Integrated Data Processing with the Univac File Computer

R. P. DALY

THE Univac file computer is an intermediate computer which combines a large-capacity internally stored file of information with high-speed electronic computing. This information file is a "random access" file with sufficient speed and capacity to permit integrated data processing.

First, integrated data processing will be defined as it relates to the processing of data through a computing system. The term "integrated" means the complete or the whole function. As used in the phrase, "integrated data processing," it means the complete processing of the data involved in a business transaction to obtain the desired result and take all necessary action. In addition to obtaining the primary result and taking all necessary action, all the various business records affected by the transaction and the subsequent action taken are automatically posted and adjusted as necessary to reflect the current situation.

Now the requirements of a computing system capable of integrated data processing will be considered. As each of these requirements is looked at, the specific characteristics of the Univac file computer designed to handle each requirement will be described. To be capable of integrated data processing in business applications, the computing system must have extremely versatile input-output capabilities. Because of the diverse requirements of various business problems, it must be possible to communicate with the system on information media which best lend themselves to a specific operation. Commonly used media on which information is handled and with which the system must communicate include punch cards, magnetic tape and perforated tape. In addition to these prepared media, the system must be capable of "on-line" operation accepting data through directly connected manually operated devices such as electric typewriters and other keyboard devices. "On-line" operation of a computing system simply means the capability of the system to process instantaneously, random or sequential data from business transactions as they are passed to the system through some directly connected input device such as an electric typewriter or 10-key keyboard. On the other hand, "off-line" operation of a computing system involves the scheduled processing of batches of previously recorded data such as punched cards or magnetic tape. Information from devices such as paper tape perforators, and magnetic tape recorders, commonly used today for recording data, must all be acceptable to an integrated system.

In addition to this capability of working with any information-handling media, the input-output capabilities of the system must have common language versatility. This means that the system must be capable of communicating with any input or output device regardless of the language or coding, as it is called, of information peculiar to that device. Some examples of commonly used machine language which an on-line system must be capable of accepting are 5-, 6-, 7-, or 8-channel perforated paper tapes, 80- or 90-column punch cards. One more requirement of input-output versatility is the ability of an on-line system to work with multiple input-output devices at the same time and to make available simultaneously, on a time-shared basis, the data processing service of a central computer system to a number of input-output information-handling devices in various work centers of a business.

Each of these input-output features are necessary in a system capable of integrated data processing. Information in business applications is initiated from many sources. It is important, therefore, that no limitation be placed on the type of media on which information may be recorded. Each of the various sources of information will adapt itself best to one of the many types of recording media available today. Some will find a punch card the most readily adaptable means of initially recording a business transaction, others will find paper tape better suited as an initial recording media, and still others will find their requirements best suited by initiating business transactions directly into the computing system through directly-connected devices such as an electric typewriter or 10-key keyboard. As to common language versatility, data on business transactions may originate at remote points and be teletypewritten into the computing system; they may originate on punch cards which are forwarded to the computing center for processing, or they may originate through directly-connected keyboard devices in a third coded language. The system must be capable of accepting these various languages: teletypewriter, punched cards, or directly-connected keyboards which are peculiar to the particular communications link best suited to connecting a specific source of information on business transactions to the central computing system.

The capability of working with a number of input-output devices simultaneously on a time-shared basis is vital to successful operation of an automatic data-processing system in many business applications. Sources of business data are numerous. To avoid the time-consuming processes of data collection, data manipulation and scheduled data processing, input devices directly connected to the central computer must be available at the various locations where business data originates. In many cases the number of business transactions at a given location is such that several manually operated keyboard devices are required to process the data initially. If each of these keyboard devices is not connected on-line to the central computer, costly delays are again incurred in data collection, data manipulation and scheduled data processing. Many business operations require that the results of processing certain data be sent to a number of output locations. This may be necessary where identical business functions are being carried on in many different locations or where the results of processing certain types of business data must be continually furnished to a number of different locations to facilitate certain accounting and management controls.

