Chrysler message switching today and tomorrow

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The Chrysler corporate Teletype network was established primarily to provide increased capability for written communications between corporate locations. This system utilizes Model 28 Teletype equipment with associated 81D1 selection equipment as remote terminals and a General Electric Datanet 30 as the central computer switcher.

The Datanet 30 is a 16K machine with 18.8 million characters of random-access disc storage. It is connected to approximately 60 locations through a network of dedicated, full-duplex Teletype grade circuits. The network is international in scope, talking directly to London, Mexico, Sydney, and Panama. The domestic circuits operate at 75 baud and the international circuits at 50 baud.

To perform the function of message switching, each message must contain inviolate header information. The header consists of one to eight addresses of the message recipients, the originating station message sequence number, the code identification of the addressee, and the message priority level, normal or rush. The text follows with the message being terminated by an end of message code. Any violation of the header information will cause the computer to completely reject the entire message. If the message is in error, the computer will initiate a service back to the originating station indicating an error was detected. The header must then be corrected, and the entire message must be retransmitted. The switching computer software has three primary functions which operate on these data—storing, forwarding, and processing. Storing's function is to move the data received from the line to permanent storage on the disc file. Processing then performs header validation on the data as to: (1) the transmit location, (2) the receive location, (3) the message sequence number, and (4) the priority code. Passing the validation check, the message is then placed in a line buffer or queue for transmission to the message recipient. Forwarding performs the function of transmitting each message on a first in—first out basis, depending on priority, to the respective receiving location.

Three other software functions essential to an effective operation are: (1) message retrieval, (2) message intercept, and (3) network analysis. Message retrieval allows for retrieval of a message already sent to a location. It is retrieved by the received message number and the requesting station's identification code from permanent storage on the disc file. The message intercept function allows the computer to hold traffic for a station which it has determined is inoperative or through reception of a control message from the remote location. Messages are held (intercepted) until the station becomes operative and/or a control message from that location is received, removing it from the intercept status. Network analysis is provided to give operating personnel the means for network management. This analysis is in the form of written messages, which indicate the status of each line as to the number of characters sent and received and the queue which has developed for each station on a particular line. These reports can be requested for any hour throughout the operating day or as a summary of the day's traffic. The reports are requested through specific control messages from the network control teletype station. In addition to these traffic reports, a cost allocation report is generated once a month and is used to charge each user of the system its cost based on transmitted characters only.

During idle time, the computer performs routine diagnostic checks on itself. This program is designed to identify marginal hardware conditions, which, if not corrected, could eventually cause a hardware failure, shutting down the system. Any condition not passing these checks is identified and printed on the network monitor. The operator then takes the appropriate corrective action, which, in most instances, means notifying a General Electric customer engineer that maintenance is required. This maintenance is generally performed at the end of the normal working day. The operation of the network is directly under the control of the computer. The only manual intervention required is for start-up in the morning and shut-down in the evening. Most of the circuits are multi-point circuits which require the DN-30 to poll each station to initiate transmission. Polling on the single-point circuits is done to provide both station control and line control. Each message transmitted to the remote contains a discreet call directing code for each station on that line. This code operates the 81D1 selectors to turn on the proper receiving station and blind all others to reception of the message. Line control is provided by using the poll pattern and "H" answer back, in conjunction with identification of line mark or space conditions. If, after a poll, neither traffic or an "H" answer back is received, the computer assumes trouble with that particular station. The computer immediately places the station or line on intercept and will not transmit data to these locations until the trouble is corrected and the station requests the computer to remove itself from intercept.

The computer, presently, is in operation 24 hours a day, five days a week. One hour is needed out of the 24 to clear the file of all transmitted traffic and to repack all unsent traffic to the beginning of the file. The system is not backed-up at this time due to the fact that short duration outages, up to one-half hour, can be made up quite easily since our circuits are loaded at about 70 per cent capacity during the busy hour. However, with the increased use of the system by our international locations, along with a general volume increase, we realize some back-up is now required. Therefore, we are currently installing a second disc. This means that messages entering the system will be written sequentially on both discs. This will provide security against lost traffic due to a catastrophic failure to the disc file. We have found through past analysis that 88 per cent of the failures in the computer have been traced to the disc.

