MANAGEMENT PLANNING for DATA PROCESSING

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Preface

Brandon Applied Systems, Inc., is a technical management consulting firm specializing in the application and installation of electronic data processing systems. In the course of its work it is often called upon to provide basic orientation in data processing to client management and client personnel responsible for implementation of this new technology. Out of this work has grown this basic text, whose purpose is to introduce the reader to the concepts of electronic data processing, in simple, understandable language.

The book has been written for the layman in data processing, as a basic guide to computers. It is not technical, and does not describe the inner workings of a computer or computer component. It does, however, describe the components of computers, how they work, how they are used, and what kinds of problems they present. The book is intended for all who will come in contact with computers, and for those who want a basic understanding to appreciate the capacity, strengths and weaknesses of a computer system.

The book may be used as an introductory text on computers, or as a prerequisite to a more advanced course on programming or computer design. It is intended to be understandable at Senior High School and College level, as an elementary introduction to the subject.

D.H.B.

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CHAPTER 1

Introduction

This is a basic text on computers, their characteristics, and components, their impact on business and business management, and the planning steps necessary to use them effectively. It is a basic guide for management personnel not normally directly concerned with the implementation or use of computers. Nontechnical, it does not describe the electronic circuitry or components of a computer; rather, it describes the way major components work together to perform the required functions.

The subject of computers is complex, and detailed coverage requires a book of far greater scope than this. The present book can only highlight the major constituents of computers, and their applications; it cannot provide the details required for the technical expert. The bibliography provided indicates additional reading possible on various topics.

AUTOMATION

To understand a computer, its basic method of operation, and the framework into which it fits, it is necessary first to define what we mean by automation, and to set down the broad areas in which automation currently is put to use. The word "automation" was coined in 1946 by Del S. Harder, then a Vice-President of the Ford Motor Company, to describe the automatic control of parts handling in automobile manufacturing. Since it was coined, the word has often been used without a real understanding of the processes it describes. It is an abbreviation of the word automatization and, as used by Mr. Harder, described the process of materials handling control and the use of mechanical parts transfer machines in a discrete manufacturing process.

Automation may now be generally defined as the technology of using mechanical or electronic methods to control any process, whether it be flow of information or the manufacture of parts.

It is recognized today that there are four general types of automation:

1. *"DETROIT" AUTOMATION, OR MANUFACTURING AUTOMATION.* The process originally referred to by Mr. Harder when he coined the word is currently referred to as manufacturing automation or "Detroit" automation, since the use of parts transfer machines and automatic control of assembly lines is typified by the automobile industry. Obviously, numerous other industries using or manufacturing discrete parts now employ automation.

2. *PROCESS CONTROL AUTOMATION.* The second form of automation is the application or use of automatic techniques in the control of a flow process; specific examples of its use are in oil refining, power generation, and in many major chemical manufacturing processes, such as the manufacture of ammonia. To monitor and control these processes, a computer is directly connected to various control devices that are capable of providing instantaneous data about the behavior of the process.

3. *NUMERICAL TOOL CONTROL, OR NUMERICAL CONTROL.* The third form of automation, the use of computers in the control of machine tools, is referred to as numerical machine tool control, and is normally abbreviated to numerical control. A typical example of numerical control is a computer-controlled milling machine whose instructions are provided by a paper tape fed into the computer to define the direction and depth of cuts to be made by the machine.

4. *INFORMATION PROCESSING AUTOMATION, OR INFORMATION AUTOMATION.* The application of computers in the control and processing of information is the fourth form of automation. This use of computers, whether it is to perform the massive mathematical calculations required by an engineer or to process the data necessary for a payroll, can be categorized as information processing.*

It is this form of automation that will clearly have the greatest impact on our society and that is the principal subject of this book.

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* When computers are applied to information processing, the terms describing the use are usually (1) automatic data processing (ADP), (2) electronic data processing (EDP), or (3) information systems.

ELEMENTS OF INFORMATION PROCESSING SYSTEMS

Information processing systems of all kinds consist of five elements that work together to provide the required processing. Although these five elements may differ from system to system in terms of type of component or device used, they function in basically the same way in each. A discussion of the five elements follows.

1. The ability to receive information: *Input.* The ability to receive information is the first element of any information processing system. Man uses his sense organs, principally his eyes and his ears, as input devices. An example of his input can be drawn in the situation where he is processing his income tax return: he reads, and receives information from, the instruction booklet, his cancelled checks, and his W-2 forms (or the like).

In a machine system, input can be provided in many different forms. It can be made up of punched cards, punched tape, documents that can be read directly by the machine, or even a translation of the human voice into electronic signals directly intelligible to the machine.

