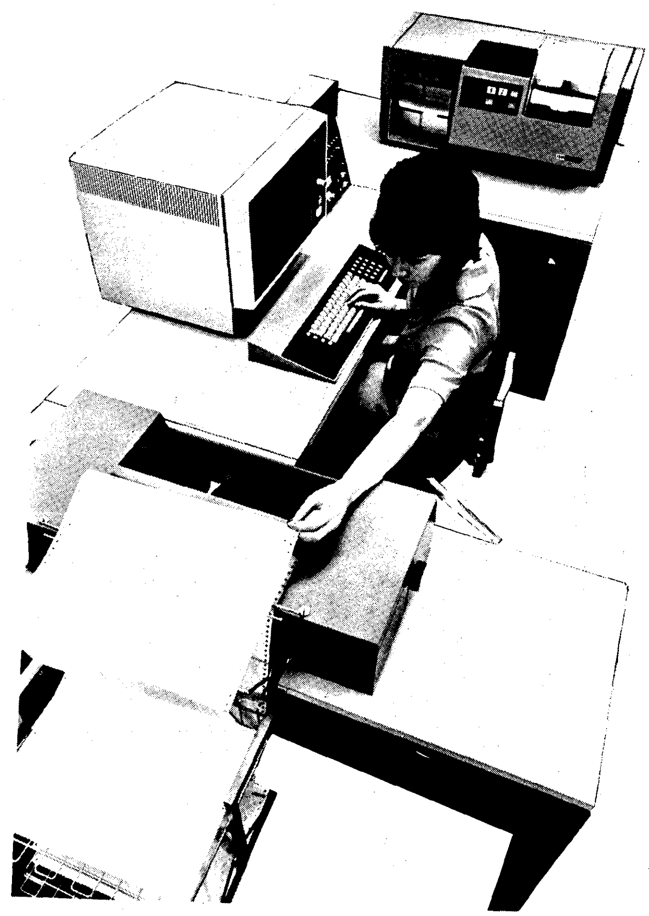

Figure 25. IBM 2770 Data Communication System

The basic unit of the 2770 Data Communication System is the IBM 2772 Multi-Purpose Control Unit, with a 128-character buffer and a keyboard as standard equipment. Numerous types and combinations of input and output devices are available from among the following terminal components:

- IBM 2213 Printer– has a maximum speed of 66 characters/second with optional vertical control of continuous forms
- IBM 2265 Display Station – displays a maximum of 960 characters. See the "2265 Display Station" topic later in this section for more information on the 2265.
- IBM 2502 Card Reader – is available with two speeds 150 or 300 cards/minute
- IBM 545 Output Punch – punches data transmitted by the system at up to 20 characters/second
- IBM 1017 Paper Tape Reader – reads 5-channel to 8-channel tape at up to 120 characters/second

- IBM 1018 Paper Tape Punch – punches 5-channel tape at up to 120 characters/second
- IBM 50 Magnetic Data Inscriber – reads prepared tape cartridges at up to 117 characters/second
- IBM 1255 Magnetic Character Reader (a six-pocket reader/sorter) – handles up to 500 encoded documents/minute

The 2770 System provides for efficient transmission of batch and large volume data using cards, magnetic tape, MICR encoded documents and paper tape. On the other hand, inquiry and data entry applications may be performed using the keyboard/2265 display or keyboard/printer combinations.

The 2772 control unit handles either EBCDIC or USASCII codes and transmits at one of three rates: 1,200, 2,000 or 2,400 bits per second, using Binary Synchronous Communications. It monitors all transmitted data and automatically re-transmits when it detects an error in line transmission. Its audible alarm alerts the operator to situations that require manual intervention.

When operating off-line, any input unit can send data to any output unit attached to the 2772. For example, punched cards can be listed on the printer. When operating on-line, output units can be selected under computer control.

The 2770 is simple to operate. A convenient selector dial lets the operator choose among five different job applications as easily as switching channels on a television set. A sixth position is provided for manual set-ups. The IBM 2770 offers a number of optional features. Among them:

- Buffer expansion – doubles the buffer size, provides multi-record transmission and minimizes turnaround time.
- Multipoint data link control – allows use of multiple 2772's on the same communications line. In addition, under control of System/360 Model 25 and up, the 2772 can operate on the same leased communications line as other BSC devices such as the IBM 2780 Data Transmission Terminal, 1130 Computing System and System/360 Model 20.
- Automatic answering – handles incoming calls from another 2772 or the central computer without operator intervention.
- Transmit-receive monitor-print – causes printing after data has been successfully transmitted to or received from I/O devices.
- EBCDIC transparency – as with the 2780, the 2772 can receive and transmit all 256 EBCDIC codes as data characters. No conversion occurs, but checking and auto re-transmission remain operative.
- Keyboard correction – allows the operator to correct data by backspacing one or more characters, up to an entire line.
- Display format control – provides features for horizontal tabulation and data protection.

Because of its modularity, the 2770 can be customized to meet special needs. The system has many applications in business, industry, education, government and other fields/applications like inventory control, personnel records, order entry, sales analysis, management information, data entry and data transmission.

With the 2770, the user can accelerate the flow of information between his headquarters and branch offices, plants, retail outlets, warehouses and other remote locations. Its flexibility permits him to select the best configuration for his requirements at any one location without limiting system capability elsewhere; and each location can be provided with the processing capabilities available at the computer site. In addition, the user can begin with an initial system employing just a keyboard and printer and then add other devices as the need for expansion occurs.

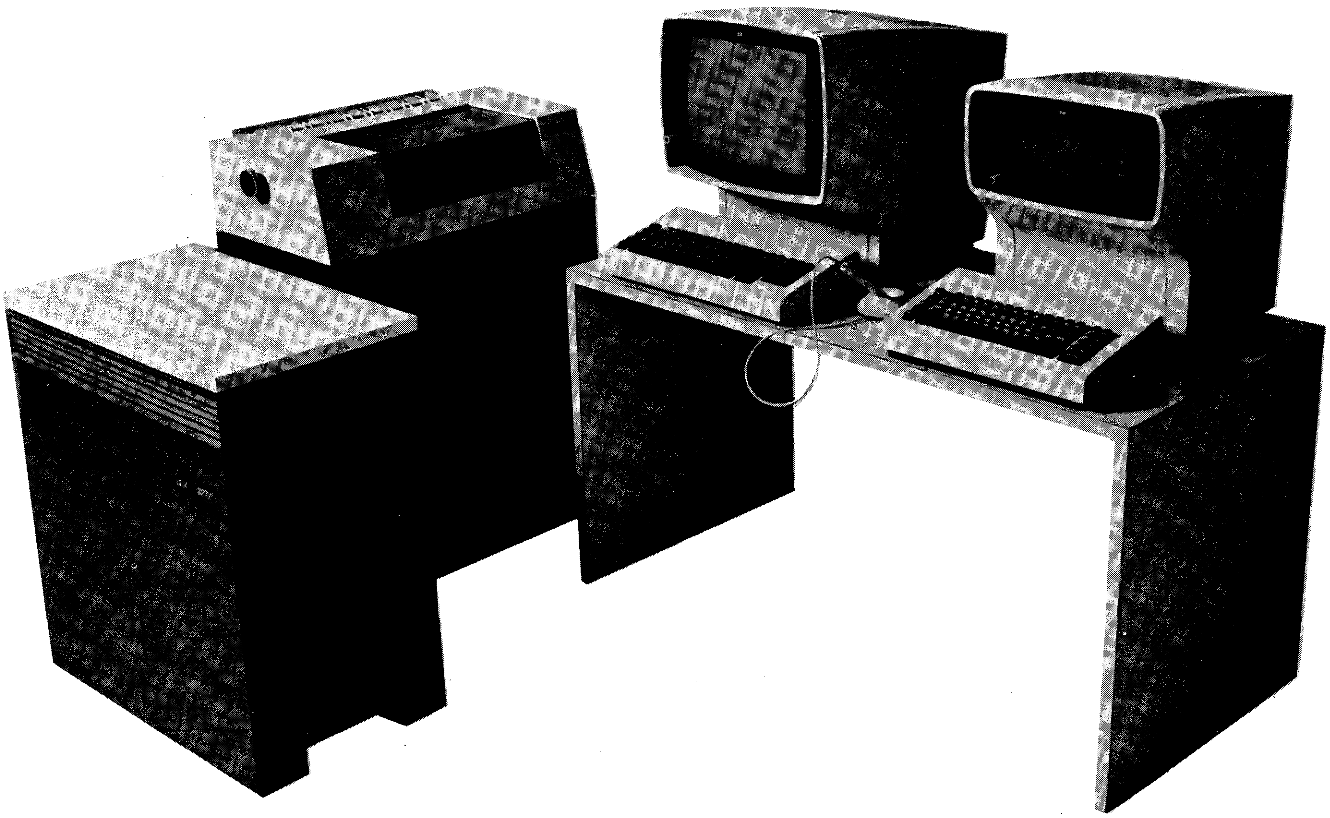

Figure 26. IBM 3270 Information Display System

3270 Information Display System

The IBM 3270 (Figure 26) is a family of products designed to meet the alphameric display requirements of inquiry, conversational mode, data entry, display operator console and other associated applications.

As a modular-design system, the 3270 can operate from a single display unit or from hundreds of displays and printers within the system. The advanced design and functional capabilities of the 3270 offer improved operator efficiencies and significant reductions in total system costs.

The 3270 is fully compatible with System/360 and System/370 computers.

3271 Display Control Unit:

- Permits remote attachment via 2701 Data Adapter Unit or 2703 Transmission Control or 3705 Communications Controller.
- Uses binary synchronous transmission. Four speeds available – 1200, 2000, 2400 or 4800 bits per second.
- Can accommodate either 480- or 1920-character display screen.
- Basic unit attaches up to four devices.
- By adding seven adapters, 3271 can be expanded to control a combination of 32 displays or printers.
- Attached devices can be 2000 feet from control unit.

3272 Display Control Unit:

- Permits local attachment of displays and printers to System/360 or System/370.
- Has same display and printer attachment capabilities as the 3271.

3277 Display:

- Attaches the 3271 or 3272 Display Control Unit.
- Provides 480-character or 1920-character quality images.
- Choice of three keyboards – data entry, alphameric typewriter or operator console, with or without function keys. *
- Each keyboard is movable for operator convenience.

* Optional Feature

- EBCDIC or ASCII codes and WTC languages are available. *
- Other features including typamatic cursor, tab, back tab, insert-delete, erase (end-of-field, unprotected data, entire screen).
- Selector Light Pen allows operator to select information from the display screen as input to the CPU. *
- Audible Alarm alerts operator when next to last position on screen is reached or may be sounded under program control. *
- Security lock prevents display or modification of data unless key is turned to "On" position . *
- Non-displayed keying mode permits data to be entered to the CPU but not displayed on the screen. *

3275 Single Remote Display

- Attaches to System/360 or System/370 via 2701 Data Adapter Unit or 2703 Transmission Control using binary synchronous transmission.
- Four transmission speeds available: 1200, 2000, 2400 or 4800 bits per second.
- Availability of ASCII code.
- Can be multidropped with 3271 Display Control Unit.
- Provides all the capabilities of the 3277 Display.
- Permits attachment of 3284 Printer Model 3.

3284 Printer*

- Prints at a rate of 40 characters per second.
- Model 1 contains a 480-character buffer.
- Model 2 contains a 1920-character buffer.
- Model 3 is unbuffered and attaches to a 3275 Single Remote Display.
- Models 1 and 2 attach to a 3271 or 3272 Display Control Unit. Up to 31 printers can be attached.

3286 Printer *

- Prints at a rate of 66 characters per second.
- Model 1 contains a 480-character buffer.
- Model 2 contains a 1920-character buffer.
- Attaches to a 3271 or 3272 Display Control Unit. Up to 31 printers can be attached.

3735 Programmable Buffered Terminal

The 3735 (Figure 27) consists of an IBM Selectric keyboard, printer and a desk side control unit. The control unit houses the arithmetic and logic circuitry, as well as a magnetic disk and an adapter for Binary Synchronous Communication.

The basic disk unit provides about 45 thousand bytes (characters) for the Terminal Control Program and a buffer with 62.8 thousand bytes (expandable to 314.1 thousand bytes for customer Form Description Programs (FDP) and data storage). Data can originate from the keyboard or from the computer.

Optionally, an IBM 5496 Data Recorder can be attached to provide 96-column punched card input and output to enter information from punched cards or to record processing results in cards. Also an IBM 3286-3 Serial Printer can be attached to give higher speed printing.

Figure 27. IBM 3735 Programmable Buffered Terminal

*** Optional Feature**

The 3735 does not tie up computing operations. It is controlled by its own stored programs. Operating off-line, the 3735 creates source documents, performing basic arithmetic and logical functions, and selecting data from storage at the 3735 and/or batched transmissions to the computer.

Operation of the 3735 is like that of a typewriter. Functional buttons and lights supplement the stored programs in helping the operator prepare source documents accurately and handle source data effectively. The versatile 3735 can be programmed to handle many different kinds of forms for a wide range of source recording applications.

Communicating with the computer is fast, easy and efficient. Transmission is half duplex, at 600, 1200, 2000, 2400 or 4800 bits per second in either ASCII or EBCDIC code. The 3735 uses existing communication network facilities. It can be operated in switched point-to-point (dial up) or multipoint (leased) networks. In multipoint networks, using the efficient Binary Synchronous Communication Data Link Control, the 3735 can share the communications facilities with other BSC terminals such as the 2770, 2780 or another 3735.

IBM 2701, 2702 AND 2703 TRANSMISSION CONTROL UNITS

Earlier in this chapter the transmission control unit (TCU) was introduced as the interface between the central processor and the communications network and performs, among others, the following functions:

- Assembly of bits received from the terminal(s) into characters
- Checking of received data for validity
- Inserting and stripping of individual terminal control characters
- Buffering of data prepared by the TCU for release to the processor

This section examines the actual capabilities of the specific TCU's in relation to line speeds, line availability, and terminal support.

Before proceeding with a discussion of line speeds, however, it is advisable to examine the method by which transmission control units communicate with the central processor.

Multiplexor Channel Operation

Transmission control units are attachable to the System/360 through a multiplexor channel, which can be thought of as a large tube divided into subsections (subchannels) leading from the TCU to the central processor. One of these subchannels exists for each line attached to the control unit, thereby providing independent operation over each of the lines through the TCU and then through these subchannels to the processor.

For discussion purposes, let us assume that each subchannel has a processor-like module (subprocessor) attached to it to control the execution of TP instructions relating to the particular line involved. These instructions are passed to the subprocessor from the main processor, analyzed to determine the function of the instruction and executed in a "time-shared" manner with the program which is resident in the main processor.

Line Speeds

There are four major categories of line speeds available with the transmission control unit:

- Low speed (up to 15 characters per second)
- Intermediate speed (up to 150 characters per second)
- Medium speed (up to 400 characters per second)
- High speed (up to 28,800 characters per second)

All of the IBM transmission control units have low speed line capability. This speed range provides for the transmission both to and from most of the keyboard terminals available in the IBM product line, including: 1050 Data Communication System, 2740 and 2741 Communication Terminals and 1060 Data Communication System. In addition, certain teletype devices can be attached to IBM TCU's over low speed lines.

Intermediate speed lines can also be handled by all transmission control units. Examples of IBM terminals which operate over intermediate speed lines are: 1030 Data Collection System (60 characters per second), 2740 Model 2 Communication Terminal (66.7 characters per second), 2770 Data Communication System and special custom terminals which operate at 105 characters per second. The present maximum speed of IBM terminals in the intermediate range is 105 characters per second.

Medium speed devices include such terminals as the 2260 Display Station and the binary synchronous 2780 Data Transmission Terminal.

High speed has been categorized as up to 28,000 characters per second, which is the transmission rate from one System/360-370 to another. There is not only a wide range of line speeds, but also a large number of lines that can be attached to a System/360-370. The total number of lines attachable on a single system is dependent upon the size of the processor.

2701 Data Adapter Unit

The IBM 2701 Data Adapter Unit (Figure 28) is capable of controlling up to 4 low speed lines, 4 intermediate speed lines, 2 medium speed lines or 2 high speed lines –– or certain combinations of these line speeds.

The communications user who is developing a small system or expanding from data processing to teleprocessing frequently would select the 2701 for his operations because it has minimum capabilities in terms of low speed lines (4 only).

Data processing users who have two or more System/360's-370's located in different areas can use the 2701 with two high speed lines for load sharing from one computer to another or to connect a smaller processor to a larger system.