Prior to July 1963, the installation date of the DN-30, Chrysler recognized the need to improve its capabilities in the area of written message communications. The basic approach taken was to replace the then operational manual torn tape system with a computer. Justification was based on the need to: (1) reduce operating costs, (2) increase our operational capabilities, and (3) reduce the incremental costs for system expansion. Our success in all three areas is evidenced by the fact that this system has been in operation for over five years. The inherent capabilities of computer switching did, in fact, meet our immediate and long-range requirements at a reduced cost. Very briefly, those areas which were of significant cost to warrant replacements were the manual torn tape equipment, the multiple address reproduction equipment, and the staffing necessary for the central switching operation.

As in 1963, we in Chrysler are still sensitive to the need for a higher capability in the data communications field—a capability not limited to computer switching for message traffic, but one which recognizes and integrates the requirements of several types of data communications which are necessary in an industrial environment.

There are many other companies who are also experiencing pressures of the expanding need for transmission of data between several data processing installations. The demand for increased capability for automatic message switching, remote data entry, and real-time remote inquiry is also becoming more insistent. These demands are resulting in quick obsolescence of most corporate communication systems.

We have, therefore, completed a study presenting a conceptual communication system tailored to Chrysler's precise requirements. It is a system which offers the capability to adjust and expand to meet changing requirements with a minimal corporate disturbance and at minimal related costs.

The design of this conceptual system is based upon the use of electronic computer components which will be completely modular, flexible, and expandable. The single outstanding feature of this system, the **Chrysler Data Communication Information Interchange,** will be the division and specialization of the data processing and data communications functions.

Three major requirements prompted the development of data communications as an effective management tool:

(1) The need to speed the flow of information;
(2) The need to capture raw input data at its source;
(3) The desirability to consolidate resources by centralization of data processing capabilities.

Data communications as a management tool does not change a system. It does, however, change the methods of data handling and expands the scope of the data processing environment.

Initially, data communications was used in a batch processing environment; i.e., data was prepared at its source, transmitted to a central location, entered in batch to a processing system, and then, via data communications, distributed to the recipient. As system requirements began to place more emphasis on the speed of the information flow, the integration of data communications and data processing became a major system consideration.

The general approach taken by most computer manufacturers was to develop, around a general-purpose computer, the required data communications capability. Within Chrysler corporation, our systems have evolved concurrently with the development of computer system technology. These systems have been the responsibility of the various data processing centers, which have, until now, evolved within an organization which is basically decentralized. It is natural then to expect that the systems themselves are decentralized; i.e., confined to functional problems and not having any direct relationship to other systems. Since many of Chrysler's activities have plants and offices in diverse locations throughout the country and the world, these functional systems have become data communications oriented. This was done to take advantage of the data processing capabilities, which could be had on a centralized basis. Recently some of our systems have crossed the decentralized lines of our organization. This has happened, primarily, to facilitate the capturing of data at its source.

As we stand today, our systems remain basically decentralized and unifunctional in design. However, it is not difficult to look down the road and see that future system requirements will dictate a design which will satisfy many functional and organizational requirements.

In conventionally-organized computer-centered information networks, a large percentage of central computer time can be taken up with communication processing tasks such as speed buffering, error control, code conversion, line management, and similar functions. A general-purpose digital computer is not designed for this role. At Chrysler, we are using the general-purpose computer to handle both the data communications tasks and the systems processing requirements. This approach, which has been our only alternative, does give rise to some very interesting problems. One such problem, as we see it in the long run, is the allocation and use of our manpower. Varying degrees of expertise in on-line data communications exist in Chrysler today. However, these are scattered throughout the corporation associated with the various unifunctional systems. We depend to some degree on the vendor in this area to aid in programming and/or providing software packages to effect data communications. As more and more of our systems become data communications oriented, the dependency on vendor assistance could result in minimal in-house capability to make changes in the data communications, let alone the "grass roots" programming.

We realize that a decentralized approach to data communications will produce inefficiencies in the use of transmission facilities. These inefficiences are in two areas:

(1) **Duplication or less than full usage of line facilities for each system.** This exists because each system now must individually control its own communications environment. The lack of a collective data communications base restricts the corporation from maximizing lines and terminals and in turn, minimizing our costs.

(2) **A limited choice of remote terminals for any single system.** This limitation occurs because of incompatible hardware between remote terminals and general-purpose computers. Once a central site computer is adapted to accommodate a specific terminal, the system is restricted in use to that terminal or terminals with exactly the same characteristics. A remote terminal's communications characteristics are generally hardwired and unalterable. Therefore, a change in remote terminals usually requires an extensive change in system programming.