The Univac file computer has common language versatility. There is no code restriction on the input or output data. The machine operates internally in Remington Rand's standard Univac Code, and a general-purpose code translator provides the common language link with various input or output devices. Some of the input-output devices which are available for use with the Univac file computer include 80- or 90-column punch card equipment, magnetic tape, perforated paper tape and key-driven devices such as electric typewriters and 10-key adding machines. As other devices now under development, such as character

R. P. DALY is with Remington Rand Univac, a division of the Sperry Rand Corporation, St. Paul, Minn.

readers and magnetic cards, become commercially available, these devices can be directly connected for operation with a file computer system. A large variety of input, input-output and output devices can be connected to the system and simultaneously time-share the computer. The file computer has ten programmable input-output demand stations. Each of these stations may have as many as 24 devices connected to it and scanned sequentially by the central computer. Multiple input-output devices can be connected to the computing system through these stations and share its computing capabilities up to the capacity of this intermediate speed computer. Six different program routines are available at each of the ten stations. The Univac file computer is a system with the complete versatility of input-output operation so necessary to accomplish integrated processing of the data involved in handling business transactions.

To accomplish integrated processing of business transactions data, a computer system must have adequate internal random-access storage with sufficient speed so that it can accept a particular transaction and completely process it, obtaining any desired end result. To process completely random business transactions, it is necessary to have available on immediate call from internal storage all of the business records which might be affected by the transaction and the action taken on it. The internal storage then must be of sufficient capacity to contain the necessary business records, and the access time to this storage must be fast enough so that it does not seriously impede the traffic on the system. It is estimated that an intermediate system such as is being considered today should be capable of processing approximately 100,000 average business transactions in an 8-hour day. The Univac file computer system meets this requirement with large-capacity random-access magnetic drum storage. Each large drum can store 180,000 alphanumeric characters, and additional drums can be added to the system as required to increase the total storage capacity to 1,800,000 characters. With special adapter equipment, this magnetic drum capacity can be expanded to almost 6,000,000 characters. The speed of these drums is 1,750 rpm, making the average access time to a selected business record approximately 17 milliseconds. This intermediate computer system can process an average business transaction in approximately 250 milliseconds, or 15,000 transactions an hour, or 100,000 transactions a day. In addition to this internal working file of business records, the system must be capable of storing large additional files of records. This additional storage is made available through magnetic tape equipment. Various blocks of records from this large external magnetic tape file can be called into the system's internal storage as required in handling various types of business transactions. These large capacity external files of business records add the necessary balance to the computing system. The magnetic tape provides an expandable storage media with tremendous capacity. As larger capacities of storage are required, magnetic tape units can be added to the basic system as one or multiple sources of blocks of business records.

Fig. 1 illustrates how data are handled by most data processing systems today. The author calls this "Off-line data processing." Information is collected as a result of business transactions and sent to the computing center. At the computing center the data is collected, batched, sorted, collated, reproduced, etc., to prepare it for processing on the computer. These operations, of course, require equipment, people, and time at the input. Periodically, as the necessary business data has been collected and manipulated, it is scheduled for computer processing and "spoon fed" to the computer. The circle marked "calculator" is the high speed counter, the computer. This is the device that must be used efficiently. Data must be collected for it, transmitted to it and scheduled for processing on it. After the computing operations are completed, the output data must again be manipulated in much the same manner as at the input, sorting, collating, reproducing, etc., as required, in order that the data can be usable for management reports, operation summaries, customer notifications, etc. These necessary operations, of course, require additional equipment, people and time at the output.

Many business data-processing operations can best be accomplished in this "off-line" manner. The sequential nature of their operation lends itself very well to off-line data processing. Many other business data-processing operations, however, are done in this manner only because equipment is not available to do them in any other way.