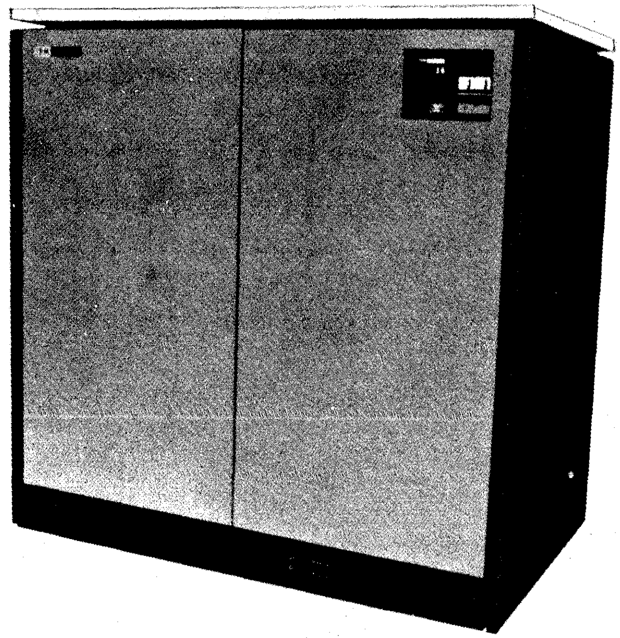

Figure 28. IBM 2701 Data Adapter Unit

In addition to low and high speed lines, the availability of up to 4 intermediate or 2 medium speed lines on the 2701 offers a great deal of flexibility in systems design. Combinations of these line speeds are also available: for example, 2 low speed lines and 2 intermediate speed lines, or 1 medium speed line and 1 high speed line. With specific adapters, the 2701 Data Adapter Unit can control a wide variety of terminal devices including:

- IBM 1030 Data Collection System
- IBM 1050 Data Communication System
- IBM 1060 Data Communication System
- IBM 2260 Display Station – (IBM 2848 Display Control)
- IBM 2265 Display Station – (IBM 2845 Display Control)
- IBM 2740 Communication Terminal
- IBM 2741 Communication Terminal
- IBM 2760 Optical Image Unit
- IBM 2770 Data Communication System
- IBM 2780 Data Transmission Terminal
- IBM 2790 Data Communication System
- IBM 3270 Information Display System
- IBM 3735 Programmable Buffered Terminal
- IBM 3740 Data Entry Unit
- IBM System/3 (in terminal mode)
- IBM System/7 (in terminal mode)
- Other System/360-370's equipped with IBM 2701's or 2703's or 3705's
- Telegraph type terminals

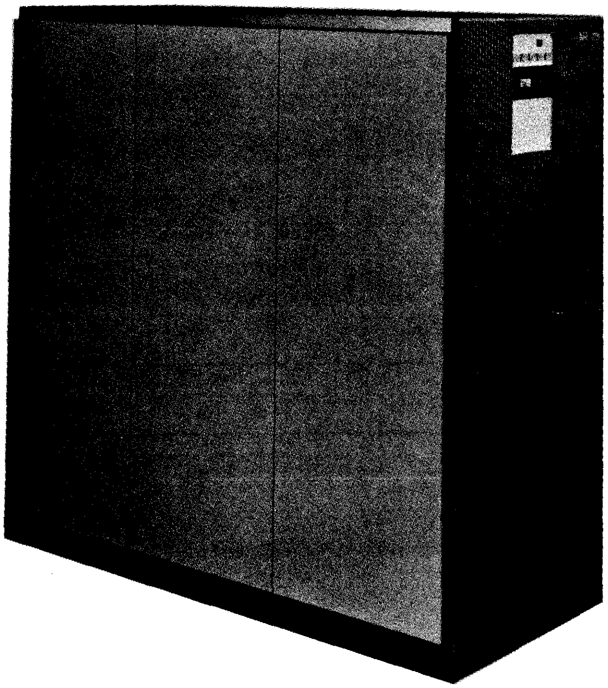

Figure 29. IBM 2702 Transmission Control

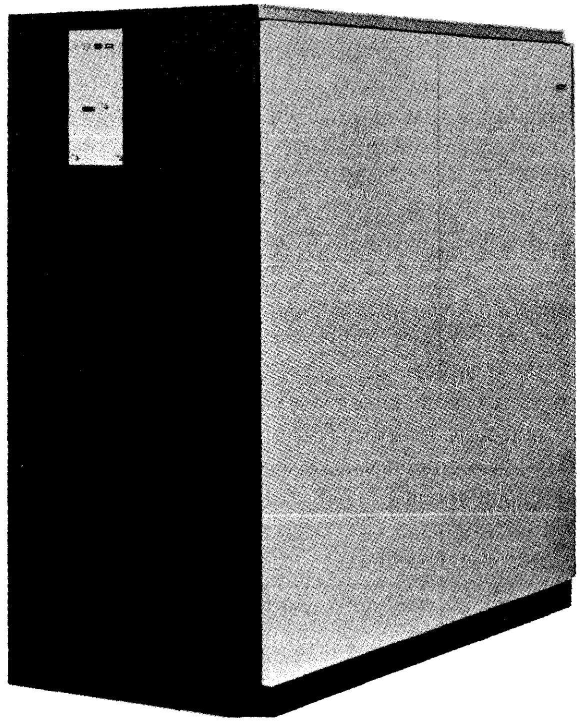

Figure 30. IBM 2703 Transmission Control

2702 Transmission Control Unit

The IBM 2702 Transmission Control Unit (Figure 29) is essentially a low and intermediate speed device, capable of controlling 31 low speed lines or 15 intermediate speed lines, or certain combinations of these line speed types (for example, 10 low speed lines and 10 intermediate speed lines).

Among the devices which can be attached to the System/360 -370 via the 2702 are:

- IBM 1030 Data Collection System
- IBM 1050 Data Communication System
- IBM 1060 Data Communication System
- IBM 2740 Communication Terminal
- IBM 2741 Communication Terminal
- IBM 2760 Optical Image Unit
- Telegraph Terminals

2703 Transmission Control Unit

The IBM 2703 Transmission Control Unit (Figure 30) is the largest of the IBM control units available and can accommodate up to 176 low speed lines, 72 intermediate speed lines, or 48 medium speed lines, or combinations of these line speed types.

The extensive line capacity of the 2703 can significantly reduce costs for the TP user who has a requirement for a large number of lines, and it also frees valuable positions on the multiplexor channel for other control units.

Devices supported by the 2703 include:

- IBM 1030 Data Collection System
- IBM 1050 Data Communication System
- IBM 1060 Data Communication System
- IBM 2740 Communication Terminal
- IBM 2741 Communication Terminal
- IBM 2760 Optical Image Unit
- IBM 2770 Data Communication System
- IBM 2780 Data Transmission Terminal
- IBM 2790 Data Communication System
- IBM 3270 Information Display System
- IBM 3735 Programmable Buffered Terminal
- IBM 3740 Data Entry Unit
- IBM System/3 (in terminal mode)
- IBM System/7 (in terminal mode)
- Other System/360-370's equipped with IBM 2701's or 2703's or 3705's
- Telegraph type terminals

Figure 31. IBM 3705 Communications Controller

3705 Communications Controller

The IBM 3705 Communications Controller (Figure 31) is a programmable teleprocessing control unit that:

- Performs most IBM 2701, 2702, 2703 functions, as well as selected host access method functions to improve CPU availability.
- Improves CPU throughput and reduces CPU load by assuming much of the message control program functions formerly performed by the CPU, such as:
  - Addressing
  - Polling
  - Data Link Control
  - CPU status to active terminals
  - Error Recovery
  - Data buffering
  - Editing of data
  - Code translation
- Reduces CPU metering.
- Reduces subchannel requirements.
- Provides easier system growth (352 lines per subchannel).

Optional Features – 3705

- Expandable to 240K bytes of core storage within 3705 in increments of 32K.
- Maximum of 352 lines with optional adapters ranging in speed from 45 bps to 50,000 bps.
- Type 1 Channel Adapter – Slow speed attachment to CPU Emulation of 2701-2702-2703.
- Type 2 Channel Adapter – High speed attachment to CPU.
- Type 1 Communication Scanner – Low speed transfer of TP data.
- Type 2 Communication Scanner – High speed transfer of TP data.
- Two Channel Switch – manual switching of 3705 between two CPU channels.
- Internal clock – provides timing to modems.

As a programmable teleprocessing control unit, the 3705 is supported by three program components:

- System Support Package (SSP)
  CPU-resident utilities:
  - Assembler
  - Generation Macros
  - Loader
  - Dump
- Network Control Program (NCP)
  Drives the communication network
  Generated by SSP, loaded into 3705
- Emulation Program (EP)
  3705 resident program emulates functions of 2701, 2702, 2703 transmission control units.

The following terminals are supported by the 3705 Network Control Program:

- IBM 1050 Data Communication System
- IBM 2740 Communication Terminal, Models 1 and 2
- IBM 2741 Communication Terminal
- IBM 2770 Data Communication System
- IBM 2780 Data Transmission Terminal
- IBM 2790 Data Communication System
- IBM 2972 General Banking Terminal System, Models 8 and 11
- IBM 3270 Information Display System
- IBM 3735 Programmable Buffered Terminal
- IBM 3740 Data Entry Unit

The NCP can run with the following IBM data processing systems operating in a terminal mode:

- IBM System/3
- IBM 1130 Computing System
- IBM System/7
- IBM 1800 Data Acquisition and Control System
- IBM S/370 Model 135 with Integrated Communication Attachment
- IBM S/360 Model 25 with Integrated Communication Attachment
- IBM S/360 Model 20 with Binary Synchronous Communication Attachment.

The NCP supports System/360 or System/370 via an IBM 2701 Data Adapter Unit, IBM 2703 Transmission Control Unit or another IBM 3705 Communications Controller.

In emulation mode, the 3705 can support IBM terminals and systems (in terminal mode) already listed, plus the following IBM equipment:

- IBM 2260 Display Station via a communication line
- IBM 2265 Display Station
- IBM 3670 Brokerage Communication System
- IBM 1030 Data Collection System
- IBM 1060 Data Communication System
- IBM 2760 Optical Image Unit

The NCP can run with the following line controls:

- AT&T 83B2/B3
- WU115A
- TWX Model 33/35

CUSTOM SYSTEMS PRODUCTS

The Custom Systems function is responsible for developing terminals and systems in response to the needs of a particular customer or industry. This could include modification to existing products, or equipment tailored to a specific operation, environment or advanced application, and devices to improve the efficiency of teleprocessing systems.

Most products from Custom Systems are purchased by the customer. The purchase price would include the cost of development, engineering and manufacture. Program support and equipment maintenance by IBM may be included as part of the contract, be negotiated separately, or be provided by the customer.

Obviously, the cost per unit for a few devices or products would be relatively high since they must bear the full burden of the development and engineering cost. For this reason, the number of units required by the customer or within a particular industry sector, and the estimate of the resulting per unit cost, are major factors in the evaluations of a new request. It might be economical to manufacture a few units of a highly sophisticated product, but it would probably take a significant number of units to economically justify a "low cost" device.

Usually existing and proven components and technology are utilized to minimize the investment in development and engineering. The objective in Custom Systems work is to provide the customer with a product to meet his requirements at the best possible cost and schedule.

As new technologies and devices are developed, they are examined for incorporation into custom products. An example is the document feed in the 1255 Magnetic Character Reader which was subsequently adapted as a bank-note feed mechanism in a cash issuing terminal for the banking industry. As new industry requirements emerge, such as improved defect reporting in the automobile industry, Custom Systems responds with devices such as the 2990-16 inspection work station for use by the inspector on an automobile assembly line. While some of these devices satisfy specialized applications for a particular customer or industry, others become the basis for products with broad industry applications.

The user interested in devices to meet a particular functional requirement should consult with his local Marketing Representative. A joint study is often helpful to define the required functions in detail and to determine the need for a Custom Systems device.

Communications Terms and Concepts

The basic definition of teleprocessing as previously presented in this publication is data processing plus communications. To users of TP systems who are already familiar with the terms and concepts of data processing, this definition indicates that there is an additional need for understanding communications terms and concepts as well –– simply because communications play such a vital role in teleprocessing systems.

The jargon of the communication industry is foreign to most data processing users and, conversely, data processing terminology may be foreign to the communications user. Teleprocessing, therefore, forces a merger of both if the user is to evaluate, design and implement communications-oriented systems effectively. Not only must the teleprocessing decision maker (or implementor) be familiar with communications fundamentals, but he must also be familiar with the devices and facilities available to him.

The objectives of this chapter are to describe the following primary requirements of a TP system:

- Communication networks
- Communication equipment connections
- Character codes
- Modes of transmission
- Error detection
- Terminal control
- Communication tariffs

COMMUNICATION NETWORKS

The main function of a communication network is to carry information from one location to another. These paths of data movement are referred to as channels (also called circuits or lines).

A channel may be a group of wires, capable of being a path for electrical transmission, or part of a radio frequency spectrum. For example, IBM has accomplished data communications between the United States and Europe via orbiting communications satellite, which obviously was neither a two or four wire electrical transmission. Also, transmission of data can be accomplished via micro-wave or coaxial cable transmission facility. The common carrier may provide data transmission service to any location as either a two-wire or four-wire connection, at his convenience, however, and with very few exceptions, the user should not be concerned with the number of wires the common carrier uses – only the service provided.

There are basically two types of networks available for teleprocessing:

- Switched
- Non-switched

A switched (also called dial) network is one in which the connection between a terminal and a CPU is made through common carrier exchange equipment. Switched networks are those used with private home and business telephone transmissions and may be characterized by low line utilization from an individual terminal (one terminal dialed or connected per line at one time to the CPU). Dialing establishes a connection, and the connection is maintained only while transmitting data.

Typical IBM terminals utilizing a switched network are the 1050, 2740, 2741, 2770 or 2780. The switched network implies one terminal per line; therefore, buffered terminals like the 2740 Model 2 would not produce an economic communication cost reduction. The buffer, you may remember, is provided to allow multiple terminals to coexist on the same communications line.

If the TCU at the central site is equipped with an automatic calling facility, it can, under program control, issue a sequence of dialing digits. Otherwise, manual dialing is used at either the terminal or the computer. Another very helpful and desirable facility is auto-answer, whereby the answering location automatically responds to the originating location. There is also a provision at each location to change the "mode" of transmission between talk mode (for normal voice communication) and data mode (for transmitting data).

A nonswitched network is one in which the lines connecting the computer and terminals are permanently established. These do not require dialing and are available for use at any time. They are known as:

- Leased Lines – Lines leased from the communications common carrier on a monthly contract basis and attached directly to the computer and the remote terminal(s).

- Private Lines – Lines privately owned by your company and attached directly to the computer and the remote terminal(s).

Figure 32 illustrates the communications facilities available.

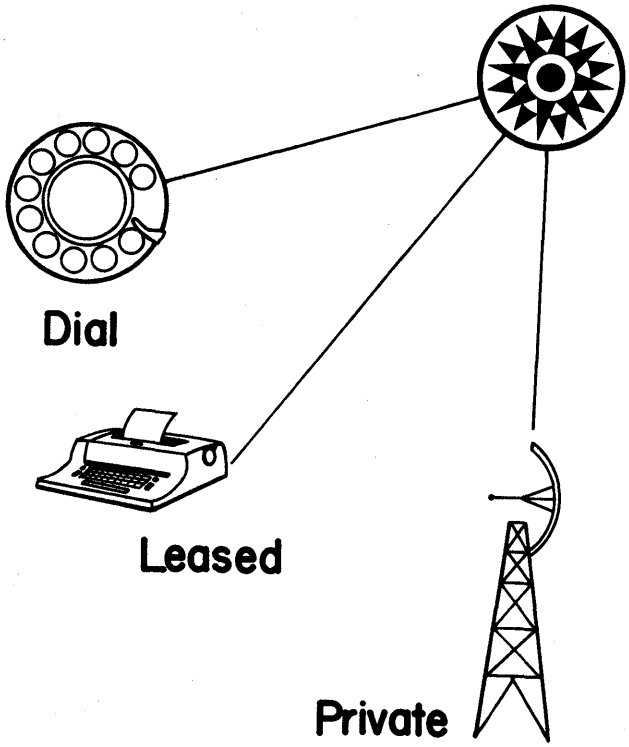

Figure 32. Communications Facilities.

TYPES OF CHANNELS

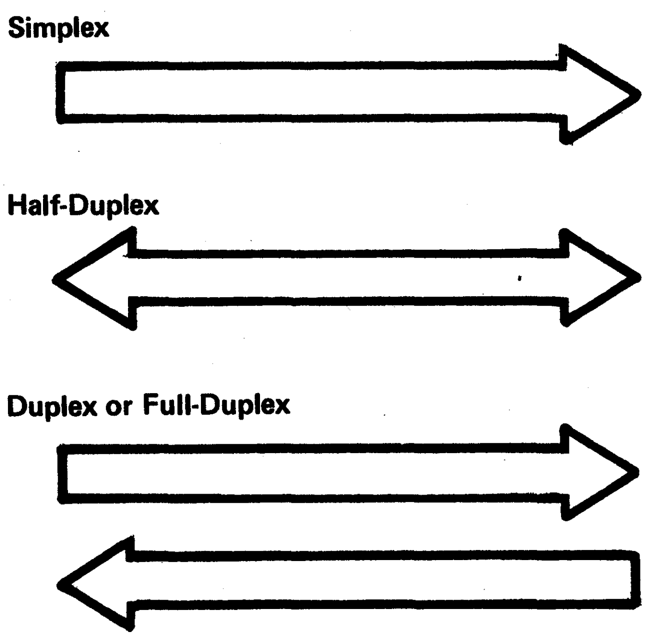

Figure 33. Movement of data over communications channels.