The characteristics of a data transmission terminal vary within a vendor's line as well as across vendors. These characteristics can be categorized as follows, and we call them the **Family of Incompatibles:**

(1) transmission speed;
(2) terminal synchronization and interface;
(3) transmission character structure; and
(4) transmission error control.

You can expect many problems to arise in implementing data communication systems. Many of these problems will stem directly from the efforts to marry on-line communications and background processing. Many of these problems can and have been solved; however, each time a new system is implemented, or a major system change takes place, a renewed effort is required to solve the same problems over again.

The obsolescence of communication networks, the costly multiplicity of the present communication systems, and the associated problems and inherent limitations have demanded that a solution be found. This solution is embodied in the primary objectives of the Chrysler information interchange system.

The primary objectives of this system are to:

(1) Minimize the affect of the physical constraints placed on any data communication system;
(2) Perform all the control and interface functions of present data communication equipment; and
(3) Maximize the utilization of both the remote terminal equipment and the line facilities.

Accomplishing these objectives will immediately gain the following advantages:

(1) Elimination of the complex software needed to support the present integrated systems;
(2) Increase the availability of data communications to all corporate activities;
(3) Reduce the incremental costs associated with

new and/or expansion of present systems;

(4) Use of our manpower resources more effectively by reducing the efforts now required to launch new systems.

These above-stated objectives dictate that the integrated data communication data processing environment can no longer exist. The data communication task must be separated from the data processing task. We have, therefore, developed a conceptual standard data communication interface which will form the nucleus for the information interchange system. This interface will be specialized computer equipment and programs specifically designed to perform the interface function for a number of diverse data communication data processing tasks.

The design of this information interchange system will incorporate the following characteristics:

(1) the hardware will offer the latest techniques in system design, using integrated circuits and thin film technology to a maximum degree;

(2) the realtime communication software will be tried and proved;

(3) it will be an investment in line with initial requirements and at the same time render obsolescence a minor consideration in development of the total system; and

(4) the requirement for individual system programming for data communications will be eliminated.

The data communications information interchange concept offers several economic advantages. These advantages are:

(1) core requirements for holding overall executive and mainline communications programs will be reduced (see Figure 1);

(2) Data processing computers are free to handle the tasks for which they are designed rather than being forced to spend large amounts of time handling routine communication tasks;

(3) new systems can be implemented with less programming and reduced start-up costs.

To illustrate the use of the data communications information interchange, a typical integrated data communication data processing system can be used as an example. Figure 1 is a model depicting a typical hardware and software configuration of an integrated data communication data processing system. The central site computer, equipped with a data transmission terminal unit and appropriate line adapters, communicates with other computers as remote terminals.

Control of the remote terminals is a function of the central site **data handler.** Processing of received data is done via the **data processing** program. Control of these two program segments and that which allows for integration of the communications and processing functions is through the **master control program.**

In this integrated environment, **time** is an essential factor which must be considered—time allotted for the communication function and time allotted for the