2. The ability to produce information: *Output.* The second element of all types of information processing systems is the ability to produce information. Man has two output devices: his ability to speak and his ability to produce written or signalled information. Again, a machine system may have many different types of output; we will only consider as applicable to our discussion those devices that produce output intelligible to human beings. The electronic signals produced by a machine system are not ordinarily directly useful to man and therefore not a valid output.

3. The ability to retain information: *Storage.* Vital to the processing of information is the ability to retain it. Information processing systems require substantial amounts of stored data in various forms. Humans use the brain as their principal storage medium, although man is also capable of storing information in handwritten or printed form, or in audio or visual media. A man processing his income tax return undoubtedly has retained in his storage the number of his dependents (as defined by the Internal Revenue Service), so that he will be able to deduct the proper amount of money. A machine system uses various electronic devices to store information. It is therefore capable of storing and recalling sizable amounts of information more rapidly than man, but it cannot always store as much information as can the human brain.

4. The ability to manipulate information: *Arithmetic*. The ability to manipulate information in a way that follows the basic principles of what we call arithmetic is an important element of information processing systems. As part of his basic education, man learns and stores certain manipulative routines, for example, the multiplication tables. A machine system generally manipulates information electronically and can do so at rates that approximate the speed of light.

5. The ability to control the process: *Logic*. The ability to control the process, what we refer to here as logic, is the ability to follow a specific, predefined set of instructions. This final element is perhaps the most significant of the five. It is exemplified in the case of the man filling out his income tax return by his following the processing instructions provided by the Internal Revenue Service. The machine system follows similar instructions but uses smaller units of instruction. Whereas a single instruction can tell a man to enter his income on line 9, page 1, the machine might require 20 to 30 instructions for the same purpose.

Figure 1-1 shows the relationships of the five elements of an information processing system. The man system, shown as Figure 1-2, has the same elements, although they are often not as obviously separable as in a machine system.

INFORMATION PROCESSING SYSTEMS

All types of information processing are performed by a *system*, a group of elements working together to achieve a specific objective. Four different types of such systems can be identified. Each of these systems comprises essentially similar elements and performs its functions using somewhat different components, in a similar manner.

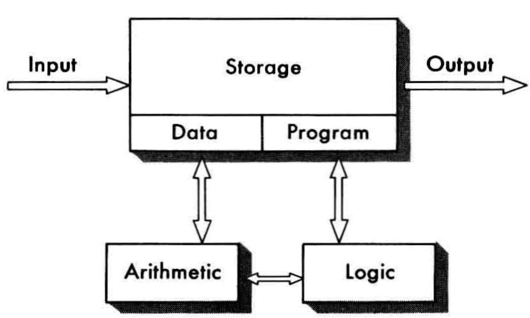

Fig. 1-1 ***Input–output relationships of an information processing system.***

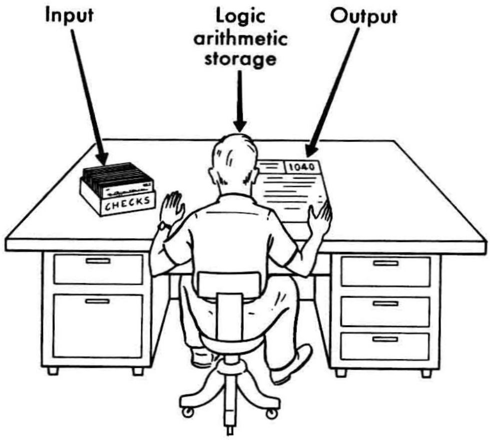

Fig. 1-2 ***The man system using information-processing elements similar to those in Figure 1.***

1. *The Man System.* The simplest of these systems from an information processing viewpoint is the man system—essentially a person working, commonly with paper and pencil, to process the necessary information. A man filling out his income tax return is such a processing system. He receives information through various sensory devices, and he produces written or oral information after suitable processing.

2. *The Machine-Assisted Man System.* The second level, in order of increasing complexity, is the machine-assisted man system. By providing the person with a simple machine, we can enhance his capability in one or more processing areas. For example, if we provide him with a typewriter, we clearly increase the quality of his output. By providing him with a simple adding machine or calculator, we may increase his ability to manipulate information arithmetically, and we certainly increase the speed with which he can manipulate it.

3. *The Man-Assisted Machine System.* The man-assisted machine system represents a substantial increase in complexity. This system, in contrast to the machine-assisted man system, which operates at human speeds, is fundamentally a machine system and operates at machine speeds, except when it depends on a person for specific assistance. An example is an autotyping device capable of generating numerous facsimiles of a letter; when such variable information as names or addresses must be added, the machine system requires an operator to provide this specific information.

Another example of the man-assisted machine system is a punched-card processing system in which each machine is capable of performing a single processing function. A man is required to carry the cards from one machine to the next, to supply the necessary control, and to ensure that the data are processed in the correct sequence, using the correct machines.