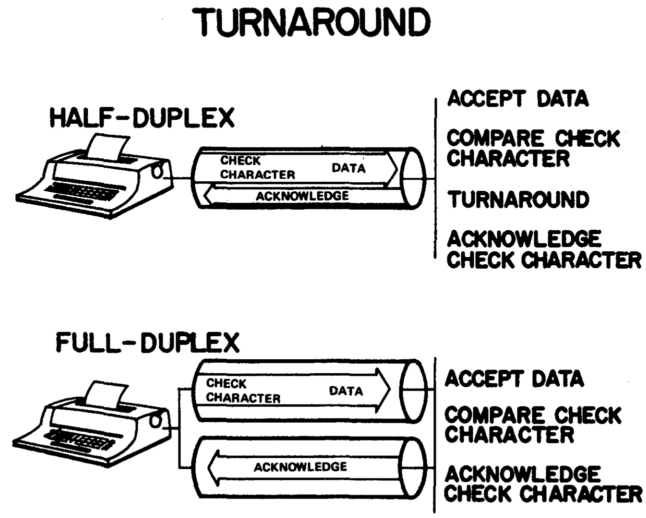

Figure 34. Line turnaround for half-duplex and full-duplex channels.

A communications line can be further classified according to the direction in which it moves data:

1. A line that can transmit data in only one direction is a Simplex line. Simplex service is no longer available from the common carriers and is mentioned only from an academic viewpoint. The common doorbell would be an example of a Simplex circuit.

2. A line that can transmit data in either direction, but not simultaneously, is called half-duplex. This is a service offered by the common carrier and is used daily in voice-to-voice transmission and data transmission. Dial (switched) lines are half-duplex only and constitute a major portion of the line types used in data transmission.

3. A line that can transmit data in both directions at the same time is called duplex. Duplex is possible only on leased or private facilities. The main advantage of full duplex is the reduction of turnaround or error checking time required in transmission. There are very few terminals today that can accomplish true duplex transmission of data.

Figure 33 shows the movement of data over communications channels.

Figure 34 compares the line turnaround for half-duplex and full-duplex channels.

TRANSMISSION SPEED

A line can also be classified by its speed; that is, the maximum rate at which it can accommodate data transmission. Modern transmission techniques utilize the features of A.C. (alternating current) to accommodate this transmission.

Many familiar items are of the A.C. family:

- Ordinary home electrical power
- Sound waves
- Radio waves

A.C. signals vary, or oscillate, at different frequencies and different amplitudes. For example, ordinary home electrical power oscillates at 60 cycles per second and has an amplitude of 120 volts.

The human voice falls in the frequency range of 50 to 16,000 cycles per second. 3,000 cycles per second range, or frequency band, has been found sufficient for recognizable voice transmission.

Normal transmission of voice frequencies is superimposed on another higher transmission frequency (modulated). Several of these "modulated" frequencies can be transmitted on one transmission line, as long as they do not overlap. Once the data arrives at the receiving location, the various voice frequencies must be separated out or "demodulated".

The quality or number of these modulated frequencies is sometimes expressed in terms of bandwidth or the range of frequencies the line can accommodate. Directly related to the bandwidth of a line is its speed capabilities in bits per second.

A bit is a section of a digit or character. In Morse Code Transmission, dots and dashes can be thought of as bits. In the transmission of data using business machines, there exists a "charge" of electricity on the line or the absence of a charge, a change of frequency (or tone) or the absence of a change. These frequencies of electricity oscillations can be defined as "bit" or "no bit" conditions. It takes several bits (or segments of a character as in Morse Code) to determine a character, the number of which depends on the transmission code and transmission technique used. Each bit transmitted requires a specific amount of time on the line, and the bit rate, expressed in "bits per second" (bps), is the reciprocal of this amount of time. Normal data transmission is handled by five, six, seven or eight bits to produce a character, although added control bits will normally expand this by 2 or 3 bits.

Another term frequently used to express speed capability is baud. To properly define this term would require a more detailed discussion of transmission techniques than is warranted in a publication of this scope. Because the numerical value of a line's speed in bauds and in bits per second is often the same, the two terms have come to be used interchangeably. This is, however, incorrect as the two terms are not synonymous. The term baud should be avoided, and the more useful bits per second used instead.

Speeds of transmission (for example, 75 bps, 150 bps, etc.) are determined by the kind of telephone or telegraph line used. At times speed is referenced in terms of characters per second (cps), where low speed transmission might be defined up to 15 cps and high speed could be defined up to 28,800 cps. On the other hand, telegraph lines historically have been referred to in terms of having 60, 75, or 100 words per minute. Normally, six characters are considered a word in data communications; however, the speeds of lines that are faster than teletype are usually referred to in either bits per second (bps) or characters per second (cps), rather than in words per minute (wpm). Summarizing, a bit is a binary digit; a character is normally 5, 6, 7, or 8 bits; a word is normally 6 characters and transmission speeds are defined in terms of bps, cps and wpm.

Many different types of channels in a variety of speed capabilities are available. For data communication purposes, they may be classified as follows:

1. Narrow-band, or low-speed lines have a bit rate of up to 300 bits per second (bps). Included in this category are telegraph-grade and sub-voice grade lines, which refer to the lower speeds in the narrow-band range.

2. Voice-band or voice-grade lines operate at medium speeds — over 300 bps. The term voice-grade is used because this range can be accommodated by the circuits used for ordinary voice communication in the audio range (frequencies that can be heard by the human ear).

3. Wideband (also called broadband) or high-speed lines operate at bit rates of about 18,000 bps and higher. These lines often are used for transmitting data directly from one computer to another at very high speeds. Broadband can be subdivided into several voice grade lines or telegraph lines.

Note that the foregoing discussion pertains to the rated capacity of a communication line. Actual data rates will be lower. The actual speeds depend upon the sending speed of the terminals attached to the line and, in the case of keyboard-entered data, upon the keying speed of the terminal operator.

COMMUNICATION EQUIPMENT CONNECTIONS

The interface between the communication line and the processor is called a TCU. A remote terminal is connected to the communication line, which in turn is connected to the transmission control unit. Finally, the TCU is connected to the processor unit via a multiplexor channel. (See Figure 35.)

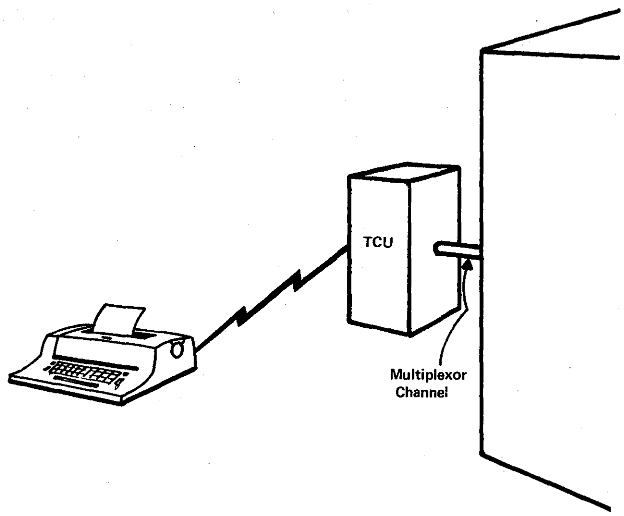

Figure 35. Multiplexor channel connecting the TCU and the processor

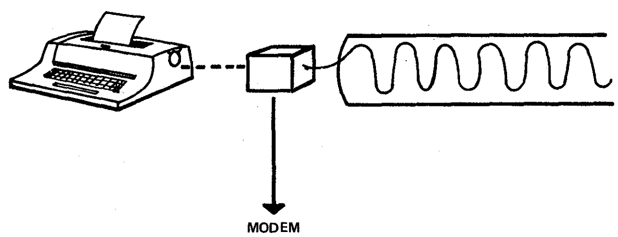

Figure 36. Intermediate interface between the device and the line

Telephone grade facilities are the type used most frequently for data communication because of higher speed capability. Telephone lines have been engineered to handle human voice; therefore, it is necessary to convert business machine signals to something that may be transmitted over the lines. In order to convert business machine language to that of the telephone line, it is necessary to have an intermediate interface between the device and the line.

This translator (or conversion) function is referred to as modulation or demodulation (see Figure 36). It converts the tones into direct current (or vice versa) such that the business machine can accept the pulses in a meaningful manner. There are frequently used terms (or names) to describe the modulation/demondulation device. The term used by IBM is line adapter. Frequently, the line adapters are referred to as modems (an abbreviation of modulation/demodulation). Another synonym is data set (used by the common carriers in regard to their specific types of modems or line adapters). Modems supplied by IBM or any vendor other than a communications common carrier may presently be attached to leased lines only.

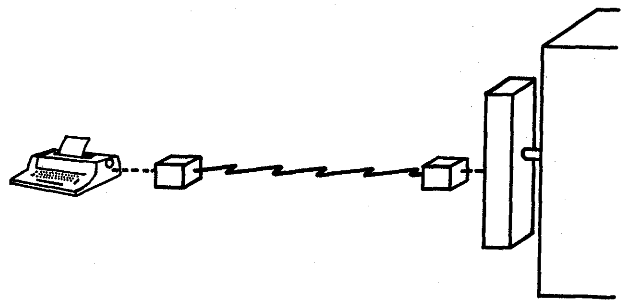

Figure 37. Modems of same type and speed at both ends of communications line.

(This applies to modems which are electrically interconnected to the line; acoustically coupled devices may be used on dial lines. This presentation does not concern itself with acoustic modems.) In this publication, the term line interface is used.

The modulation and demodulation function must be performed at both ends of the communications line which is attached to the business machine. The modems must be of the same type and speed on any single line attached to a system (see Figure 37).

There are four major types of data sets furnished by the common carrier; namely, the 100, 200, 300 and 400 series.

The 400 series is a parallel tone data set which enables tones (bits) to be received or transmitted in parallel. The common carrier classifies these as the 400 series or parallel tone data sets. They can be used with IBM 1001, 1093 or the audio response unit (7770/7772). The touchtone phone may be used as a remote terminal generating tones which are compatible to these data sets for audio response.

The most common type of data set that can be attached to voice grade lines and transmit information into the terminals or transmission control units using common carrier lines is low speed serial (100 series).

Medium speed serial data sets (200 series) perform modulation/demodulation up to 2,400 bits per second. As examples, these are used for 2780, 1130 or Model 20 transmission. It is possible to use lower speed models for transmission at 66.7 CPS for the 2740-2 and 60 CPS for the 1030.

The 300 series data sets are used with high speed (or broadband) transmission.

Figure 38 illustrates the operation of the modem types described above.

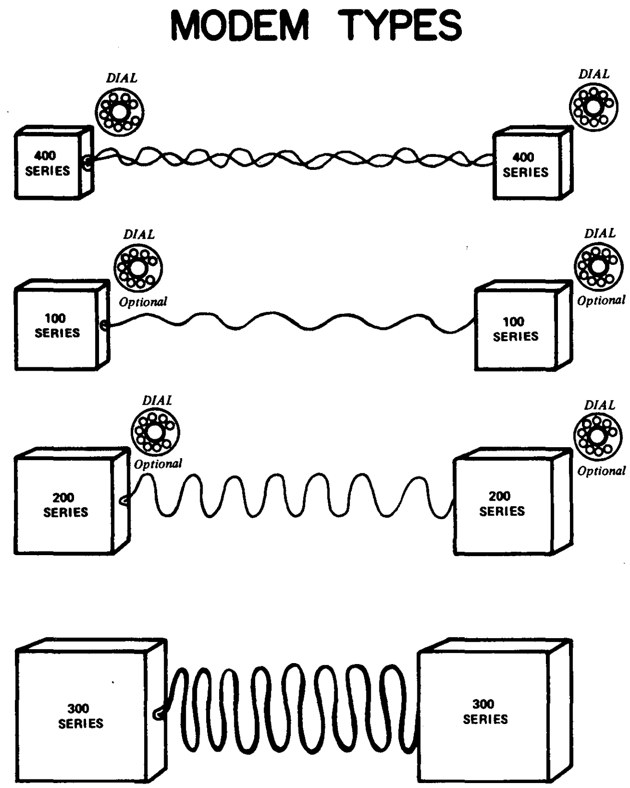

Figure 38. The operation of modem types.

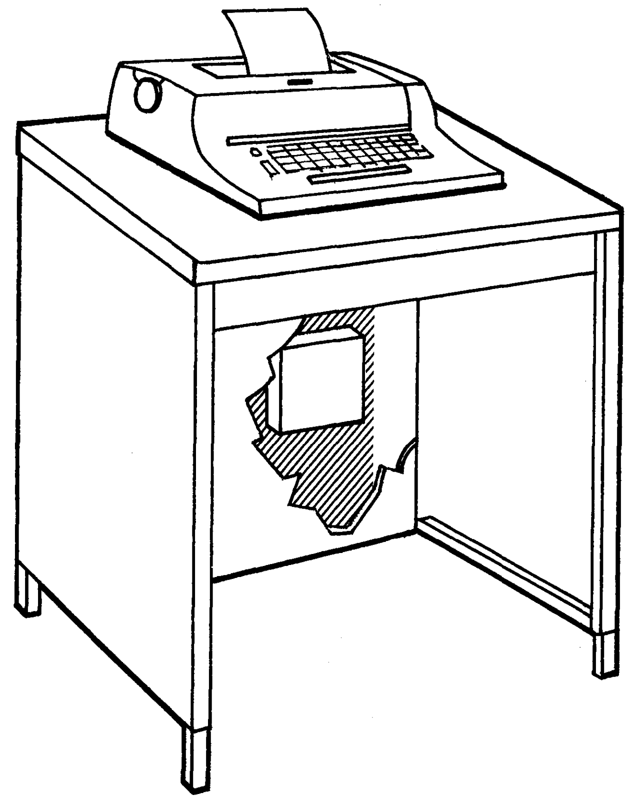

Figure 39. IBM Line Adapter

IBM Line Adapters

IBM's line adapters are used in conjunction with leased voice grade lines (Figure 39). They do not have dial-up facilities nor are they designed to accommodate voice transmission. Data transmission is their specific purpose.

Three types of line adapters are marketed by IBM:

- Local line adapter
- Leased line adapter
- Shared line adapter

Local Line Adapter

There are two types of local line adapters: the eight-mile line adapter and the 4.5-mile adapter (circuit miles). These are limited distance line adapters that are used in industrial complexes where the terminals are located within eight miles (or 4.5 miles) of the central processing unit. Examples are the 1030 Data Collection System or an internal 1050 System that is communicating within a campus, a plant or manufacturing area. The 4.5-mile limited distance line adapter is designed for exclusive use with the 2740 and the 2741. The eight-mile line adapters are designed for use with 1030, 1060, 2740 and 2741.

Leased Line Adapter

The leased line adapter is identical in terms of physical appearance to the local line adapter, inasmuch as it is a series of printed circuit cards under the covers of the terminals. The leased line adapter, however, has the capability of being attached to long distance or unlimited distance leased voice grade lines supplied by the communications common carrier. It is the equivalent of common carrier leased line data sets where no dialing facilities or no voice communications are required. It should be emphasized that no common carrier data set is required where the IBM line adapter is installed.

The leased line adapter has a transmission capability of up to 600 bits per second and can be used in a multi-drop fashion on a line with several terminals attached. For example, if a computer system in New York had a leased line to Los Angeles, the adapter could be used on the "drops" in Chicago, Denver and Los Angeles. In each of these cases, the terminals could have the leased line (or unlimited line adapter) and transmit and receive in the same manner as a common carrier data set.

IBM LINE ADAPTERS

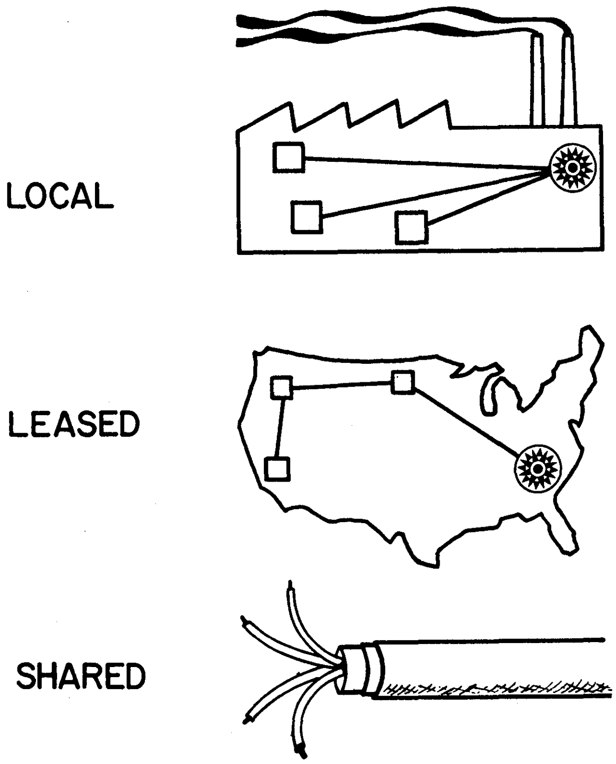

Figure 40. The three types of IBM line adapters.