A TYPICAL INTEGRATED DATA COMMUNICATIONS, COMPUTER DATA PROCESSING

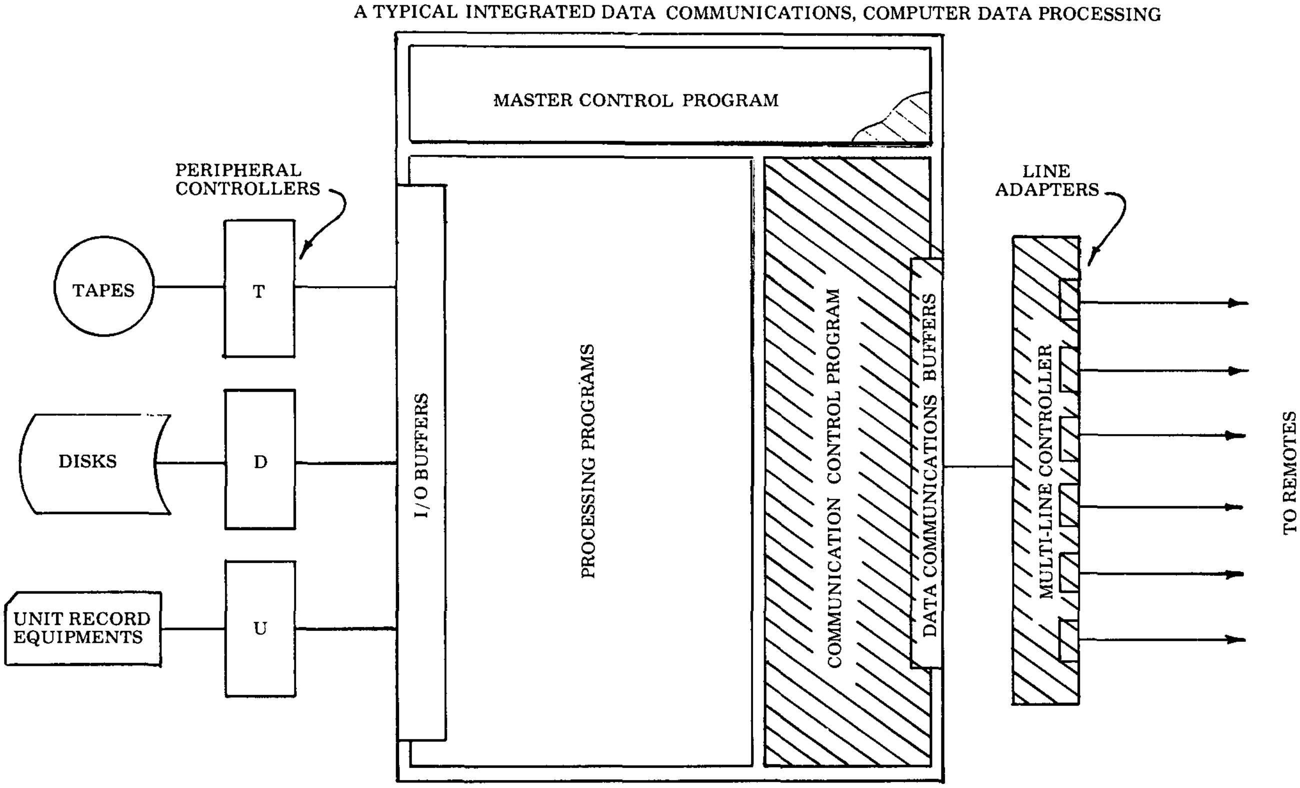

Figure 1

processing function. A typical sequence of events involving both communications and processing is as follows:

(1) The "master control program" instructs the **data handler** to poll a remote.
(2) The **data handler** polls the remote.
(3) The remote acknowledges the poll and transmits a data block.
(4) The **data handler** receives the block and acknowledges back to the remote the correctness of the data.
(5) The remote sends the next data block; and the process of check, acknowledge, and send is continued until all data is received.
(6) The entire message is built up as it is received in an **in-buffer** storage area which will hold the data for processing.
(7) After all the data has been received, it is available to the **data processing program.**
(8) The **master control program** will instruct the **data processing program** to begin processing the data available in the **in buffer.**
(9) The results of this processing are placed in an output storage area called the **out-buffer.**
(10) The **master control program** now instructs the **data handler** to initiate a **poll**; and the communication sequence takes place again, outbound from the central site computer to the remote.

This basic ten-step procedure is repeated for each remote and for every message sent from the remote.

Since there are several transmission lines and many remotes and since the computer is extremely fast, compared to the data transmission time, the basic steps for processing and communication are intermixed; i.e., each remote can be considered to have its own ten steps so remote "A" could be at step one, remote "B" at step eight, etc. The **master control program** then must keep track of what functions are being performed, what functions must be performed next, and when the functions are to be performed. There is a highly-complex interplay being performed in the central site computer. Figure 2, the data processing computer, shows the physical breakpoint of the concept: the information interchange interfaces between the remotes and the data processor. Through hardware and software, data are transmitted between the interface and the processor, thus, forming the communication and processing on-line environment. The only function the central site computer would have is processing (steps 8 and 9 above); all other functions will be per-