Fig. 2 is the same illustration as Fig. 1 with an additional box marked "large-capacity random-access storage." The addition of this one device makes it possible to consider integrated data processing for those operations where sufficient random-access storage capacity is available to store the necessary business records. Business data generated as a result of random business transactions, collected at the point of origin by an efficient information collecting device, as mentioned in the foregoing, and transmitted to the central computing system by means of capable communication facilities can now be processed in the random order in which they arrive with no collecting, batching, scheduling delays or data manipulation. Most business transactions because of their very nature are random transactions. With sufficient large-capacity random-access storage, all necessary business records can be stored

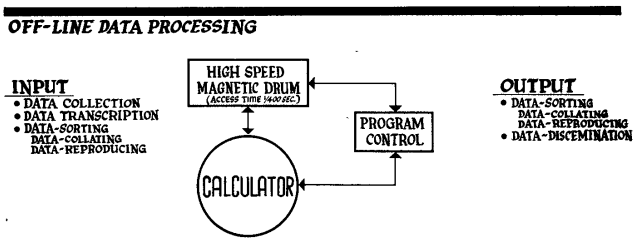

Fig. 1. Off-line data process system

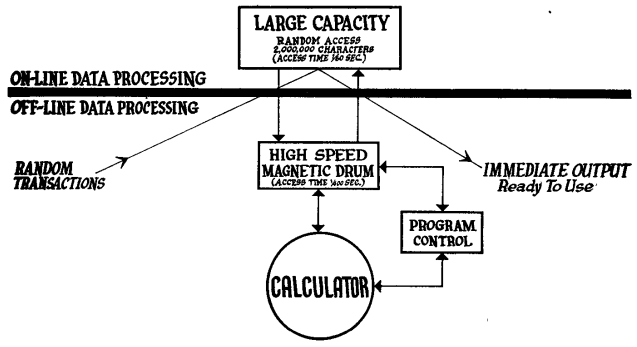

Fig. 2. Data process system showing large capacity random access storage

where they are immediately available on random call. As random business transactions are received and processed, the business records affected by the transactions are automatically up-dated.

With the ability to up-date business records automatically as a result of day-to-day transactions, the basic operation of file maintenance can be mechanized. Up to the capacities of available random-access storage devices, business record files can be maintained automatically so that they always reflect the current situation. This means that the many management reports now derived by periodic review and analysis of these files are always present. The inventory control, sales analysis, profit and loss, accounts receivable, accounts payable, etc., reports are automatically prepared, maintained, and always available on instant demand from the central computing system. As the action taken on a particular business transaction affects the ledger sheet, the inventory level, and the sales records, these records are automatically changed to reflect the current expenditures against a department budget, the current profit or loss condition, the current inventory level or the current sales volume. With complete and current report information automatically maintained and instantly available, an era of "reportless reports" can now be achieved. Management information "monitors" can be stored in the large random-access storage file and changes in various elements of operating information affected by the business data generated as a result of day to day business transactions, can be constantly and automatically "watched." Every time the inventory level of an item is changed, the new level can be automatically compared with the "monitor," the minimum reorder level. If the action taken as a result of a business transaction causes the current inventory level of any item to drop below the reorder level, an immediate alarm can be sounded. In any case, at the time an inventory report is requested, it is not necessary to prepare a complete report on every item. An exception report can be prepared automatically. The central computing system can analyze the inventory status of each item and report on just those items that have dropped below their minimum reorder level or do not meet some other qualification of the computer reporting program. This same technique can be applied to all of the filed operating data. Necessary management and operating reports are always prepared, always current and ready to use. The computing system can read out a report on any specific item or condition, a complete report or an exception report. The profit or loss condition is continually available. In fact, before a business transaction is consummated the forecasted results can be quickly reflected against the present profit and loss situation to determine if the transaction will be a profitable one or not.