Shared Line Adapter

The shared line adapter is identical to the leased line adapter in terms of distance; however, it has one additional capability for increased line utilization. The 600 bps voice grade line is divided into four subchannels or sections, each capable of 150 bps operation. Consequently, the volume of data transmitted on this voice grade line can be increased by a factor of four, and the user can multi-drop terminals off each of the four subchannels in the same manner as he would on one leased line. This increased line utilization can result in considerable dollar savings to the user.

The shared line adapter is a line savings device and can be used very effectively where linear clusters are centered. A linear cluster is a number of terminals that are located in a long line or linear configuration either across the United States or within a state.

Figure 40 represents the three types of IBM line adapters available.

The electrical interface between data processing equipment and communications equipment is defined by industry standards. This means there is little need for system designers and programmers to become intimately familiar with modulation techniques.

CHARACTER CODES

As previously discussed, TP systems use several different methods to represent data characters. Some of these were originally designed for communications equipment; others are derived from codes used for representing data on computer equipment.

In some codes, often termed shifted codes, certain control characters are used to specify the way in which following characters are to be interpreted. With the use of control characters in this manner, each bit pattern can represent more than one symbol. Thus, in this type of code, the number of characters that can be represented is greater than the number of distinct bit combinations. However, these codes have the disadvantage of sometimes requiring two coded characters (a shift control character and a graphic character) to represent one symbol. The following coding structures are the most commonly used coding schemes.

Baudot Code

The Baudot code uses five bits to represent each character. This coding structure allows only 32 combinations and therefore does not permit identification of the 26 alphabetic letters and 10 digits of the decimal system. To overcome this problem, the Baudot code assigns two characters to many of the five bit combinations.

To distinguish between two characters having the same code and thereby increase effective code structure to 57 characters and functions, two "shift characters" are utilized. A "letters" character is used to signify lower case printing; a "figures" character is used to signify upper case printing. The necessity to insert "figs" or "ltrs" shift codes when going from alphabetics to numerics with devices using Baudot code can be significant because more characters must be transmitted for a given application than would be needed for a "non-shifted" code set.

USASCII

The absence of checking and the limitation on the number of characters representable in Baudot Code have led to increasing use of a code termed ASCII or USASCII (United States of American Standard Code for Information Interchange). This is a seven-level code and provides 128 possible characters. An eighth parity bit, though not part of the standard, is often associated with the seven data bits. The

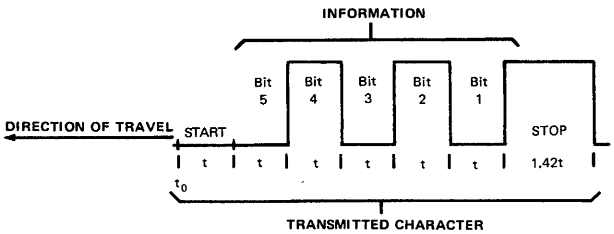

Figure 41. Asynchronous signal

USASCII character set consists of 34 control codes and 94 text characters including the letters of the alphabet in both upper and lower case, the 10 digits, and a number of special characters.

EBCDIC

Another widely used code is EBCDIC (Extended Binary Coded Decimal Interchange Code). This is an eight-level code and, as the name implies, it is widely used for exchanging data between computer systems. It has 256 possible combinations: 17 of these are used for control purposes, 96 are used for text characters and the remaining code combinations are unassigned.

In addition to the dissimilarity of code structure between the EBCDIC and USASCII codes, their collating sequences (ordering of the binary representations of the characters) differ. In the USASCII collating sequence, for example, digits precede letters; in EBCDIC, digits follow letters. Thus, the characters A, B, C, 1, 2, 3 are in sequential order (ascending) in EBCDIC, but not in USASCII.

Many TP systems can accommodate several different codes by providing for code conversion or translation between different code representations. For example, data may be received in one transmission code, converted to another code suitable for computer processing, and then converted to still a third code suitable for transmission to an output terminal.

Translation tables are used to convert from one character code to another, and special computer instructions often are available to utilize such tables automatically. Another aid for conversion to and from 5-bit codes is the incorporation of a shift bit along with the five data bits to form a 6-bit code, thus eliminating the need for explicit shift characters. This considerably simplifies internal processing since all characters are represented by a single byte (8 bits) rather than a pair of bytes.

MODES OF TRANSMISSION

Regardless of the bit configuration (code) used to transmit data, some method must be devised to allow the mechanical interface to recognize the specific beginning and

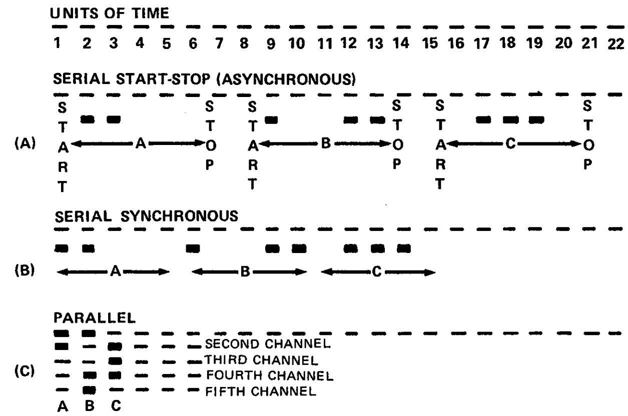

Figure 42. Transmission modes

ending of each character.

There are two primary methods or modes of transmission:

- Asynchronous
- Synchronous

Asynchronous Transmission

A typical asynchronous signal (used in Baudot Teletypewriter machines) is shown in Figure 41.

The five information bits representing a character are preceded by a zero bit, one unit of time in length and followed by a one bit of 1.42 units of time. These "start" and "stop" bits are used to separate characters and to synchronize the receiving station with the transmitting station. When signal elements or bits of a character travel in a transmission medium in sequence (first bit first, etc.) as shown in Figure 42(A), it is called a serial mode or serial transmission.

With the start and stop bits added, this type transmission is called serial start-stop or asynchronous, meaning each character is individually synchronized. (See Figure 42.)

Synchronous Transmission

Figure 42(B) shows a series of bits traveling in a communications medium without the start-stop bits. This is synchronous transmission. It requires more complex and usually more costly terminal equipment because synchronous systems are "clocked" or "fixed rate" systems, meaning that the line is sampled at regular intervals to receive and record information bits. Synchronous transmission permits more information to be passed over a circuit per unit time because no transmission time is required for the insertion of start-stop signal elements. Figure 42 (A and B) shows that 21 units of time are required for asynchronous transmission compared to only 15 units for synchronous transmission of the same information.

	SERIAL		
	START-STOP	SYNCHRONOUS	PARALLEL
ADVANTAGES	Little, if any, data lost through lack of synchronization as each character is individually synchronized	Good ratio of data to control bits (low redundancy)	Low cost transmitter
DISADVANTAGES	High rate of control information to data information (low redundancy)	Much data can be lost between synch pattern if devices become "un-synched"	High cost receiver may waste bandwidth

Table 2

It is possible to send all the information bits in a character simultaneously over separate paths or channels as shown in Figure 42 (C). This mode of communication is called parallel transmission.

The advantage of parallel transmission which makes the transmitters less costly than the receiving equipment is the relatively low cost of producing such a signal. The parallel mode of transmission is most commonly used where the increased bandwidth is cheaper than serializing equipment, or where more transmitters are required than receivers.

Let us summarize the advantages and disadvantages of various methods of transmission discussed so far (see table 2).

ERROR DETECTION

The subject of checking is extremely important in any discussion of data communications systems. Communications lines are subject to interference that may distort or mutilate bits being transmitted. The purpose of "error detection" or "checking" is to determine that the data received is identical to the data transmitted. Cost is a consideration in selecting terminals with or without error-detecting capabilities. The first problem to be resolved on this topic is to determine the degree, if any, to which management can compromise the integrity of the data being transmitted. Systems primarily involved in administrative traffic do not require "checking" capabilities as would systems designed primarily for processing financial data (for example, accounting or banking systems).

Common carrier facilities do not generally provide automatic checking facilities. The burden of error detection and correction falls upon the computer and terminal equipment at either end of the communication channel. These checking requirements are handled through a combination of terminal, TCU and programming systems.

Checking characters are generated by the sending IBM terminal so that the receiving or processor terminal can determine the validity or acceptability of that particular message. An acknowledgement is sent back to the sending terminal by the receiving terminal after the check character has been compared. This acknowledgement identifies the message as correct or incorrect for subsequent action. There is a turnaround time required by the electronics for this return transmission.

When a message is transmitted into the CPU, the central unit compares the check character received from the terminal, the electronics "turn the line around" such that the CPU or transmission control unit can transmit the acknowledgement back. Finally, the acknowledgement character which is sent back is either a positive or negative response based upon the comparison of the message in relation to its validity and accuracy.

This turnaround time in a large network can become extensive. One advantage of full duplex capability is that the acknowledgement can be transmitted back faster because of the reduction in time required to turn the line around. For full duplex, the line is already electronically set to transmit the positive or negative acknowledgement back to the transmitting terminal.

Three types of checking facilities are used with IBM machines:

- Parity check
- Longitudinal check
- Cyclic check

Parity Check

The "parity check" or vertical redundancy check (VRC), as it is sometimes called, is a count of the number of bits in a character to determine if there is an odd or even number to construct the character. If odd parity is used, the number of bits transmitted must be odd. Since the actual data could be either odd or even, the parity bit is generated at the remote terminal and placed in the character that does not comply with the odd condition. When the character is received from the line, it is checked for odd parity. This tells whether a bit is missing or generated as a result of line distortion for that particular character. This type of checking, however, does not check for substitution or transposition of bits within a character that could cause it to be received as another character.

Longitudinal Redundancy Checking

The problem of transposition is satisfied by Longitudinal Redundancy Checking (LRC). The LRC check consists of a final character transmitted at the end of a message to check message parity. This will check for the addition or omission of valid generated characters formed by line problems.

Cyclic Redundancy Checking

Finally, there is a new concept in data transmission checking that is used with Synchronous Communications – Cyclic Redundancy Checking (CRC). CRC is more efficient for higher speed transmission than the VRC/LRC combination because parity is not required with each character. The CRC is a two-character sequence that is transmitted at the end of each message in the same manner that the longitudinal check is transmitted. Although Cyclic Redundancy Checking in communications is relatively new, it has been recognized as an excellent means of checking by virtue of its use in the IBM disk storage files for a number of years.

TERMINAL CONTROL

Most computer input/output equipment uses separate paths (or lines) to transmit data and to indicate control functions. TP equipment is connected to a computer with one or (in the case of duplex transmission) two lines. Consequently, conventions must be established to identify and distinguish between the data and the control information that must be transmitted over the same communications channels. Several factors are involved.

One factor is that, unlike other I/O devices, a terminal often is not continuously connected to the system. The terminal user may dial the computer to submit input, or the computer may establish contact with the terminal (via the automatic calling facility described earlier) prior to transmitting output data. Although most of this is handled by automatic calling and answering, the system must still initiate and confirm the communication link to the terminal. This introductory communication is sometimes called "handshaking".

A second factor is that several terminals may be attached to the same private or leased line. This reduces the cost of the communication facilities but requires additional control conventions to determine which of the terminals is to send or receive data. Terminals designed to operate on multi-point lines (those connected to multiple terminals) have special control units or "buffers" that provide this capability and operate in one of two modes: control or test. When in control mode, a terminal interprets received characters as special control codes; when in text mode, a terminal treats most characters as normal textual data.

In the case of input, the computer sends one or more control characters to place all terminals in the control mode and then, using "polling" characters, it invites a specific terminal to send any messages it may have. If a polled terminal is ready and has a message to send, it reverts to text mode to transmit the message. Other terminals on the same line remain dormant. If a polled terminal is ready but does not have a message to send, it usually responds with a code indicating its ready status. If the computer does not receive any response within a brief time, then the terminal "times out" and is considered not ready.

Output from the computer to the terminal is controlled in a similar fashion. The computer first addresses (attempts to select) the receiving terminal by means of a control sequence. If the terminal is ready to receive, it responds to the computer with an acknowledge character and goes into text mode. The computer then transmits the output message.

COMMUNICATION TARIFFS

The previous section presented the functions relating to some of the communications hardware and communications lines. This section examines the monthly charges for the use of the communications lines; that is, the dollars that the user must pay to the common carrier.

Long distance telephone frequently represents the most economical means of handling data traffic. Where volumes are relatively low and medium speed transmission terminals (up to 2,000 bits per second) are used, time can be reduced significantly. This might be especially true in a TP network involving a limited number of locations. For a greater volume and perhaps more locations, WATS may be considered. The Wide Area Telephone Service or WATS service, as it is frequently called, is a dial-up service that is available from the telephone company and will provide for transmission up to 2,000 bits per second.

WATS is a six-zone billing method for service over the regular switching networks based upon the distance from the central terminal to the remote terminal. The user can place a call anywhere in the United States if he has requested a zone six service. Zone five service covers a somewhat smaller area; zone four is even more restricted, and so on. The user may call any zone of lesser distance up to and including the zone service he purchases. WATS is available on either an Inward or Outward use and either on a full time or part time basis. The billing arrangements for leased lines are different from the dial-up WATS lines because leased lines are hardware connected to the computer and the terminals, and there may be several terminals on a line. A leased line might go from New York to Chicago to Los Angeles, for example, with terminals in Chicago and Los Angeles and the data processing center in New York. The leased line running from New York to Chicago is called an inter-exchange line. Every time a terminal is attached in a different city, we have a channel termination and the channel is also terminated at either end in the telephone office. The additional line running from the telephone office out to the specific factory or headquarters where the terminal is located is called the local loop.

There are monthly charges for leased lines that are filed with the Federal Communications Commission (FCC). These are called tariffs and are based upon many factors that relate to distance, geographical locations and the speeds of lines. Another cost, which is a monthly charge, is the channel termination charge, which can vary depending on the types of lines and the local operating company and the tariffs filed with the state, Public Service Commissions or the FCC. The channel termination charge is for connecting the leased line to the particular telephone office (switching office) in a terminating city.

The local loop charge is the monthly cost to connect the line from the switching center to the particular factory as mentioned earlier. This may vary from $7.50 a month up to $10.00 per month. Leased line tariffs are based upon the rates filed with the Federal Communications Commission.

For an example, suppose that a voice grade leased line from 0 to 25 miles has a rate of $3 per mile per month. From 25 miles to 100 miles out, suppose that the rates are reduced to $2.10 per mile per month for every mile, and then from 100 to 250 miles the rates drop to $1.50 per mile per month, etc. Obviously, a long line without a channel termination has very low rates at the long distances.

Line utilization is limited when the number of terminals on the line is substantial, so that there is an advantage to using the shared line adapter. The shared line adapter, which has the ability to split a voice grade line into four equal parts, would, in essence, reduce the tariff at the supposed maximum distance of $.75 a mile down to one quarter of that, or a little less than $.20 per mile per month.

This section has introduced some of the more important characteristics of commonly used communications equipment. More detailed information may be found in the technical reference manuals listed in the bibliography.

Every user of a teleprocessing system has different requirements to consider in the design of the TP system to satisfy the goals of his installation. Naturally, to provide a comprehensive and realistic study of all of the elements involved in the design of every conceivable TP system, several volumes of material would be required. This type of coverage is beyond the scope of this text, and only those areas of major concern in TP systems design will be discussed.

The elements of TP systems design presented are:

- Terminal selection
- CPU configuration
- Operator considerations
- Network design
- Systems programming (BTAM, QTAM, TCAM)
- Application programming

The topics to be discussed follow the systems design flowchart shown in Figure 43. This flowchart is keyed to the topics presented in this section to provide easy reference.

SYSTEMS DESIGN OVERVIEW

The subject of TP Systems Design may be divided into two major areas of investigation: REMOTE and CENTRAL.

The central staff includes the trained personnel who possess the DP knowledge to operate, program, design and manage the CPU and its peripheral devices. These people "understand" data processing terminologies, guidelines and limitations.

The remote user, on the other hand, is concerned only with the terminal devices available to him for communication with the CPU. These devices are located at some distance from the central installation, at a location which could be one floor, one block or five thousand miles away. This distinction between central and remote is made because the users of these terminal devices are not data processing (DP) experts and require a different orientation than do DP personnel in the area of systems design.