A TYPICAL DATA PROCESSING COMPUTER USING THE INFORMATION INTERCHANGE

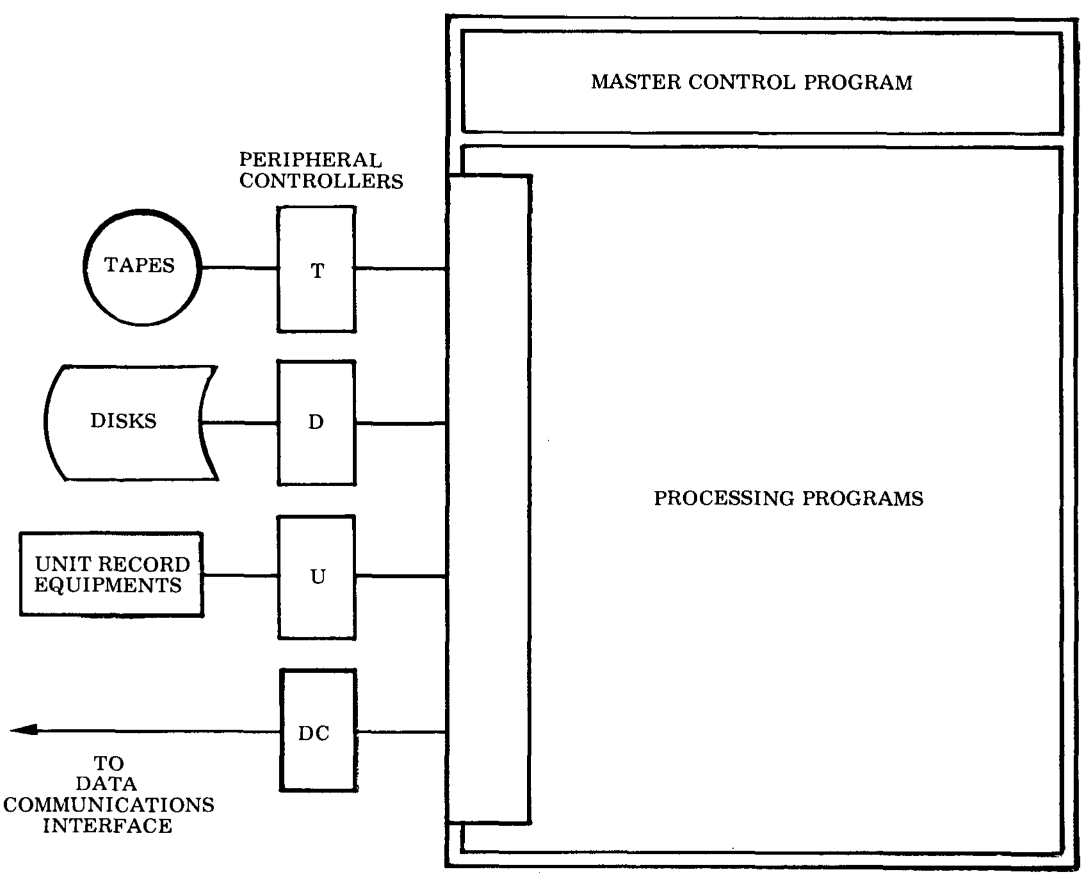

Figure 2

formed by the information interchange. The conceptual interchange will perform all the communications functions. A **get** from the central site would cause the interchange to dump data at approximately 40.8 kilobits/second. The central site would process the data and a **put** would cause the interchange to accept the processed data and route it to the remote terminals.

Applying this concept to decentralized systems, Figure 3 depicts the interchange system environment. The systems remain basically decentralized but yet integrated through the information interchange. This diagram is the basic approach to an overall system. One point to remember is that by separating the data communications and the data processing, the system gains the flexibility of being able to mix, add, or delete remote terminals without making a change at the central site computer. Additionally, the data communications for the system can be maximized along with data communications of other present or planned systems. In effect, it will provide common access to uncommon files.

The planned implementation of the information interchange will be, of necessity, a multi-phased program. The multi-phased program will accomplish two prime things: first, it will minimize the corporate disturbance to the varying processing functions; second, it will