4. *The Machine System.* The ultimate level of complexity or sophistication in information processing systems is the machine system, exemplified by a computer that is completely furnished with all components necessary to carry out the five processing elements discussed earlier. This system is totally independent of man for assistance, provided he has properly planned it. Part of the greater complexity of a machine system lies in the discipline it imposes on man, since he must plan the system so carefully as to provide for every possible contingency; he must define his requirements uniformly, so that the machine system can process them accurately, and he must provide the data to be processed in an accurate, usable form.

The machine system, because of the scope of its information processing capability and because of the rapid speeds technology has made possible, has had and will have the greatest impact on society, on our methods of doing business, and on our concepts of management.

Although each of the four types of information processing systems is made up of five comparable functional elements, the components and capacities required to fulfill these functions are obviously not the same. Man's quantitative ability to read is obviously not as great as the machine's ability to digest information using electronic signals. Man's ability to store information in his brain may well compare favorably to the machine's ability. Man's ability to write swiftly and to simultaneously manipulate large numbers of variables is not nearly as great as that of electronically controlled machine components. The differences between man as an information processing system and the machine are illustrated in Figure 1-3; it shows that man's input devices are substantially slower. Also, although the machine produces electronic output with enormous speed, this output cannot serve as a basis for comparison. Electronic output is not ordinarily useful to human beings, and since the machine is a servant of man, who requires that the output be intelligible to him, a meaningful comparison can only be made with respect to understandable output.

Even here, in the production of intelligible information, the machine is perhaps six thousand times faster than man. Now, man must *use* the output produced by the machine and can do so only at his input speed.

	MAN	MACHINE
Input	Eyes/Ears 200 words per minute	Electronic 1,000,000 words per minute
Output	Voice/Writing 40 words per minute	Printed 30,000 words per minute
Storage	1 billion items (lifetime)	10 billion characters
Arithmetic	10 sets of 5 digit numbers added per minute	3,000,000 sets/minute
Logic	15 - 25 instructions per minute	15 million instructions per minute

Fig. 1-3 ***Systems comparison between the man system and the machine system.***

If his input speed is approximately two hundred words per minute, and the machine is capable of generating information at thirty thousand words per minute, it can clearly be seen that the output ability of the machine outstrips man's input or "use" ability by a factor of one hundred and fifty to one. This means that to use a machine effectively, it requires one hundred and fifty men to read or use the output.

Similarly, the machine's swift manipulative capacity far outstrips that of man. As an arithmetic device, man is not efficient, and a factor of two or three hundred thousand to one is not at all uncommon in comparing the ability to calculate. This indicates that the machine is a powerful device for eliminating many rote calculations previously performed by man.

A specific comparison of storage capabilities is difficult, since the machine stores characters, that is, small, discrete particles of data, whereas stored human information is more aggregated, in the form of *items*. For purposes of contrast, we can say that the machine's capability of storing ten billion characters is roughly equivalent to a man's storing of one billion items. Thus, a telephone number is stored by a machine as ten characters (311-555-2368). In the brain it is stored as one item, recalled as a "picture" by man. The significant contrast we wish to make between man and the machine is not in the ability to store large quantities of data but in the amount of time required to feed the data into the system and make it available there. Man requires, in essence, a lifetime to accumulate, say, a billion items of information. By contrast, some machines, which are capable of reading items electronically at speeds in excess of ten million characters per minute, can assimilate a billion characters of information in a matter of a few hours.

A comparison of logic is equally difficult. Man follows instructions substantially slower than the machine; one could assign a factor of five hundred thousand to one, or better, to this difference, but it is not too meaningful in light of man's intuitive abilities. A man does not require detailed explanations of every contingency and every facet, whereas the machine's ability to interpret instructions is relatively simple. It can only understand very small, discrete instructions and ordinarily requires many more instructions than man for each task. This constrast will be made clearer in our illustration of an analogous computer, following.

COMPUTER OPERATION

The Analogous Computer

Although the components of a machine system can be defined, and it is possible to contrast the machine favorably with man as an information processing system, it is far more difficult to explain, nontechnically, how a computer processes information. The most feasible method for doing so is to structure an example capable of illustrating the computer by analogy—that is, to conceptualize an analogous computer, composed of components familiar to everyone and capable of performing information processing functions in a manner quite similar to the way a machine system performs them. This computer must have each of the five elements of an information processing system: input, output, storage, arithmetic, and logic.

The construction of this analogous computer will require certain assumptions. First, we shall assume that the processing of certain income tax information is the task we shall set our computer. The basic input information will be a series of cancelled checks—in this example, for medical deductions. We require (1) that the computer provide a list of these checks and a sum total of the value of such expenses, and (2) that each check be augmented by adding a fixed amount, say, ten dollars, to ensure that transportation for medical purposes is covered.