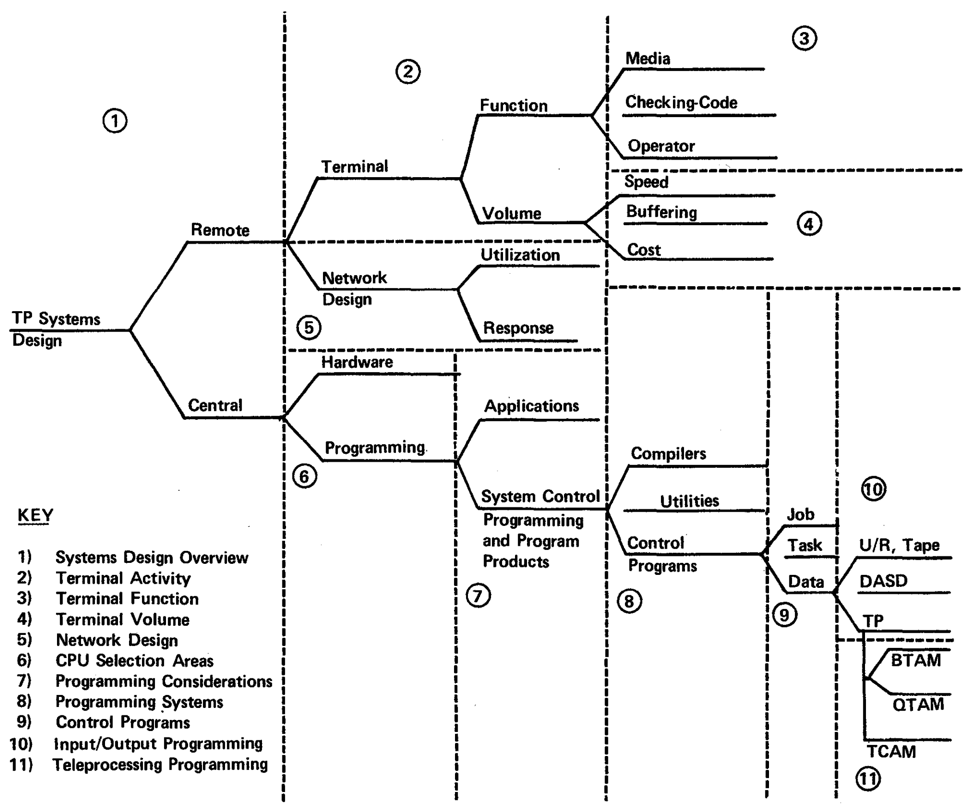

Figure 43. Systems design flowchart

For example, if a terminal operator is in the process of entering data via a visual display terminal and the display screen suddenly becomes blank, she will probably telephone the central CPU site to query the trouble. The central CPU personnel will most likely inform the operator that the program just failed, but she has no idea what a "program" is, much less what "failed" implies. Obviously, some type of terminal operator/CPU site interface is required, and this interface should be considered as part of the extensive planning in the design of a TP system.

TERMINAL ACTIVITY

The remote area can be further subdivided into two categories: the TERMINALS and the NETWORK.

The terminal(s) to be used must be selected before a realistic network design can be made. As previously discussed, terminals fall into several classes and operate over many different network speeds using a number of coding structures, Consequently, both the terminals and their respective speeds must be decided upon before any intelligent decisions can be made regarding the network required.

Terminals may be categorized by class as function-oriented (visual display, hard copy output; and audio) or volume-oriented (1050, 2770 and 2780 batch systems and intelligent terminals).

Function-oriented terminals are too often chosen by infatuation, hasty examination of the terminal function itself or pure guesswork. An individual who listens to an audio response demonstration and becomes overwhelmed with the thought that a computer can really produce a meaningful and intelligent sound might be so impressed by the audio response unit that he selects it without understanding its purpose or its application. After all, the terminal in use is an everyday telephone, and it may or may not be the proper choice. Assume that this user, based on one or more of these "quick" decisions, designs, plans and installs a nation-wide audio system. A considerable amount of time and money are then spent in developing the universal data base that is required to provide remote audio inquiry and record update functions.

Soon after the first month of operation, the company controller detects a sizeable dollar error in the A/R balance. He then pinpoints the remote office responsible for the error. This branch manager is then informed that his location is $5,000 out of balance and is requested to take the necessary action to correct the "books". First, the branch manager will probably isolate the approximate date the error occurred. He will next request from the terminal operator a list of all the A/R accounts updated between the first and thirteenth of the month. Remember, she only has a telephone as the input/output terminal, and no hard copy documentation was provided. Undoubtedly, the operator will question why she should have kept a record of the transactions made at "any" time, much less last month.

Please note that the terminals were installed to solve remote input problems and it appears that this installation may have selected the wrong terminal to meet its requirements. If an audit trail was required at the remote location, possibly a typewriter-oriented terminal would have been a better choice, since the requested audit information would have become a by-product of each inquiry or update.

The audio response system yields a very desirable TP system for some applications, but it is definitely not designed to produce remote audit trails. The central CPU site should have provided, in the system design, an adequate audit trail for each record updated, but this requirement was either ignored or overlooked. In the design of a TP system it is always wise to examine what "might" occur because what "might" occur inevitably "will" occur.

Another example of an incorrect terminal choice is as follows:

A customer designed an accounts receivable inquiry system to allow 60-day, 30-day, current and total balance inquiries for the entire 60,000 customer records on file. The terminals chosen for inquiries from the remote locations were the 2740 typewriter-oriented devices.

One afternoon, a very good and reliable customer, Doe Smith Electric, called the remote offices in his town to pay his current balance in full. The operator requested Mr. Smith's account number to obtain his record. He replied, "I'm not quite sure what my account number is, but it definitely has 440 as the first three digits". The terminal operator had no customer name list which would possibly yield the correct account number, but she did know that all customer account numbers were five digits in length.

She had to make a decision fast. Should she ask Mr. Smith to call back after she contacted the home office to determine his customer number, or attempt to locate his record herself? She decided she should attempt to locate Mr. Smith's account number herself. The typewriter-oriented terminal was not designed to scan large files in search of name/account number data as a visual display terminal might. The operator began the inquiry search; 44050 was entered; one minute later 44001 was entered, etc. When she finally located the correct number, Mr. Smith had hung up, called the president and moved his business to the company's competitor.

The question that should be answered is what design techniques were bypassed? First the synonym name search ability of devices such as visual display terminals was not deemed necessary by the installation planners. After all, this requirement would only occur one out of a thousand times. Second, no name/account number list was supplied to the remote user. In this case, a single visual display terminal, to service many 2740's could have been installed to allow rapid search of customer files for correct account name and number. The critical area bypassed during TP system design was again unexpected requests. These types of requests will occur and a solution should be designed before system implementation. Another terminal consideration is volume. Volume is really a measure of how fast data must be transmitted and received at the remote site. Several terminals fall into the volume category (1050, 2770, 2780, tape-to-tape devices and system-to-system units). A good example of an incorrect choice in selecting a volume terminal is an account that analyzed its message traffic over the communications lines, between the remote locations and the central CPU site prior to implementation. The survey performed determined that 5,000 records had to be transmitted and received daily, and the lowest cost terminal that adequately satisfied these requirements was a 1050 system with an attached paper tape reader and punch.

On the first day of operation the account had all the data ready for transmission by 4:30 p.m. The terminal was then placed on line via a dial-up connection to the CPU and transmission began. At 6:00 p.m. the terminal suddenly stopped. The remote operator immediately telephoned the central site to determine the problem. "No problem" was the answer. "All data must be at central by 6:00 p.m. for today's posting. After the day's posting, we will accept the remaining data". It was a rather shocking fact that the terminal chosen was not the correct device. Why? The 1050 selected was adequate to transmit the projected 5,000 records in a typical day, but not in one and one-half hours. Turnaround then should have been a predominant factor to consider in the choice of a volume terminal, because new examination of this customer's requirements found the 2780 to be the correct terminal for processing this daily volume of data.

Of course, there are some alternative solutions. First, the 1050 would have worked if the central cut-off time had been extended to 8:00 p.m., but the impact of this extension on the central processing was more critical than the additional cost of a higher speed terminal. Remember – turnaround time.

TERMINAL FUNCTION

Function-oriented terminals can be further examined according to:

- Input/output media
- Checking-code structure
- Operator considerations

Various input/output media have been discussed by terminal type in the section entitled TELEPROCESSING EQUIPMENT, and they will not be covered in any further detail.

Checking techniques are used by the terminal and the TCU to insure that data sent from one device to the other device arrives in the same configuration as it was sent (i.e., that there was no loss of data). Many administrative terminal systems in use today do not employ checking capabilities and really do not require them. For example, no one would be greatly disturbed if an administrative message which is sent from New York as, "Mr. John Doe will arrive 4:30 p.m." arrives in Los Angeles as "Mr. John Dee will arrive 4:30 p.m." For such administrative systems, messages with misspelled or omitted words or characters have very little effect on the user.

On the other hand, if the user should walk up to his bank teller to deposit $5,000 and the teller enters this amount via a teller terminal producing a small deposit slip with an amount of $5,000 shown for his record, he should feel confident that the money had been applied to his account. If later that same day he purchased a new automobile for $4,000 and the automobile dealer telephoned his bank for check verification–and his account reflected a recent deposit of only $500–he could be quite disturbed that the bank teller terminal dropped that insignificant zero on his deposit. If banks employed terminals without the necessary checking ability, they would soon have many dissatisfied customers.

If the user must process data (the useful composite of information), it would be wise to plan on terminals with checking. If he plans, however, to process information only, he may not require a terminal with checking.

Code considerations in the selection of functional terminals become necessary because different terminal types do not possess the same internal code structure, even though many different terminals may perform exactly the same application functions. The 1050, 2740 and 2741 may all be used to make inquiries, and these different terminals may easily communicate with each other via the CPU. What would happen, however, if a 1050 wished to communicate directly with a 2740, not utilizing the CPU? These two devices have entirely different internal coding structures and cannot communicate directly with each other, so that when this type of local off-line operation is required, it becomes advisable to have "like" terminals in each location. Remember—terminals may look alike and perform the identical on-line functions, but they can be quite different internally.

In this discussion we have finally come face to face with the person or persons who are most crucial to the continuing operation of a TP system. It is true that TP systems can be considered installed only when the application and programming system have been defined and programmed correctly. It is also true, however, that following this initial installation the overall success of the system is dependent upon the operator's use of the terminal devices that have been selected. The operator then becomes the key to a successful system.

In the area of operator orientation, there are certain facts that must be considered: a terminal device must be easy to learn and easy to use, and it must also provide some kind of discipline.

At the very offset, the user of a TP system must accept the fact that there eventually will be many people using the remote devices in his network. It is true that as any user begins installation of the system he may restrict the number of people using the system and thus maintain a better control over the level of operating capability. As systems expand he will find himself faced with more and more terminal devices and operators, and with this comes the turnover problem.

There are very few companies or institutions today that are not faced with the problem of employee turnover, and with this turnover comes the need for training new personnel. This problem is easily recognizable in a college environment in which many students or faculty members use terminal devices on an unscheduled basis. The implication is obvious: for any TP installation, the terminal selection and application design must provide an approach that is easy to learn.

There are several approaches to the solution of this problem. The user may provide a computer-assisted operation for each application on his system. This type of guidance is frequently referred to as conversational entry or system prompting. The application is written to guide the operator step by step through a job, thus making it easy for her to learn the terminal and application functions. The user may also provide an off-line education approach to understanding the application and use of the terminal through a combination of text material, long play records or tape recording. The terminal operator merely remains seated at the terminal device and proceeds with the material at his own pace. Whichever method is selected, the user must consider terminal familiarization carefully prior to laying out the plans for initial installation and expansion of his system.

The user can take the above straightforward approach of step-by-step prompting for actual terminal operation as well as operator training, or he may choose to make the applications or terminal operations extremely complex with regard to the number of variable factors that the operator is required to enter into the system. If complex input or entry is a system requirement, the user should simplify the task through the use of punched cards for certain constant information and control of the input/output devices.

Special keyboards with customized function keys have been designed expressly for this purpose. For example, such transaction codes as "deposit", "withdraw" and "Christmas Club" could be converted into functional keys on a typewriter keyboard used in a financial application. This approach relieves the operator of the responsibility to remember all the various transactions or function codes in use because she need only read them as they are identified on the keys. Using a combination of approaches such as this, it is possible for even the most complex terminal or application to be simplified in such a way that it does, in fact, become easy to use.

On the other hand, simplified keyboards and computer-assisted instruction may be rendered worthless unless a procedurized approach to the entry of information into the system is available. Most applications are designed so that certain information always comes first, followed by other special information and so on. The program will expect data to be entered in that order. Consequently, the user should plan for a well-disciplined approach for data entry.

Off-line procedures could be used to combine cards and paper tape for prepunched constant information. On the other hand, in an on-line environment the earlier approach of system prompting is encouraged. The system tells the operator step by step which functions are to be performed on the job, and as this discipline is provided, the operator gains both confidence and proficiency.

These points may have seemed too obvious; however, they are too often left until the very last—or frequently not even considered. They must be included in designing a good TP system.

TERMINAL VOLUME

Volume terminals can be further examined as to:

- Speed
- Buffering
- Cost

Speed relates to the throughput requirements demanded by the individual installation. This topic is presented in detail in Communication Terms and Concepts, and no further discussion will be made in this section.

Terminals are designed with buffering (temporary storage of data for bulk on-line transmission or off-line printing) to provide less operator-communication line contention. Devices such as the 2740 Model 2 are designed to allow many 2740's to be attached to the same communication line thereby reducing the cost of the required network. These buffers also allow for faster rates of data transmission between the terminal and the CPU.

Another major advantage of buffering is the reduction of line turnaround time. Line turnaround is required whenever data is transmitted or received by a terminal operating on a duplex line (normal telephone type circuit). This is the acknowledgement to the terminal that data has been transmitted/received correctly or incorrectly. Line turnaround time will vary depending on the grade and type of service used but will normally range from .2 second for leased lines to .33 second on dial facilities.

Let us suppose that user A has a 2780 terminal installed and wishes to transmit three 80-column cards, without terminal buffering. Figure 44 illustrates the cards and necessary line turnaround for a dial-up, 2000 bps communications line.

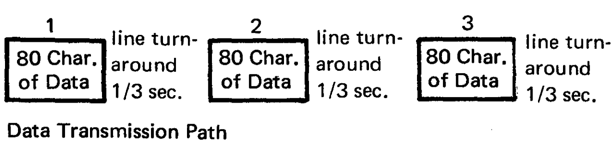

Figure 44. Cards and necessary line turn-around for a dial-up, 2000 bps line

The cards would be read in order: card 1, card 2, then card 3. The total line turnaround required is 1/3 + 1/3 + 1/3 or 1 second. The rated speed of data transmission for this terminal is approximately 300 characters per second. This means that 300 characters of data are lost for each 240 characters transmitted. This certainly is not a desirable situation.

A solution to the above situation is to store the data in these three 80-column cards in a magnetic core buffer at the terminal and then transmit the entire 240 characters at one time.

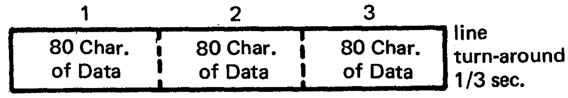

Figure 45. The data as it is transmitted

Figure 45 illustrates the data as it is transmitted. Cards 1, 2 and 3 are all transmitted together and only one line turnaround is required. This permits a savings of 2/3 of a second or the time it would take to transmit 200 characters of data. This then is the first step toward increasing the data transmission rate, yet without increasing the physical speed of the terminal, data set or communication line. If repetitive data, such as blanks or strings of similar characters and packed numeric data (i.e., one 8-bit transmission character to represent two digits 0-9), could be removed prior to transmission, speed could be increased even more. This type of data manipulation may be accomplished through the use of intelligent terminals (i.e., small or intermediate computers), and it is one advantage in employing intelligent devices as terminals.

Terminal buffers are available in a rather wide range of storage capacity and vary widely in size according to the terminal type. In some cases, for example the 2740 Model 2, the terminal buffer is available in any one of several capacities, and the user must select from the buffer sizes available. Generally speaking, the larger the terminal buffer supplied, the faster data may be transferred between the CPU and the terminals. Therefore, large buffering may be most applicable for batch-oriented systems, but may not be desired for conversation-oriented terminals.

Cost becomes a rather important consideration in the selection of a volume terminal because it really depends on the user's minimum wait time. If he can satisfactorily wait hours instead of minutes or seconds for output response, a slower terminal may be more than adequate. But cost works something like this—the more bits, the more bucks. In other words, the more data that must be transmitted in a given time period, the more dollars that will have to be spent for terminals, data sets, lines and CPU hardware.

NETWORK DESIGN

Now that a terminal selection can be made, what network is required to connect these terminals?

Suppose User B selects four terminals to be located in four different areas of the country. The specific terminal to be used does not have to be selected in order for him to design his network intelligently, but the functional coding structure and terminal transmission speeds chosen will affect the communication line selection. Communications facilities are offered in many different grades of service and the terminal class selection made by User B may dictate the communication grade selection out of necessity. A 2780 terminal class, for example, requires at the least a voice grade communication line capable of operating at 1200 or 2400 bps, depending upon the data set selected.