The large capacity random-access storage of the Univac file computer with an access time of 1/60th of a second permits a large volume of traffic to be handled on the system. The storage capacity of these drums can be expanded in a standard system to contain up to 2,000,000 alpha-numeric characters and with special adapting equipment this "high traffic-random access" storage can be expanded to contain up to 5,000,000 characters as indicated in Fig. 2. Fig. 3 is the same as Fig. 2 with the addition of a box labeled "mass storage." This larger capacity of random-access storage is being developed for use with the Univac file computer. Mass storage units will have capacity for from 50,000,000 to 100,000,000 characters. The access time to this larger capacity storage may be 1 second or more; however, and, as such, might seriously limit the traffic on a system without the large-capacity, relatively short-access magnetic drum storage.

Notice in Fig. 3 how the three storage boxes or echelons of storage balance the flow of information to the calculator or high speed counter. The first echelon of storage must have fast enough access to feed the high-speed counter information at a rate fast enough to keep the calculator busy. The second echelon of storage can have a little slower access time but greater storage capacity to balance the flow of information. This second echelon of storage must have a fast enough access time to support the necessary traffic on the system. The third echelon of storage, of course, has very large capacity but relatively slow reference time. These three echelons of storage make up a balanced system designed to permit the necessary flow of information to use the high speed calculator efficiently.

To accomplish integrated processing of business transactions data, a computer system must have adequate program capacity and simplified programming techniques. To process data on many different types of transactions from many different sources; to edit the data at the input for computer operations and re-edit the data at output to match the requirements of any specific output devices; to co-ordinate and control the multitude of diverse operations necessary to accomplish the posting and up-dating of business records affected by any transaction, these functions require a large capacity for program instructions. The programming process itself must be simple because of the amount of day-to-day program variations generated by the many diverse data-processing operations and the daily changing requirements of business operations. Much of the information required and the data processing necessary is in the form of unscheduled demands by management. These management demands for information each require a different type of analysis of the basic data recorded in the storage file of the data-processing system. Programming techniques must be simple in order that computer operations may be easily changed and new programs readily supplied to meet the special demands of day-to-day business operating requirements.

The Univac file computer is designed to use plugboard programming. Program instructions can also be stored on a high-speed magnetic drum. It is a 3-address-logic machine and, as such, programming techniques are just an extension of punched-card logic. One program step performs the complete operation of $A+B=C$. This complete operation involves obtaining the operands A

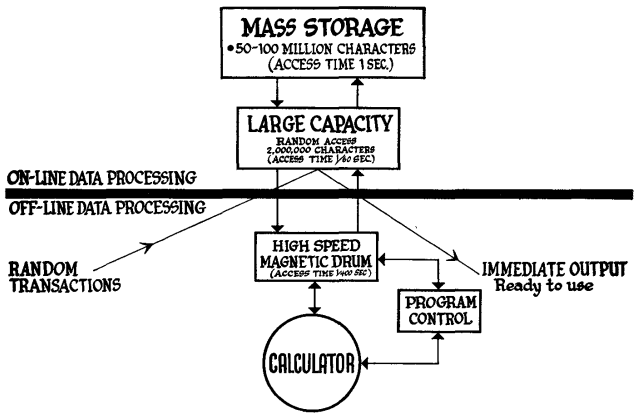

Fig. 3. Data process system showing mass storage

and *B*, performing the command function indicated and storing the result, *C*. "Plus," "minus" or "zero" branching is available on the result of any program step and "equal," "greater" or "less-than" branching is available on any comparison. Three-address logic offers the most direct and simple approach to programming business problems. The plugboard has proved through its years of use in punched card machines to be the most adaptable and flexible means of programming for business operations. Its versatility through the use of multiple boards, its ease of application, its flexibility, its ready availability for immediate use, these are a few of the reasons why a plugboard programming technique has been selected. The unscheduled non-routine demands of day-to-day business operations on automatic data-processing systems can be easily handled through plugboard programming techniques.

