Principles of Data Processing

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PRINCIPLES OF

DATA PROCESSING

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To COLLEEN, HOLLIS, and ZACHARY

PREFACE

Computer systems have become an integral part of business, government, and society in a relatively short period of time. Academic institutions have recognized the importance of understanding computers and are requiring introductory courses in data processing for most students. The purpose of this book is to provide a brief but comprehensive overview of data processing principles.

Based upon ten years of experience in introducing college students, business and government executives, and military officers to computer concepts, I have developed the approach incorporated in this book. The text material may or may not be utilized in combination with a laboratory experience gained through a programming language.

The text is divided into four major parts: (1) Information Processing, (2) Technology, (3) Programming, and (4) Systems. The Information Processing section presents the basic concepts of data processing, including information flow and processing methodology. The Technology section concentrates on computer hardware from internal storage to selected input/output devices. The largest section in the book, the Programming section, is involved with computer software, especially, program flowcharting and the programming process. Finally, the Systems section provides a discussion of the application of computers in organizations and their potential impact. Section summaries, review questions, and a glossary are included to assist the reader.

The material in this book has been thoroughly field tested by over one thousand business and computer science students at Bowling Green State University in a course entitled "Introduction to Computers." I am indebted for their cooperation and suggestions in this effort. In addition, I must acknowledge the tremendous assistance provided by my graduate teaching assistants. Background work done by Ann Clark was invaluable to the success of this undertaking, and the editing of Edith Tow and James Bernot was essential to the finished product.

PRINCIPLES OF

DATA PROCESSING

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PART I INFORMATION PROCESSING

PART II TECHNOLOGY

PART PROGRAMMING

PART IV SYSTEMS

PART I
INFORMATION PROCESSING

Background

When many individuals think of the word *computer*, they envision an electronic marvel with mystical powers. In reality, its capabilities are quite limited and its success can be directly attributed to the imagination of people. A computer possesses no independent intelligence. It cannot perform any tasks that a person has not predetermined. Therefore, the computer's IQ is zero!

The number of different instructions that can be performed by a computer is quite limited, often less than 100. The operations controlled by these instructions are fundamental logic and arithmetic procedures such as comparison, addition, subtraction, multiplication, and division. All of the procedures constitute the instruction set of the computer. They are designed into its electronic circuitry by the engineers who plan the machine. Computer power is then harnessed by the people who manipulate this small instruction set; they use it to create computer programs. Most computers are general-purpose machines. The major limitation to their application can be found in the humans who determine the combinations of instructions they perform.

Computers derive most of their power from three features: speed, accuracy, and memory. Modern computers are capable of performing millions of calculations in a second. They are fast reaching the physical limitation of the speed of light. Error-free computation is for all practical purposes a reality, due to internal self-checking electronic features. However, each computer user must realize that this accuracy relates to internal operations: it does not imply that what comes out of the computer (output) is correct unless what was initially put into the computer (input) was also correct. "Garbage in — garbage out" (GIGO) is a phrase used to describe the effects of incorrect input. Its meaning is fundamental to understanding computer "mistakes." The ability of a computer to store and recall information is almost unlimited. In addition, the physical size of data storage devices is continually shrinking though their storage capacity is increasing. The time required to retrieve stored information is also shrinking.

Figure 1-1. Data Flow.

All computer processing follows the same basic flow pattern. This pattern is shown in Figure 1-1. Output consists of the desired results in the appropriate form as determined by the users/customers of the computer system. In order to generate the output, data must be collected and placed into a machine-readable form so that it can be used as input. The computer processing step then transforms the input into output through arithmetic and logic operations. Therefore, the development of the computer instructions necessary for the transformation is based upon both input and output requirements.

This same basic flow is common to all data processing, whether a computer or a human does the processing step. However, when a computer is used, the processing is directly dependent on the capabilities of the instruction set of the computer. This forces the transformation to be both objective and mathematical in nature.

Stored Program

After the instructions necessary for computer processing have been determined, they must be placed into the computer memory so that execution can take place. The storage unit operates in a manner similar to that of a tape recorder. Once a copy of the instructions and data are recorded, they remain until they are erased or new instructions and data are recorded over them. Therefore, it is possible to execute the same instructions and process the same data over and over again until a change is desired. The same principle then applies to the new instructions and data. This basic concept of memory is known as *non-destructive read,* *destructive write.* Each set of instructions placed into memory is called a *stored program.*

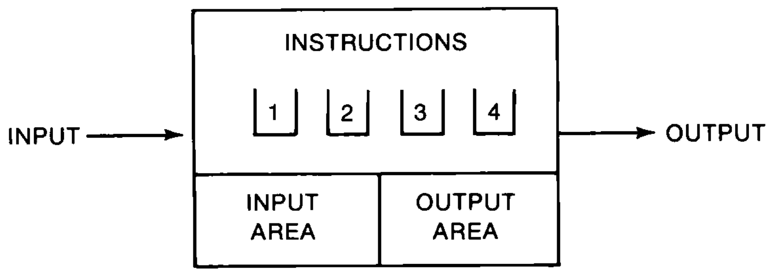

Figure 1-2. Stored Program.