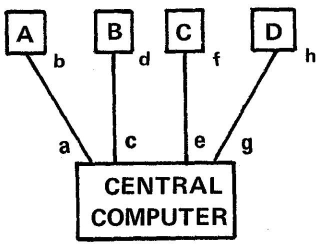

Figure 46. Schematic of the selected terminals and their respective locations

Figure 46 schematically illustrates the selected terminals and their respective locations. The common carrier provides a dollar cost per mile for each communication line and the necessary connecting charges at each termination point (i.e., points a, b, c, d, e, f, g, and h). By selecting these locations and the communication tariff as well, the user can obtain a total communication cost for attaching these four terminals to the central CPU.

After the first computation of line cost, the user may well question the need for the selected route of the communication lines since a re-routing might possibly yield a lower cost and still provide adequate response at each terminal.

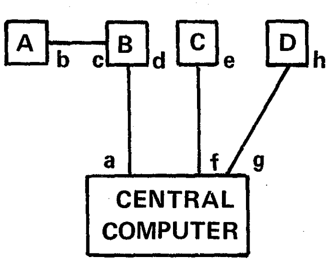

Figure 47. The system of Figure 43 re-configured to reduce network cost

Figure 47 illustrates a diagram of the same system that may provide a significant reduction in total network cost over the system in Figure 43. It would be advisable to reconfigure the four lines in as many different possible combinations as there are locations. By examining all of these combinations, an optimum system will eventually be found.

The above network design deals with only 4 locations. If, for example, as many as 2000 or 3000 different locations were involved instead of just four, it would take much too much time to price every possible line combination to determine the optimum network. By the time the optimum network was finally produced, the actual TP system requirements may have significantly changed, sending it back to the drawing board.

In the above design two factors were not considered in the optimization: response time and utilization.

Utilization is the network design criterion for keeping each line on a TP system busy at all times. This optimum use of the lines necessarily implies the following:

1. Data should be moving over these lines continually.
2. Only the minimum number of lines to support the terminal configuration should be considered at all.
3. Some terminal will always be waiting to obtain transfer time on the network.

Response time is the design criterion which must be considered to allow immediate terminal-to-CPU communication for a large percentage of the data transfer (usually 90 or 95%). This implies that there will always be some idle communication lines on the network. Consequently, this approach is in direct opposition to utilization and normally is used in the design of terminal systems that must interface with customers. Some examples of response systems would be airline reservation systems, bank teller systems, motel reservation systems, etc. It is possible for the user to design a communication network that employs both utilization and response time design criteria, but both should never service the same terminal(s).

Design aids are available to the terminal user who wishes to obtain an optimum communication system but does not have the manpower or time to configure the optimum network manually. An IBM confidential program (confidential in the fact that the source or object program is not available for installation in customer locations) is provided as a service, at no charge, to assist in optimizing network selection. This program is available in each IBM Field Systems Center and may be utilized through the direction of local IBM Marketing Representatives.

The program is called CNDP (Communication Network Design Program). The goal of this program is to provide a dollar cost per mile of each communication line, a total communication cost and optimization of the network to provide the least number of lines for design specifications. Possibly the best description of CNDP is to summarize the necessary input which must be provided to obtain the above output.

INPUT OVERVIEW FOR CNDP

- Locations
- Tariff
- Utilization or Response Time
- Messages
  - Length
  - Volume

OUTPUT OVERVIEW FROM CNDP

LINE A

- Distance
- Cost of Line
- Traffic Rate
- Connection Cost

LINE B

- Distance
- Cost of Line
- Traffic Rate
- Connection Cost

TOTAL SYSTEM COST

Suppose that User C wishes to design a network based upon the following response time: 95% of all messages shall be answered within one second. In other words, one second is the maximum acceptable customer wait time that can be tolerated. With the necessary input data and the above response criteria, CNDP will produce the necessary output. If the network cost is out of the user's range, $30,000 per month for example, User C may wish to increase the customer wait time to three seconds and re-submit the data for another CNDP configuration. A new cost and line configuration would result, possibly indicating a new total cost of $26,000 per month. This is a check and balance situation for User C and he must make a decision. How long can he afford to make his customers wait, and how much will the network cost decrease? He must realize that it is entirely possible that the reduced network cost is really no savings at all to him if competition begins to take away more and more of his business because of reduced customer service.

CNDP is also a very desirable tool for projecting network requirements into the future. If a user plans to add ten new locations to his network in the next two years, the network cost will undoubtedly increase. In addition, it may be necessary to re-configure the network every six months or so. Whether or not this is feasible can be answered by using design tools like CNDP.

One important point to remember is that if a user chooses to prepare the required data for CNDP and never examines the output listing, he really has not wasted his time. These design tools require the user to make vital decisions that only he can make. Where will the terminals be located? What tariff is acceptable? What is the maximum customer wait time acceptable? What are the various message lengths and volume? These are facts that many users never consider prior to implementation of programming effort. Of course, it is very easy to "estimate" each point and determine the overall results when the entire TP system is brought on line, but this may be too late. Design tools give guidance and discipline as to what, where and when data should be obtained. These design tools normally save the user a great deal of time and installation hardships.

CPU SELECTION AREAS

At the central site there are two major areas in TP System Design that should be examined: Hardware (the CPU size and speed to operate the network and terminals selected) and Programming (the logic necessary to perform the functions designed at the remote and central location).

PROGRAMMING CONSIDERATIONS

Programming considerations may be further subdivided into application programming, system control programming, and program products.

Application programs are those functions to be performed by the selected hardware, network and terminals. The user is responsible for designing, programming and testing these programs himself, and they may be batch oriented and/or TP oriented. To assist his staff in the design and education necessary to perform these programming requirements, IBM conducts customer education courses in various education centers throughout the U.S. These classes cover systems design, various programming languages and techniques, operating system concepts and internals, management concepts, industry seminars and various related subjects.

System control programming is a set of developed, tested and documented programs to assist the user in the operation of his data processing hardware. These programs are supplied and maintained as an IBM product and are designed to correctly interface with the IBM data processing hardware.

Program products are a set of application-oriented programs designed to satisfy a specific industry, function or device. These products are supplied to the user by a license agreement between IBM and the user for a specific CPU. In the remaining portion of this text programming systems will refer to System Control Programs and Program Products.

PROGRAMMING SYSTEMS

Three major areas that should be examined in the programming systems selection are:

- Compilers
- Utilities
- Control Programs

Compilers are programs written by IBM to convert the programming language written by a programmer (i.e, COBOL, PL/I, FORTRAN, etc.) to acceptable computer language (machine language) and they are offered in many different sizes (core requirements) and speeds.

Since compilers are offered in many different sizes, the user need only select the size that satisfies his installation requirements. If larger compilers are later required, additional CPU core storage may also be needed.

Utilities are IBM-supplied programs written to assist the user in the transfer of data between like or unlike storage media. For example, if the user's data bank is stored on magnetic disk, he would probably request a duplicate (backup) copy to be saved on magnetic tape in the event of accidental data bank destruction. This data transfer from disk to tape may be handled by one of the supplied utilities. These utilities are provided to handle repetitive data transfer functions (whether it's card-tape, disk-tape, tape-tape or whatever) allowing the user's programming staff more time to devote toward designing and programming his application needs.

Control programs are operational overseers called supervisors (as previously described in TP Systems Concepts) and the necessary sets of program modules for daily data processing operation. Control programs are offered in different versions, each providing additional functions to reduce the user's involvement in the data processing operation. TP systems will generally utilize either the Disk Operating System (DOS) or the Operating System (OS). For an overview of these two systems please refer to the following manuals:

Disk and Tape Operating Systems Concepts and Facilities - Form GC24-5030

Operating System Concepts and Facilities Form GC28-6535

CONTROL PROGRAMS

Control programs handle three major functions of computer operation:

- Job Management
- Task Management
- Data Management

Job Management is a function provided by the operating system used to control input job streams (a series of separate jobs or applications) and system output. Job Management also obtains input/output resources for jobs and regulates the use of the computing system by jobs. An additional function provided by job management is operator-to-system communication. In other words, the supervisor is the overriding medium for controlling the use of the entire computing system.

Task Management is a function of the control program that regulates the use by task of the CPU and other resources. A task by definition is a unit of work for the CPU from the standpoint of the control program (i.e., the basic multiprogramming unit of work).

Data Management is a general term that collectively describes those functions that provide access to stored data, enforce data storage conventions (method of storing and retrieving data), and regulates the use of input/output devices. Data management is a set of logic modules designed to provide an interface between the application program and the physical data processing hardware (i.e., a magnetic tape drive).

INPUT/OUTPUT PROGRAMMING

Operating with the data management set of logic modules are several classes of Input/Output device support:

- Unit Record and Serial Devices (Tape)
- Direct Access Storage Devices (DASD)
- Teleprocessing

Unit record and serial device support allows the application program access to physical devices like card readers, card punches, printers and magnetic tape attached to the CPU and generally located at the central site for input or output of various jobs.

DASD device support provides an interface between the application program and the physical disk storage device located at the central CPU site. These data management routines allow the user an easy-to-use subset language, called macros, to relieve the detail device access programming task of every programmer in the operation.

TP device support provides an interface between the application program and the remotely connected TP devices via the TCU. Included in the supplied data management TP support is the ability to control all the previously mentioned IBM TCU's and terminals. The above support provided is divided into three access methods, which are routines to assist in the retrieval and/or accessing of data from or to the remote terminals.

TELEPROCESSING PROGRAMMING

The three access methods are called:

- BTAM (Basic Telecommunications Access Method)
- QTAM (Queued Telecommunications Access Method)
- TCAM (Telecommunications Access Method)

Basic Telecommunications Access Method

BTAM is designed to provide the basic modules for constructing a TP program, including routines for controlling a variety of terminal units, communications lines and TCU's. With a minimum of system overhead, it not only provides the basic tools to build a sophisticated system but is also easily modified to support special configurations not supported by other programming packages.

BTAM communicates with the remote devices on a READ/WRITE level. This is to say that the application program requests specific input or output from a specific terminal by coding in his application program a READ or WRITE macro instruction. This specific device addressing forces the user into handling his own scheduling of the TP system (i.e., READ LINE 1, LINE 5, LINE 2, etc.). BTAM provides the basic capabilities to:

- Poll terminals and receive messages
- Address terminals and send messages
- Dynamically chain input buffers
- Dial and answer
- Detect and correct errors
- Write output buffer chains
- Perform code translation.

As already stated, BTAM controls terminal input/output operations (initiated by READ and WRITE macro instructions) issued in the user's problem program. The primary purpose of BTAM is to provide input/output support at the message level under the operating systems. Consequently, there are really two BTAM's: one for Operating System (OS) and one for Disk Operating System (DOS). These two versions of BTAM have a similar appearance to the user. The principal external differences are:

> Audio response equipment (IBM 7770 and 7772 Audio Response Units) is supported only under DOS.
>
> Operating systems incorporating BTAM have a minimum memory size of 32K bytes for DOS and 64K bytes for OS.

The principal internal difference is that buffers are allocated to accept a maximum size message under DOS, while READ/WRITE buffers are allocated dynamically under OS.

Functions provided include support for terminals both on a switched network (dial) and on a leased or private line. On leased or private multidrop lines, line disciplines or line controls are necessary to avoid contention. Line control functions include: establishing CPU control of the line, polling terminals and components and receiving data, addressing terminals and components and transmitting data, monitoring data for end-of-record identification, and supplying appropriate responses for varying conditions (i.e., responses to polling, addressing, text acknowledgement, end of transmission, etc.)

In a switched or dialed network (as contrasted with private or leased lines) a unique dialing number is associated with each remote terminal. An auto-answer facility is provided whereby line appearances on the CPU have dialing numbers. When an operator at a terminal dials one of the numbers associated with the CPU, the call is automatically answered and BTAM polls the appropriate device (such as a keyboard or card reader) of the remote terminal. The terminal can then proceed to transmit data to the CPU.

When the CPU has data to be transmitted to a remote terminal, the auto-call feature may be used. Telephone numbers associated with remote terminals are stored in tables in the CPU. Under the control of BTAM, remote terminals are dialed automatically. After the connection has been made, BTAM addresses the appropriate devices at the remote terminal point and proceeds to transmit data. BTAM also provides for the conversation mode for both switched and leased lines, whereby the CPU can send data to a terminal after the receipt of data from that terminal without having to re-establish the connection.

To utilize core storage efficiently, BTAM provides buffer pool management. Instead of reserving buffer areas for each line, a buffer "pool" may be assigned to a group of communication lines or to all communication lines. This buffer pool is composed of a number of buffer segments. BTAM automatically chains segments together when required for efficient handling of fixed- or variable-length records. When buffer segments are no longer required, BTAM provides the capability of returning them to the pool. OS/360 provides for dynamic buffer management. This capability means that smaller blocks of core can be allocated to low-speed devices on an "as required" basis.

DOS/360 BTAM supports Binary Synchronous Communication (BSC). BSC offers a new method of medium- and high-speed communication control, which when combined with existing support, gives DOS BTAM a wide range of application flexibility. The single access method (BTAM) now supports low-, medium-, and high-speed devices. With the binary synchronous feature, the 2770 Data Communication System, 2780 Data Transmission Terminal and processor-to-processor communication capability are available with BTAM in addition to the existing array of low-speed terminals and audio response units.

Binary synchronous communication conforms to the IBM Data Link Standard designed to overcome incompatibilities associated with a host of existing line control techniques in the world of communications. While conforming to standard line control techniques, binary synchronous communication offers significant advantages in code flexibility, transmission efficiency and increased functional capabilities.

The six-bit transcode can be used in communicating with the 2780, thereby eliminating the otherwise unused bits associated with eight-bit transmission. This feature alone increases transmission efficiency by 25%. When it is used in conjunction with other binary synchronous features, such as intermediate block checking and horizontal format control, substantially larger increases can be realized.

The ability to transmit Extended Binary Coded Decimal Interchange Code (EBCDIC) and American Standard Code for Information Interchange (ASCII) eliminates the need for code translation, thereby conserving core, simplifying programming and increasing overall system efficiency. The code transparency capability allows the user to transmit any eight-bit combination without setting aside specific codes as transmission control characters. Code transparency permits core-to-core or core-to-terminal transmission including user program code, packed decimal information, floating point or any combination of eight bits without code translation.

Communications serviceability features increase system availability by providing for recovery from temporary errors, isolation of permanent errors, error statistics and diagnostic aids. Also, communication line and/or terminal failures can be diagnosed and repaired while the unaffected portion of the teleprocessing application continues to run.

The use of BTAM is recommended for those systems having either of the following characteristics:

- A small number (1-4) of communication lines.
- A requirement for a specialized TP control program.

The primary storage requirements of BTAM depend on the particular configuration of terminal equipment, the buffering requirements and the macro instructions used. A typical configuration might consist of 4 lines, each with four 1050 terminals, attached to an IBM System/360 by means of an IBM 2701 TCU. Assuming one 140-byte buffer for each line, and polling and addressing lists each having one 3-byte entry for each of the 16 terminals, the total core storage needed is in the range of 3,000–4,000 bytes for BTAM under OS and about 4,500–5,500 bytes for BTAM under DOS.

BTAM facilities are incorporated into the user's operating system at system generation time. (System generation is the tailoring of the specific operating system to your particular hardware configuration.)

BTAM is also easy to use. The programmer need only define control blocks and terminal lists (for polling and addressing) before performing the required TP communication.

BTAM, however, is not a complete TP system. The BTAM user must:

- Comprehend its basic capabilities and limitations.
- Have a reasonable understanding of terminal and TCU equipment.
- Provide programs, initiate operations, test for exceptional conditions and make decisions on control flow and the disposition of data.
- Provide routines for any necessary scheduling and allocation functions.

BTAM is an ideal tool for constructing TP programs. Since it is a general-purpose interface for input/output with TP equipment, it can be used as a component in the development of more sophisticated TP systems. It can be also employed in supporting a few TP lines on a computer configuration with limited available memory space.

Queued Telecommunications Access Method

QTAM, like BTAM, is an access method to assist the application programmer in communicating with the remote terminals in his TP system. QTAM, however, has two characteristics that distinguish it from the other access methods:

1. Scheduling and allocating functions are performed by a separate partition within the operating system.
2. Operations to control and process communications data are specified by a unique macro language.

QTAM includes the BTAM capabilities mentioned above and, in addition, provides extensive queuing facilities. QTAM is directly applicable without modifications to a number of common TP application (for example, data collection and message switching) and provides the basic capabilities for:

- Controlled and automatic terminal polling and message input
- Controlled and automatic terminal addressing and message output
- Input/output buffering
- Error detection and checking
- Message queuing, routing, and logging
- Code translation

QTAM is much more than an extension of BTAM capabilities. It not only controls message transmission between remote terminals and the central computer but also controls message queuing on a direct access secondary storage device. QTAM is a control program in its own right, and it provides synchronous operation for all programming based on completion of events, availability of resources, and processing priorities.