A plugboard of the Univac file computer has 48 program-step positions and a large complement of selectors to vary the use of these steps as a specific program requires variations. The selectors are particularly useful in handling exceptions and obtaining data from alternate storage locations. In addition to the 48 program steps on the plugboard, a small high-speed drum is available for storing instructions and data. Up to 1,000 instructions and data can be stored on this high-speed drum. Each instruction contains three 3-digit addresses, two for operands, one for the result, and a 2-digit command code for a total of 11 digits. The plugboard is used as a command coding matrix when instructions are stored on the high-speed magnetic drum. The commands necessary for specific operations are wired into the plugboard and referred to as needed by the instructions. This large capacity for program instructions can be expanded even further by storing instructions in blocks of ten on a large-capacity magnetic drum. Up to 15,000 instructions can be stored on one large drum. A "block-transfer" command is available to transfer blocks of ten instructions at a time, from the large-capacity drum to the small high-speed drum where normally, several tracks would be set aside for this purpose. The block transfer permits storing of program exception routines which must be available but are only used occasionally on the large-capacity magnetic drums. The 1,000 word positions of the small drum can thus be more efficiently used for storing primary instructions and data.

The Univac file computer is uniquely well-adapted to the integrated processing of business data primarily because of its flexibility and versatility in storing and accessing information and in controlling the movement of data in and out of the computer. Two features of the machine which particularly enhance its flexibility and versatility in these functions are a flexible command structure and variable word length of stored data.

The command structure of the Univac file computer includes three types of return jumps, an unconditional jump and five input-output control commands permanently wired in as internal instructions. All other commands to be used by the computer are selected at the programmer's option and wired into a plugboard. This philosophy gives the computer a truly general-purpose command structure with a pluggable command decoding matrix, the plugboard, capable of being wired up at the programmer's option with up to 48 command positions. Only those commands necessary to perform the data-processing functions of a given application need be wired up. This command structure flexibility permits maximum utilization of a programmer's initiative to tailor the computer control to specific applications with a minimum of the compromises normally necessary in fixed "general-purpose" command structures. A simple exchange of plugboards alters the entire command structure of the computer, quickly tailoring it to various types of applications. Such functions as interest computations and sum of the squares are easily plugged up as subroutines and referenced by a single instruction on the plugboard. Floating point addition takes approximately eight program command positions on the plugboard and can be performed by the computer as a single instruction in 40 milliseconds.

The word length of information stored on the large-capacity general storage drums of the Univac file computer is program variable within any routine in multiples of 12 up to 120 characters with the exception that the unit record length of 108 is not available. Any of the large-capacity general-storage magnetic drums or for that matter, any track on a drum, could have stored on it nine different types of information each with a different unit record length. The unit record length desired in a program routine is specified by the highest order digit of a 7-digit drum address.

In addition to variable-unit record length of stored information, the field structure of a given unit record is completely variable and specified by program control. This variable field structure applies not only to the variable size unit records of the large-capacity general-storage drums, but also to the 120-character unit record tracks of the high-speed drum. Any unit record can contain from 1 to 20 designating fields of from 1 to 12 characters in length. The field pattern of a unit record on either the large capacity general storage drums or the high speed drum is determined by block transferring a prestored field designation pattern to the field designation register of the large capacity general-storage drum or the field designation register of the high-speed drum. Automatic editing of input and output data is easily accomplished through program control of the field designation pattern of input-output storage.

The integrated processing of business data requires a complete data-processing system. Furthermore, this system must be flexible and versatile enough to be tailored easily to specific applications. The Univac file computer qualifies because it is a system of equipments the heart of which consists of intermediate-speed arithmetic equipment to which is connected control equipment made completely versatile by means of a flexible plugboard-defined command structure. To this "central computer" is connected on one hand, the particular type of storage best applied to a specific application large capacity, random-access magnetic drums, magnetic tapes, punched cards, etc., and on the other hand the input and output devices which best match the data processing requirements of the application: 80- or 90-column punch card readers and punches; 5-, 6-, 7- or 8-channel perforated paper tape readers or punches; 10-key or multiple key numeric or alpha-numeric keyboards; on-line or off-line printers; magnetic tape readers and recorders, and similar devices.