The computer processes instructions in a sequential manner unless instructed to do otherwise. This next-sequential-instruction feature requires that the instructions that constitute a program be placed in consecutive locations in memory. Since input must be brought into the computer for processing, a separate area must be designated. Output generated by the program will also require an area isolated from the instructions. Figure 1-2 depicts graphically the required memory allocation.

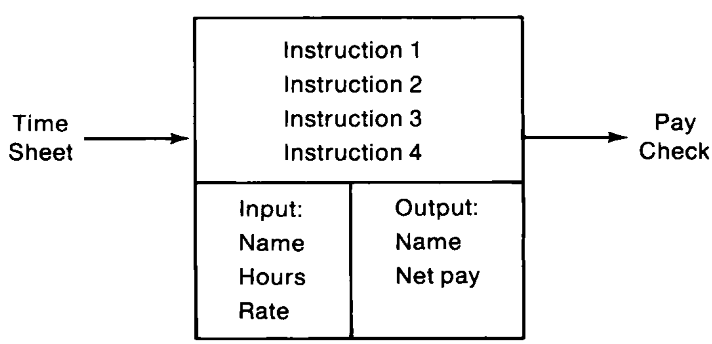

Figure 1-3. Program Execution.

Let us assume that a four-instruction program is placed in the computer memory and that it is used to calculate and print output pay checks for employees based upon input time sheets. The computer will process the input data in the same manner as a human payroll clerk.

Instruction 1: Read a time sheet
Instruction 2: Calculate net pay
Instruction 3: Write out a pay check
Instruction 4: Repeat instructions 1 to 3 (Go to instruction 1)

Because of the sequential nature of program execution, the instructions are performed in the ordered manner (Figure 1-3).

As the first instruction is executed, time data is brought into the input area (name, hours, rate). Since the input must be in machine-readable form, a device that can read the time sheet and translate the data into electronic pulses is required. Next, the mathematical calculations necessary to compute net pay are performed and the result is placed into the output area. The third instruction causes the printing of the information in the output area. If there are more employees, it is necessary to repeat these three instructions. Therefore, to override the next-sequential-instruction mode of the computer, we command the machine to go back to instruction 1.

When the second time sheet is read and the data placed into the input area, the previous employee's time data is replaced by the new data as a result of the destructive write principle of the machine. Prior to calculation of net pay for the second time sheet, the input area holds the second time sheet data but the output area still holds the result of the first pay calculation. However, after instruction 2 is again executed, the net pay for the second employee is moved into the output area, destroying the net pay of the first employee. Now the second pay check, with the appropriate name and amount, can be printed out.

When the computer has processed all input time sheets, it will stop. At this time, the sales office may need the computer for preparing invoices. The computer program written to take sales input and prepare output invoices is placed into computer memory on top of the payroll program, thereby destroying the copy of the payroll program. The machine that generated pay checks, can now be used to process sales invoices. This demonstrates the general-purpose nature of the computer.

Historical Review

Man has always used some method of keeping track of information. The progress toward the concept of a computer extended over several centuries, though many of the advances are recent. Often an invention in a widely different field found an application in the growth of the computer concept.

In the past, man's manual technique of collecting and manipulating data was known as *data processing*. As technology increased and machines did the processing, the term *automatic data processing* was used. Today, technology has reached the point where an electronic computer can achieve the results formerly accomplished by humans and machines. This is known as *electronic data processing*.

The beginning of the climb to the computer concept began with Pascal's adding machine (1642). It used gears with teeth to store digits. When a gear rotated past the tooth representing the digit 9, the next gear to the left shifted one tooth, or digit (see Figure 1-4). This concept was expanded by Leibnitz who constructed a machine to add, subtract, multiply, divide, and calculate square roots. Mechanical technology continued to advance with the invention of more complex machines.