Files accessed by the problem programmer are queues of messages incoming from, or outgoing to remote terminals via communications lines. Although the time and order of the arrival and departure of messages at the CPU are unpredictable, the programmer can handle the messages as if they were received and transmitted sequentially.

QTAM operates with a GET/PUT macro instruction set to allow the application programmer the ability to request input/output to or from remote terminals simply by requesting a GET or PUT via QTAM to obtain the data. This is also referred to as a sequential I/O access method since the user requests the next message for a particular application without being concerned with the time when it actually arrived at the CPU. This implies that the user is not responsible, as he was with BTAM, for scheduling the activity of the entire TP system.

In addition to the standard GET/PUT macro instructions support for message processing programs, QTAM provides an extremely high-level and flexible message control language. QTAM-supplied macro instructions can be used to construct a complete program that not only controls traffic between remote terminals and a data processing program, but also controls the flow of traffic from one remote terminal to another.

A QTAM message control program is generated from a number of Assembler macro instructions coded by the programmer. It is open ended, which means that the user can include functions not provided through the QTAM language by employing DOS or OS control program macro instructions and Assembler language macro instructions.

The user specifies his equipment configuration and the main storage areas (buffers) required for his applications. Macros generate the tables and lists of control information that define the environment of the system for the QTAM logic. One of the primary resources in the telecommunications system is the buffers, the number and size of which are specified by the user. The buffers are allocated to a common buffer pool from which QTAM automatically and dynamically uses them in accordance with immediate requirements.

QTAM logic modules are also provided for many procedural functions, such as message code translating, routing of messages, and error checking. By selecting the appropriate macro instructions, the user specifies which of these QTAM logic modules are to be incorporated into his message control program. In this way, the system can be tailored to the exact requirements of the applications being supported.

The message processing program services of QTAM enable a programmer to process messages from a telecommunications network with the same instructions that he uses for his local I/O devices. When a QTAM message control program is used to perform the I/O operation, a device-independent message processing program can be written. The programmer is, in effect, completely shielded from the time- and device-dependent aspects of the telecommunications environment.

The subroutines for message control occupy about 8K–12K bytes for primary storage. Many of the macro instructions generate in-line linkages to functional subroutines. If the same macro is used more than once, space is needed for the linkage, while the subroutine might occupy 100 or so bytes. Space is also needed for control blocks, tables, polling/addressing lists, channel programs and related areas. In addition, since QTAM performs message processing functions as well as message control functions, storage is needed for these processing routines.

The following example indicates the approximate storage needed by QTAM to process a typical large TP configuration. Assume 15 lines each with six AT&T 83B3 stations or Western Union Plan 115 A stations. Assume further that two 100-character buffers are allocated for each line and that message processing has three representative routines operating on three process queues held on one direct access device. The QTAM storage requirements for this system would be in the range of 25,000–35,000 bytes.

QTAM scheduling is designed to optimize use of the communication lines. The scheduling is a function of resource allocation in contrast to the opposite approach of first allocating resources and then scheduling by events.

Buffering is accomplished by dynamic assignment of storage segments. To conserve storage space, buffers are emptied as quickly as possible. The same buffer pool is used both for terminal input/output and for holding messages awaiting service by message processing programs.

Queues are specified for both processing tasks and destination terminals. Queues are organized to minimize the arm motion of the disk access mechanism and are managed by means of queue control blocks residing in core memory and containing all information necessary to schedule and locate the associated queued items on the disk.

A listing of other QTAM functions in addition to the allocation and scheduling, buffering, and queuing functions just described gives some idea of its message control capabilities:

- Controls all message traffic between central computer and remote terminals
- Performs such message editing functions as code translation and header analysis
- Routes messages to designation terminals or to processing routines
- Optionally logs all or individually specified messages
- Performs numerous error detection and correction procedures including intercepting, rerouting, or cancelling of messages in error

Telecommunications Access Method (TCAM)

TCAM is an improved access method that incorporates and extends the functions of QTAM. It provides all the functions of QTAM plus many extra features that are discussed in this section. TCAM establishes a new interface which may be utilized in the development of TP programs in an environment where multiple applications are desired for terminal devices.

TCAM, like QTAM, operates in two partitions of the user's system. Application programs run asynchronously with the message control program (MCP) and are usually in another partition or region. A message from any TCAM terminal can be routed to any TCAM application. In addition, facilities are provided that allow a terminal to be locked to a given application program for the duration of the application or until explicitly terminated.

The interface between the application program and the MCP is activated/deactivated by application program OPEN/CLOSE macros. The application program need not be resident while records processed by that application are collected from or transmitted to the terminal involved.

The application program need not be concerned with the terminal at which data originated, nor with the transmission code or line control. All device-dependent characteristics may be removed/added in the MCP. With this support, the user can write an application program just as he would normally under the operating system for sequential access support. The program may then be tested off line and then dynamically converted at execution time to operate under TCAM.

The TCAM highlights are as follows:

- Support for Binary Synchronous Communications (BSC) and Start/Stop terminals, audio and display products.
- Capabilities such as core queueing and a terminal/application program lock function provides support for conversational operations.
- Recovery and Serviceability features aid in achieving increased system availability.
- Debugging aids are provided to assist installation and program maintenance activities.
- User queueing options – reusable and/or non-reusable disk queueing with optional multiple arm capability. Also core queueing with or without disk backup.
- Compatibility – Most applications now under QTAM can be adapted by converting QTAM Message Control macros to TCAM macros and simply reassembling the application program.
- Operator Control – A variety of IBM-supplied operator Control Messages enable the user to dynamically examine or alter the state of the TP network.
- Message Control and Editing – A number of enhancements over QTAM include improvements in switched network support, buffering facilities, priority message handling, flexible queue definition, and management of buffered BSC terminals.
- Expanded Checkpoint/Restart facilities provide for restart after system failure and for warm start following a quick but orderly close.

The basic external appearance of QTAM is continued but highly refined and expanded in TCAM. A single MCP operates asynchronously from and supports one or more independent application programs. The MCP consists of routines to establish the line control required for the various kinds of terminals and modes of connection, and to control the handling and routing of messages in accordance with the user's requirements. Another important area in TCAM is the operator control facility. This facility provides a wide variety of functions that enable the user to dynamically examine or alter the status of the TP network.

One primary and any number of secondary operator control terminals may be designated. All operator control terminals can generate operator control messages and receive related responses.

SUPPORTED TERMINALS	OS			DOS	
	BTAM	QTAM	TCAM	BTAM	QTAM
START-STOP					
IBM 1030	X	X	X	X	X
IBM 1050	X	X	X	X	X
IBM 1060	X	X	X	X	X
IBM 2260-2848 (Remote)	X	X	X	X	X
IBM 2260-2848 (Local)	X		X	X	X
IBM 2265-2845 (Remote)	X	X	X	X	X
IBM 2740	X	X	X	X	X
IBM 2741	X		X		X
IBM 2760	X		X	X	
IBM 2721 (7770-3)			X	X	X
AT&T 83B3	X	X	X	X	X
WU 115A	X	X	X	X	X
AT&T 33/35	X	X	X	X	X
BINARY SYNCHRONOUS					
IBM S/360-370 TO IBM S/360-370	X		X	X	
IBM S/360-370 TO IBM 1130	X		X	X	
IBM S/360-370 TO IBM 2770	X		X	X	
IBM S/360-370 TO IBM 2780	X		X	X	
IBM S/360-370 TO IBM 2790	X			X	
IBM S/360-370 TO IBM 3270	X			X	
IBM S/360-370 TO IBM 3735	X		X	X	
IBM S/360-370 TO IBM S/3*	X		X	X	
IBM S/360-370 TO IBM S/7*	X	X	X	X	X
* OPERATING IN TERMINAL MODE					

Figure 48. BTAM, QTAM and TCAM Device Support

The operator control functions provided are:

- Activation and deactivation of terminals
- Activation and deactivation of lines
- Switching between Autopoll and the programming polling facility
- Activating and deactivating invitation list entries
- Starting and stopping the debug trace facility
- Releasing messages queued for a terminal
- Holding messages queued for a terminal
- Interrogating the status of a line, queue, or terminal
- Initiation of system closedown

TCAM operates under control of the Operating System for System/360. The requirements to operate TCAM are those device requirements of the Operating System, a System/360 Model 40 or above having at least 128K positions of main storage, and space on one or more 2311 or 2314 disk storage unit, for intermediate storage and message queues.

Summary

BTAM is a general-purpose input/output interface; QTAM and TCAM are complete TP systems in their own right. Without modification, QTAM or TCAM can perform some applications, message switching for example, in their entirety. In other cases, it provides most processing functions that are common to a variety of TP applications. Its design accommodates a majority of the system applications, equipment characteristics, and programming techniques introduced in this manual.

More detailed information on BTAM, QTAM and TCAM is contained in the reference manuals listed in the bibliography.

Figure 48 summarizes BTAM, QTAM and TCAM device support for the Disk Operating System and the Operating System.

Total System Concept

The previous chapters of this publication provide a substantial exposure to the many different elements that must be considered in the design and successful installation of a teleprocessing system. TP systems must indeed be well-designed and intelligently installed in order to be productive. The elements of the entire system (i.e., the data processing system with TP capabilities) must be well studied in the planning stage for the output of the system to be meaningful, accurate, and timely.

Unfortunately, there are no easy textbook solutions to the problems of installing a TP system. There are, however, several key points from the previous discussions that should be re-emphasized and that may provide a starting point for any future analysis of TP systems. The hardware of a teleprocessing system cannot exist by itself – it requires the added support of a complete data processing system supplemented by the necessary communications software to control the applications and the properly trained personnel to implement and maintain it.

Teleprocessing has been defined as data processing plus communications throughout this manual. This definition implies that a teleprocessing system is, in fact, a total system; and the following section presents the concept of a TP system as a functional composite of all of the elements discussed in the previous chapters.

INFORMATION SYSTEMS

In the previous sections a large amount of text was dedicated to a discussion of teleprocessing applications which ranged in variety from simple inquiry and data collection to the more complex file updating, synonym name searching, and so on. It is possible, however, to group all of these applications into one single category which encompasses all TP systems: information system.

Obviously, no single definition of an information system is adequate enough to cover the requirements for each individual user because the applications vary so widely from business to business. However, it is possible to create a basic framework for all types of information systems through an examination of some of the key words that are integral parts of every information system. These key words are as follows:

- Data Base – A data base (or data bank) is the total assemblage of information regarding a given segment of a user's business.
- Current – Decisions made by management cannot be truly meaningful unless the information available to make decisions is timely. TP devices operating on-line to the system on which the data base is installed keep this information current.
- Accessible – Even if the information on the user's data base is current, the decisions made by management might still be meaningless if the available information is not accessible at the time the decisions are to be made.
- Usable – The information provided from a user's system must, of course, be usable and understandable. The actual usability of this information is best determined by the user himself, and it is the key factor in justifying the efforts involved in design and installation.

ELEMENTS OF THE TOTAL SYSTEM

In a data communication system, the easiest mistake to make is to look at the various parts of a system singly, without regard for their interaction with the others. This approach invariably leads to problems at installation time, when it is discovered that some of the parts of the system just don't interface properly with the others. In order to circumvent the problems that might arise from this approach, it would be wise to re-examine each of the elements that are involved in a TP system in the light of the other elements in the total system.

Six major elements are involved in a total system:

1. processor
2. input/output storage
3. communications control device (the device that serves as the interface between the data processing system and the communications line)
4. communications lines (or communications facilities that are employed in the system)
5. data communications terminal device
6. programming systems that must be used to tie all of these elements together into one operating system

Of course, all of these elements must be set in an application framework because it would make little sense to consider these elements without knowing the type of application involved. Figure 49 illustrates schematically each of the above listed elements in the form of a circle.

The figure of a circle is chosen deliberately to illustrate the importance of unity and compatibility of all of the elements involved. The purpose of the following review of these six major elements is to show that it is impossible for the total system to function productively without the support of any one of these elements.

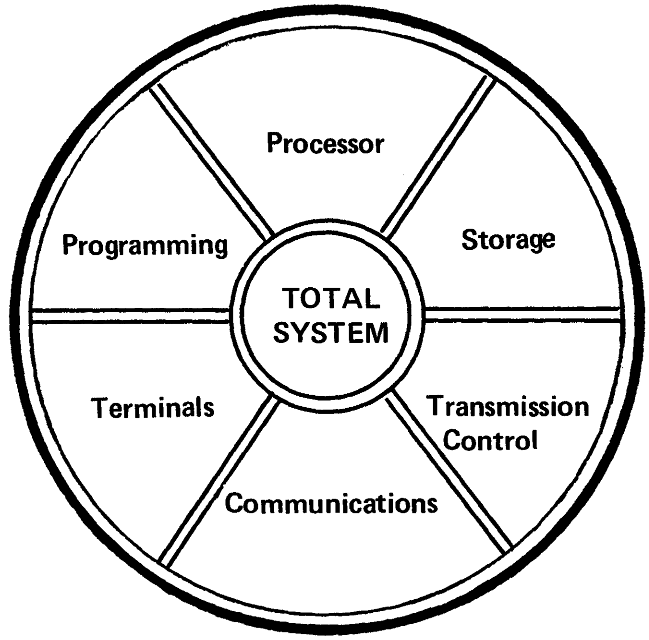

Figure 49. Schematic of the major elements in a total system.

Processor

When the user examines the processor that is to be used in his TP system, he must consider as a primary need the expandability of the system. This is the ability to expand the system as the applications and volume of data warrant such growth. The user should be able to expand in two directions: vertically, in terms of speed; horizontally, in terms of core size.

History has proven in the data processing business that systems are installed on the basis of an application or group of applications. As the systems are installed, confidence is generated on the part of the users, and additional or potential users become aware of the advantages of the use of such a system. With this confidence and awareness come additional applications and additional volumes of data. Therefore, as the user selects a data communications system, he should select one that allows him to expand as his company's needs expand.

Equally important is the ability of multi-programming: the concurrent use of the system for both on-line TP applications and the traditional batch processing applications. There are few systems today that can justify the luxury of a system dedicated only to the handling of data communications lines. Remember, the communication of the information over these lines is very slow relative to the high speed of the data processing system. For example, one of IBM's intermediate size systems can perform 30,000 instructions in the space of time it takes to speak one word via the audio response unit over a telephone line. It is with this speed differential that it becomes necessary to consider multi-programming in order to balance the power of the data processing system.

Input/Output Storage

Card readers/punches, magnetic tapes and printers are the normal complement of input/output storage devices on any system. The key element in TP systems as far as input/output storage devices are concerned, however, is the direct access storage device. Over the past several years, there has been a rather dramatic change from magnetic tape as the single most popular input/output medium on a system to a direct access device. It provides all the manipulative capability of magnetic tape and cards and, because of the flexibility it gives in systems design, it allows the user to maintain a current data base. Through the use of TP terminals the user may have up-to-the-minute or even up-to-the-millisecond information because direct access storage devices, by their very name, imply almost immediate access to information requested by a communications terminal. As a result, direct access storage devices meet the requirements of the majority of the key words mentioned earlier in reference to an information system, i.e., they provide the data base for access to the most current and usable information available.

The number and type of direct access storage devices selected will obviously vary depending upon the user's need; however, the volume of data that will be stored within the system is the primary concern. This device is used for the residence of the operating system installed, as well as storage for the operating application programs.

This becomes important as the number of applications within the system are expanded. Rather than maintaining the operating (or application) programs within the processor unit at all times, the user could choose to store the programs on a direct access device. Then, as the programs are requested by a terminal, the control program would bring them into storage from the direct access device, operate on the data, update the associated files and release the core storage to await the next program request.

Communications Control

The third major element is that of communications control or the interface between the communications lines and the system. As previously mentioned, this function normally takes different forms. It can be a device that is external to a system or a unit that is integrated within the system. In either case, the following two functions must be provided for:

- flexiblity in design
- independence of operation

There is a wide range of device types available in communications terminals products, and within this range of types are several speeds of operation and a variety of communications codes. The user must also plan on providing for connection of dial lines, for leased lines or perhaps for his own privately owned communications facilities. The speed of the terminal devices can range from six characters per second up to 28,800 characters per second, so it is conceivable that the same system will be operating with both of these extreme speeds or certainly with a range of devices within these two extremes.

It is also important for the user to provide for asynchronous operations. He may have a system that provides for only one communications line. Regardless of how many lines are required for a system, they all must be handled simultaneously. As these lines are being controlled simultaneously, there must be some overlapping with the operation within the processing unit; i.e., there must be some type of multiprogramming.