To construct the analogous computer, the first element needed is an input device. Into the room that will house all the components of our system, we place a four-legged table, which can serve as the input device since the tabletop can hold and supply at will the input data: the cancelled checks. (Figure 1-4 illustrates all the components of our com-

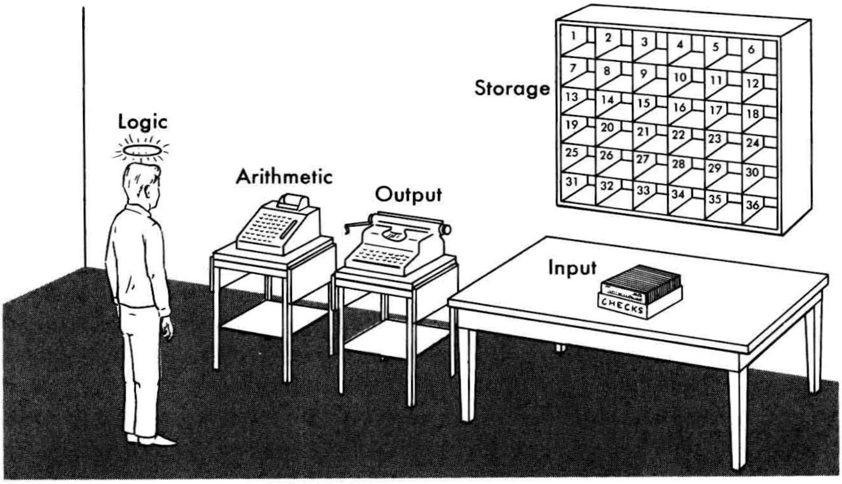

Fig. 1-4 ***Analogous computer system.***

puter.) We shall use a typewriter as an output device; it is capable of satisfying the requirement that medical deductions be listed with their totals. To provide arithmetical capacity, an adding machine is placed in the room. It is clearly capable of satisfying the requirements of providing totals and of adding a fixed amount to each cancelled medical expense check. To provide storage for the system, a series of shelves are built on one wall of the room. These shelves will be built in the shape of boxes; there will be thirty boxes, each capable of storing one or more pieces of paper, such as a cancelled check with all the data thereon. Each box will be assigned a unique identifier; we will number them from one through thirty so the information processing system can obtain specific data simply by specifying the identifier. (In computer terminology this number or identifier is normally referred to as the address of the data.)

The final element of the system is logic. To provide our system with logical capability, the only satisfactory analogous device is a man who is capable of following instructions. However, we require an unusual man, since he will be required to follow the instructions exactly, regardless of whether they are right or wrong. This is among the most significant differences between man and a machine system: man has reasoning and intuitive ability, while the machine system can only follow instructions, right or wrong. It is, then, perhaps more accurate to call the logic-providing element of our system a moron, since he cannot supply human reasoning and intelligence.

In light of this, it is clear that the epithet commonly applied to computers —"giant brain"—is totally inaccurate and should be replaced with one characterizing a large, but very speedy, moron.

The Program

Put the system we have devised to work in the processing of information will require that all necessary instructions are supplied and that each instruction is explicit. We must first give the moron the general instruction that he is to proceed from box to box in numerical sequential order unless one of his specific instructions bids him do otherwise. We can then start with the instruction to go to Box No. 1, where he will find a piece of paper setting out an explicit task, or instruction, that he must execute. Upon its completion he will go to the next sequential box, No. 2, and will find a piece of paper with an instruction to execute a task. Upon its successful completion, he will go to the next sequential box, No. 3. He will therefore go from one box to the next box in sequence until he is told to do something else by one of the instructions, or until one of the instructions specifically tells him to stop. This, then, constitutes our complete information processing system: moron following rote instructions, which are carefully planned in the minutest detail, to take specific input, process it, manipulate it, and generate from it a specified type of output.

The series of instructions to be placed in the boxes in sequence will be called a program of instructions or, in simple computer terminology, a computer program. To provide the moron with the program necessary to satisfy the objectives, the following instructions will be written on pieces of paper and will be placed in the boxes whose addresses are shown:

Box 1. Pick up a check from the table. (This is an input instruction.)

Box 2. Place the check in Box 26. (This demonstrates that the machine's storage is used not only to store instructions but also to store data to be manipulated.)

Box 3. Read the dollar amount shown on the check in Box 26 and enter the amount in the adding machine.

Box 4. Add the dollar amount on a slip of paper in Box No. 29 on the adding machine. (By placing the fixed data amount, i.e., the ten dollars we wish to deduct for transportation, on a piece of paper in Box 29, we can accomplish the desired augmentation of our medical deductions.)

Box 5. Total the amounts in the adding machine.