THE INFORMATION INTERCHANGE SYSTEMS APPROACH

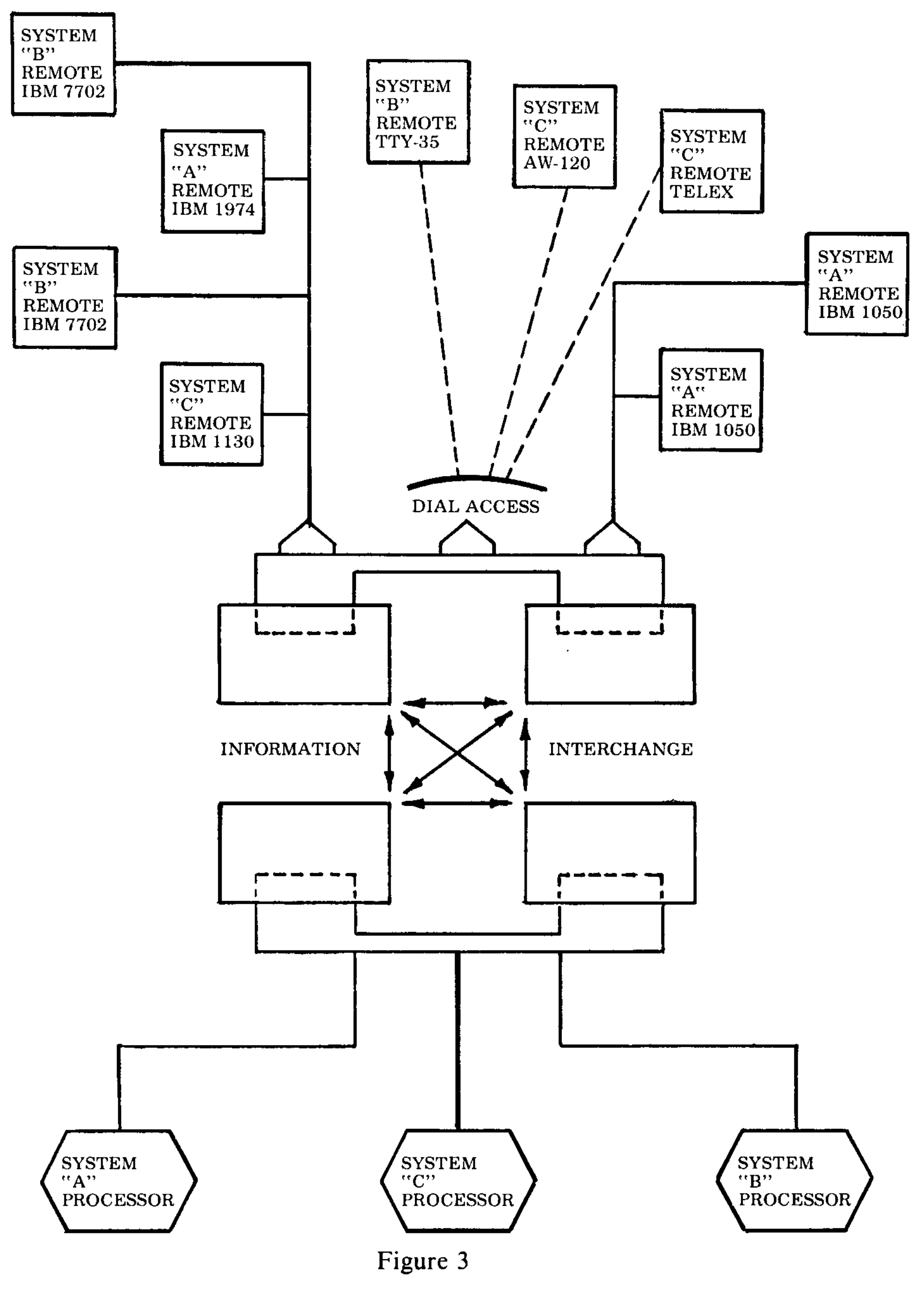

Figure 3

minimize the impact of converting the communications of a system to a new mode of operation.

The initial implementation (Phase I) would involve two existing networks, including our computer-switched teletype network. Additional systems would then be converted within the established basic interchange configuration through the modularity of design of the hardware and software. Phase II through Phase IV would involve conversion of various other Chrysler systems over a 22-month period.

At the conclusion of planned phase IV, the following kinds of on-line realtime communication will be utilized:

(1) low, medium, and high-speed lines;
(2) polled, dialed, and direct line terminations;
(3) inquiry, data collection, and data distribution; and
(4) remote to interchange to processor communication.

Essentially, all communication systems fall into the above categories. It is at this point that the concept would be considered implemented. Other systems could then be added with minimal corporate disturbance. The addition of these systems, rather than being looked at as part of the concept implementation, are to be considered as add-on to an existing system and part of the normal system expansion.

The concept should be considered in light of the operational advantages and management control it will provide a corporation in the area of data communications. Implementation should be an investment for providing the capability to handle both present and planned data communication requirements.

Using the information interchange, we estimate that teleprocessing systems, which are now being planned and designed, can be implemented and operated at about 25% less cost than under the integrated data communications/data processing philosophy.

Our main objective in presenting this concept is to show that there is little relationship between computer switching today and computer switching tomorrow. Our conceptual interchange has for all practical purposes made no distinction as to the various data communications tasks be they switching, inquiry, data collection, etc. The main concern is the environment of communications and the need to move information from one point to another irrespective of the nature of the information.