Communications Facilities

The fourth element of the total system is the communication line itself. For review purposes, the following summary of communications facilities, line speeds, and grades of service has been prepared:

Three major types of communications facilities are available:

- Dial-up operation (switched network)

- Leased line facility (lines leased on a monthly basis from the communication common carrier)

- Privately owned facility

Within these types of facilities are certain grades of service:

- Sub-voice grade – permits transmission of data only (not human voice)

- Voice grade – permits transmission of both data and human voice

- Broad band – a broader band width than the typical voice grade circuit; capable of being subdivided into either sub-voice or voice grade channels; handles both data and human voice

The communications facilities and grades of service available may be divided into the following four speed categories:

- Low (15-20 characters/second) – Devices of this speed will operate over sub-voice channels; however, they may also operate on the higher speed communications channels.

- Intermediate (up to 150 characters/second) – Product technologies today provide a maximum speed of 100 or 105 cps in this category, which provides for voice grade channel communication.

- Medium (up to 600 characters/second) – The great majority of terminals in this category operate at a maximum of 300-400 cps over voice grade lines.

- High (up to 28,800 characters/second) – High speed devices can operate at speeds greater than 28,800 cps with certain devices; however, operation at 28,800 cps over broadband channels is the most widely used maximum.

The network used to connect terminal devices into the total system has been referred to as point-to-point or multipoint. A point-to-point communications network has one terminal device per line connected to the system; a multipoint network on the other hand has a number of terminal devices per line within a single system. A mixture of point-to-point and multipoint lines on one system is entirely possible.

The use of the multipoint lines brings in another factor that must be considered in the design of a system: communications line control. Where there are a number of terminals operating on a single line, it is necessary for some control to exist. For example, the user could take the approach of a contention system, that is, a number of operators at their terminals, each vying for control of the line.

Obviously, there are problems inherent in this type of operation. First is the frustration on the part of the operators to get their chance to use the line, with the possibility of one very efficient operator monopolizing the line. Another problem is involved in programming itself, which must determine which operator has just seized the line. A combination of programming and terminal procedures can be used for the control of such contention situations, but it will add another factor into the design of a TP system.

The majority of systems utilizing multipoint lines provide for control from the central system using a scheme of polling and addressing. Each of the terminal devices is provided an identification or station code. As the system polls the terminals by specifying the station code, the terminal will respond either positively with transmission of data, or negatively with a standard negative response, and the system will go to the next terminal device. If there is nothing to be sent into the system from the terminals, the system may then repeat a similar sequence of addressing, that is, taking messages that have been generated to go to a terminal device and through the use of the terminal identification code select that device and transmit the message to that terminal.

It has been shown that the use of polling and addressing provides a desirable approach to the control of communications lines in a TP system. Polling and addressing schemes are quite flexible and may be varied according to the user's specific requirements. For example, should any one of many on-line terminals be a higher priority device or typically have a higher volume to transmit, the sequence could be varied to accommodate this.

Teleprocessing Terminals

The fifth major element is the one that receives the greatest interest because the user can literally get his hands on it – the terminal itself. Too much emphasis cannot be placed on the fact that terminals must be chosen in the context of the other elements of the system. They are the work horses of the system, i.e., all useful data is entered from and received by the terminal unit itself, but it is impossible to expect consistently useful work from the devices installed unless the terminals have been selected in the light of the application and system requirements.

The user may choose an audio or visual device or a terminal that combines cards, paper tape, printer, and a keyboard, or he may choose a combination of several terminal types.

The terminal system itself can be batch oriented to provide for transmission of information, pre-recorded on magnetic tape, in punched cards or on paper tape. This short review of types of terminal systems should not be interpreted to mean that only one type of terminal system may be operating on a data processing system at a single time because it is possible for both types to be operating concurrently within the same system, acting upon the same data files. The important point to understand is that a terminal is selected to meet the requirements of a particular application or location.

Programming Systems

The final element to be included in this discussion of the total system is the composite of programs called a programming system, which includes the operating (OS, DOS) to control and schedule the I/O devices and partitions, the control programs, application programs, system utilities, etc. Any programming system that is to be used for data communications must satisfy the following requirements:

1. It must be capable of handling a wide range of terminal configurations. The majority of teleprocessing systems will eventually utilize a variety of terminal devices, whether it be at initial implementation time or only in plans for future expandability. Consequently, the capability to handle a wide range of terminals should be planned into the system.

2. It must provide for communications line control. The programming system's control modules must maintain constant awareness of the operational lines and modes of transmission (whether it be to "transmit" or "receive"), and they must be able to handle adequately the polling and addressing of the terminal devices within the system.

3. It must provide for some method of queuing messages. Either QTAM or TCAM or the user's own control program can be used to assemble and store (queue) messages or groups of messages – both input and output – until the data processing system is ready to begin operation on them.

4. It must provide for multiprogramming. Normally, teleprocessing applications are high priority because communication lines operate at a comparatively slow rate of speed and it takes quite some time to create an entire message. Consequently, TP applications should be placed in the higher priority partitions, such that low priority partitions could be used for batch job processing. Such partitioning of the system's resources is the most productive and economic approach to the design and implementation of the total TP system.

Summary

It has been shown that the elements of the total TP system are all interactive, interrelated and interdependent upon each other. No single element can subsist on its own, neither can the entire system produce effective and meaningful results without the contributing resources of all of the comprising elements. The terminal functions, communications lines, communications control devices, processor, programming support and storage devices all must be considered in the design and implementation of the total system if the objectives of the user's system planning efforts are to be realized.

Glossary

acknowledge: to respond to polling or addressing or receipt of a message.

acknowledgement: the act of sending a response to polling or addressing or receipt of a message; also, the character or character sequence comprising the response. An acknowledgment to polling or addressing may indicate the status of the terminal that sends it; acknowledgement to a message may indicate whether it was received without error.

address (n.): the coded representation of the destination of a message.

address (v.): to condition a terminal for receiving data.

allocate: to assign a system resource to a specific function.

answering station: the station responding to a dialed call; opposite of originating station.

audio (a.): within the range of frequencies which can be heard by the human ear (usually in the range 15-20,000 Hertz [cycles per second]).

Auto Answer: the facility of an answering station to automatically respond to a call.

Auto Call: the facility of an originating station to automatically initiate a call.

band: the range of frequencies between two defined frequencies.

bandwidth: the difference, expressed in Hertz (cycles per second), between the two limiting frequencies of a band.

batch processing: processing of data after a number of similar input items have been accumulated and grouped together; contrast with in-line processing.

bit: contraction of binary digit.

bit rate: the speed at which bits travel over a communication channel, usually expressed in bits per second.

buffer: a storage device used to compensate for a difference in the rate of flow of information, or the time of occurrence of events.

call directing code (CDC): a code used to address a terminal (a Western Union term).

channel: a path for electrical data transmission between two or more stations; also called circuit (not synonymous with *data channel* in computer usage).

channel, duplex: a channel providing simultaneous transmission in both directions.

channel, half-duplex: a channel capable of transmission in both directions, but only one direction at a time.

channel, simplex: a channel which permits transmission in one direction only.

channel, voice-grade: a channel suitable for transmission of speech.

character: the actual or coded representation of a digit, letter, special symbol, or control function.

character, check: a character used for validity checking purposes.

character, control: a character used for control purposes.

character, graphic: a character used for printing or display.

checkpoint: a point in a computer program at which sufficient information can be stored to permit restart of processing from that point.

circuit: a connection between two or more points: usually, a physical, metallic path.

coaxial cable: a cable consisting of two concentric conductors insulated from each other.

code: a system of symbols and rules for their use in representing information; also, the coded representation of a character.

code unit: the number of bits used to represent a transmission character.

code level: the number of bits used to represent a data character.

communication: the transfer of information from one point to another.

communication common carrier: a company recognized by an appropriate regulatory agency as having a vested interest in furnishing communication services.

contention (n.): the condition on a multipoint communication channel when two or more locations try to transmit at the same time.

contention (a.): relating to a communication system in which contention can occur.

conversational: a mode of communication involving the alternate sending and receiving of data.

cyclic checking: a method of error control employing a weighted sum of transmitted bits.

data collection: the process of bringing data from one or more remote points to a central point.

Data Phone: a term used by AT&T to describe any of a family of data set devices.

data set: a device containing the electrical circuitry necessary to connect data processing equipment to a communication channel; also, called subset, Data Phone, modulator/demodulator, modem. (Not to be confused with the IBM System/360 Operating System term.)

data transmission: the sending of data from one place to another or from one part of a system to another.

demodulation: the process used to convert communication signals to a form compatible with data processing equipment.

dial exchange: a common carrier exchange in which all subscribers originate their calls by dialing.

display unit: a terminal device that presents data visually, usually by means of a cathode ray tube.

dynamic allocation: the technique of assigning storage areas during processing: contrast with *static allocation.*

EBCDIC: abbreviation for extended binary coded decimal interchange code.

end of address: control character(s) separating message address(es) from message text; often abbreviated EOA.

end of message: control character(s) denoting the end of a message; often abbreviated EOM.

end of transmission: control character(s) denoting the conclusion of data transmission; often abbreviated EOT. It is usually sent by an originating station to signify that it is finished with the communication line.

exchange service: a service permitting interconnection of two customers' telephones through the use of switching equipment.

FIFO: abbreviation for first-in, first-out queuing, in which items are removed from a queue in the same order as entered; contrast with *LIFO.*

free form: formatting of data fields by embedded delimiter characters rather than organizing of data in fixed-length fields.

group addressing: a technique for addressing a group of terminals by use of a single address.

hard copy: a machine-printed document, as opposed to visually displayed data.

header: initial portion of a message containing any information, control codes, etc., that is not a part of the text. Usually includes information for routing the message to its destination(s).

in-line processing: processing of input data in random order, without preliminary editing, sorting, or batching; contrast with *batch processing.*

in-plant system: a system confined to one plant locality.

interface: a shared common boundary between two systems or two devices; for example, a physical connection or a programming convention.

LIFO: abbreviation for last-in, first-out queuing, in which the next item to be removed is the most recently entered item in the queue. Also called "stack" or "push-down"; contrast with *FIFO.*

LRC: abbreviation for longitudinal redundancy checking method, in which parity is checked longitudinally along all the characters comprising a transmitted record.

mark state: state of a communication line corresponding to an on, closed, or logical one condition; contrast with *space state.*

message: a finite sequence of transmitted words and/or symbols.

message routing: the function of selecting the route, or alternate route, by which a message will proceed to its destination. Sometimes used to mean "message switching".

message switching: the technique of receiving a message, storing it until the proper outgoing circuit is available, and then retransmitting it. Also called "store and forward switching".

modulation: process used to convert signals from data processing equipment to a form compatible with communication facilities.

modem: contraction of modulator-demodulator (see *data set).*

multiple address message: a message which is to be delivered to more than one destination.

multiplexing: the interleaved or simultaneous transmission of two or more messages on a single channel during a given time interval.

multipoint line: a communication line interconnecting several stations.

multiprogramming: the interleaved (that is, concurrent) execution of two or more programs by a single computer.

narrow-band (a.): denoting a communication channel capable of a transmission rate of up to 300 bits per second.

network: a series of points interconnected by communication channels.

network, leased line or private wire: a network reserved for the exclusive use of one customer.

off-line: pertaining to devices not in direct communication with a computer.

on-line: pertaining to devices in direct communication with a computer.

out-plant system: a system not confined to one plant or locality.

parity check: a test to determine whether the number of ones (or zeros) in an array of binary digits is odd or even.

point-to-point transmission: transmission of data between two points.

polling: a flexible, systematic, centrally controlled method, for permitting stations on a multipoint circuit to transmit without contending for the line.

priority indicators: groups of characters in the header of a message, specifying the order of transmission of messages over a communication channel.

queue: a group of items awaiting processing by some facility.

real-time processing: processing data rapidly enough to provide results useful in directly controlling a physical process or guiding a human user.
record: a group of related data items treated as a unit.
response: see *acknowledgement.*
response time: the interval between completion of an input message and receipt of an output response.
restart: to return to a previous point in a program and resume operation from that point; often associated with a checkpoint.

shutdown: temporary termination of computer processing to be resumed at some later time.
space state: state of a communication line corresponding to an off, open, or logical zero condition; contrast with *mark state.*
startup: initiation of computer processing or resumption of it from a point of temporary termination.
start-stop mode: a mode of data transmission in which each character is delimited by special control bits denoting the beginning and end of the sequence of data bits representing the character; contrast with *synchronous mode.*
static allocation: the technique of assigning fixed storage areas prior to processing; contrast with *dynamic allocation.*
store and forward switching: see *message switching.*
stunt box: a device to control non-printing functions of a teletypewriter terminal.
subset: a modulation/demodulation device designed to provide compatibility of signals between data processing equipment and communication facilities. Also called modem.
synchronous mode: a mode of data transmission in which character synchronism is controlled by timing signals generated at the sending and receiving stations; contrast with *start-stop mode.*

tariff: the published rate for a particular approved commercial service of a common carrier; also, a list of services provided and requirements for their use.
telecommunication: communication by electromagnetic systems; often used interchangeably with communication.
TCU: abbreviation for transmission control unit.
Teleprinter: trade name used by Western Union to refer specifically to telegraph page printers.
Teletype: trademark of the Teletype Corporation.
Teletypewriter: trade name used by AT&T to refer specifically to telegraph page printers.
Teletypewriter Exchange Service (TWX): a semi-automatic switching service provided by AT&T for interconnecting public teletypewriter subscribers.
Telex: an automatic switching service provided by Western Union for interconnecting teleprinter subscribers.
Telpak: a tariff offered by AT&T for leasing or broadband channels.
terminal unit: equipment on a communication channel that may be used for either input or output, or both.
text: that part of a message which contains the information to be conveyed; contrast with *header.*
tie-line: a leased communication channel or circuit.
time-share: to interleave the use of a device or system for two or more purposes.
transmission: the electrical transfer of information from one location to another.
transmission control unit: a unit to interface communication lines with a computer. Sometimes abbreviated as TCU.
turnaround time: the interval of time between submission of a job for computer processing and receipt of results; the time interval required to reverse the direction of transmission over a communication line.
TWX: abbreviation of Teletypewriter Exchange Service.

unattended operation: use of a terminal unit without an attending operator.
USASCII: United States of America Standard Code for Information Interchange.

voice grade line: a channel suitable for transmission of speech.
VRC: abbreviation for vertical redundancy checking method, in which parity is checked vertically across each character in a record.
voice-band (adj.): denoting a communication channel capable of a transmission state exceeding 300 bits per second; a channel suitable for transmission of speech.

WATS: abbreviation for AT&T's Wide Area Telephone Service, providing a special line on which the subscriber may make unlimited calls to certain zones on a direct distance dialing basis for a flat monthly charge.
wide-band (a.): denoting a communication channel capable of a transmission rate greater than about 18,000 bits per second.
Word: in telegraphy, a word consists of six code combinations.

Bibliography

The following reference publications provide more detailed information regarding the subject introduced in this manual:

IBM Teleprocessing Systems Summary (GA24-3090)
Briefly describes teleprocessing equipment.

IBM System/360 System Summary (GA22-6810)
The basic features of both data processing and teleprocessing equipment under System/360 are described briefly.

IBM SRL Bibliography Supplement–Teleprocessing and Data Collection (GA24-3089)
This bibliography contains abstracts for available reference literature for hardware and physical planning of IBM teleprocessing and data collection equipment.

Data Communications Primer (GC20-1668)
This reference manual provides current information on common carrier facilities, specifications and tariffs.

Planning and Installation of a Data Communications System Using IBM Line Adapters (GA24-3435)
This reference publication describes four types of IBM line adapters available for use with IBM data communication terminals and multiplexors. System configurations, including maximum transmission line lengths are specified.

Principles of Data Acquisition Systems (GE20-0090)
This manual provides an introductory description of data acquisition systems. It acquaints the reader with many of the various items of hardware commonly encountered in data acquisition systems, the means of connecting them in a system configuration, and the central processing unit features and programming capabilities necessary for efficient operation.

General Information–Binary Synchronous Communications (GA27-3004)
This publication describes the Binary Synchronous Communications (BSC) in general terms. The major topics covered are: BSC concepts (including transmission codes and data link operation), message formats and additional data link.

IBM System/360 Disk and Tape Operating Systems Concepts and Facilities (GC24-5030)
This reference manual describes the concepts of DOS and TOS, and through an explanation of their components, guides the planner in the use of the facilities available.

IBM System/360 Operating System Concepts and Facilities (GC28-6535)
This publication explains the structure and components of OS and guides the planner in the use of the facilities available.

IBM System/360 Disk Operating System Basic Telecommunications Access Method (GC30-5001)
Included are macro instruction formats and descriptions for assembler-language programmers using BTAM under DOS.

IBM System/360 Operating System Basic Telecommunications Access Method (GC30-2004)
BTAM facilities are described as they are used under OS.

IBM System/360 Disk Operating System QTAM Message Control Program (GC30-5004)
This manual outlines specifications for the use of QTAM under DOS.

IBM System/360 Operating System Queued Telecommunications Access Method Message Control Program (GC30-2005)
This publication contains specifications for the problem programmer's use of QTAM under OS.

IBM System/360 Operating System Planning for Telecommunications Access Method (GC30-2020)
This is the planning manual for the use of TCAM under OS.

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