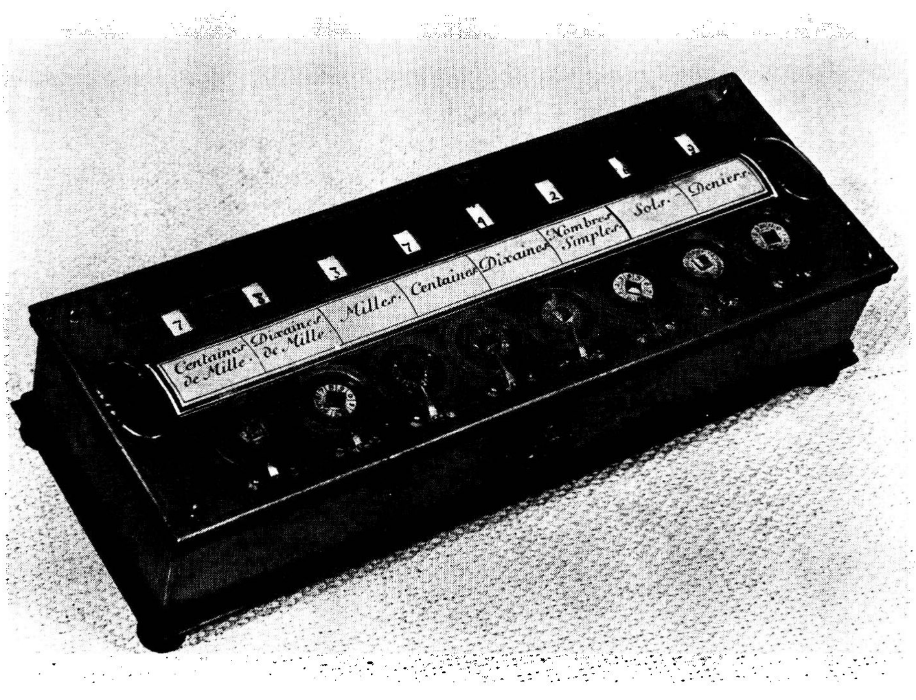

Figure 1-4. Pascal's Machine.

In 1822, Charles Babbage developed the concept of a machine that could carry out complex computations and print results without human intervention. Using this idea, Babbage built a machine called the difference engine (see Figure 1-5). This machine was used to compute mathematical tables with results up to five significant digits in length. When Babbage tried to build a larger model, he found that parts could not be produced to meet the necessary tolerances for accuracy.

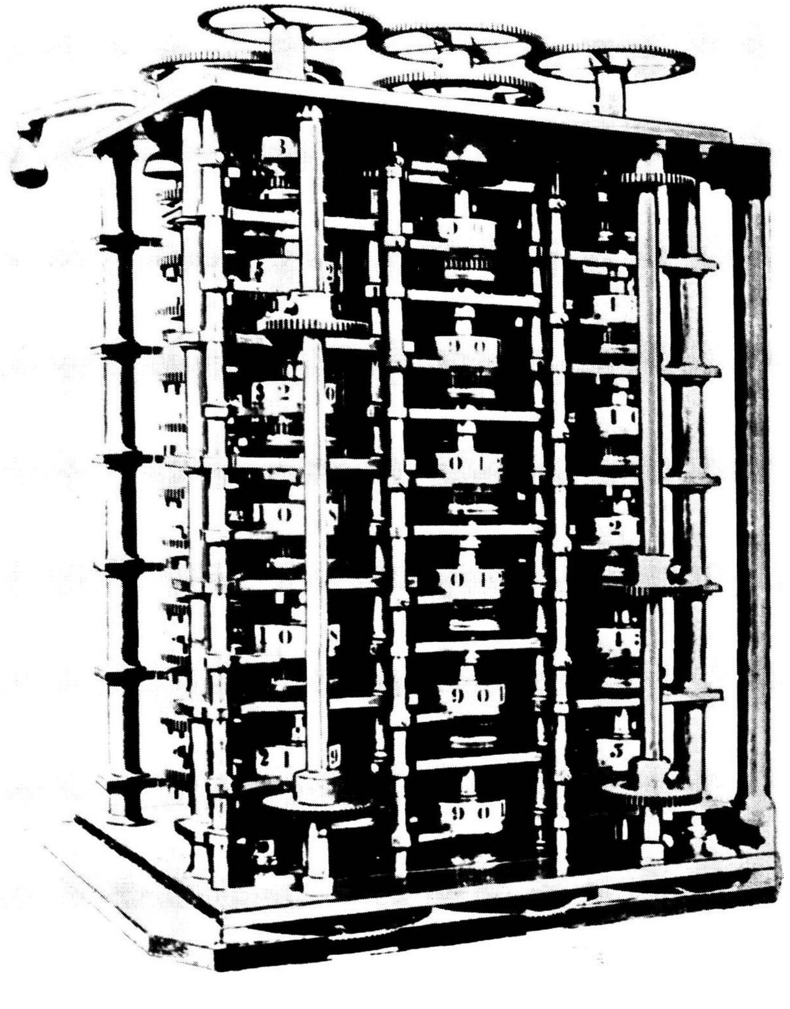

Figure 1-5. Babbage's Difference Engine

Babbage did not give up, however. In 1833 he developed the idea for an analytical engine. This machine was to be capable of addition, subtraction, multiplication, division, and storage of intermediate results in a memory unit. Unfortunately, the analytical engine was too advanced for its time, and parts could not be manufactured for it. It was Babbage's concept of the analytical engine, though, that led to the computer more than 100 years later.

In the 1880s, Dr. Herman Hollerith developed a device to code data for the United States Bureau of Census (see Figure 1-6). By using a punched card with census data on it and a machine to do the sorting, 250 cards could be sorted in one minute. This reduced the time needed to process the 1890 census data from 7½ years to 2½ years.

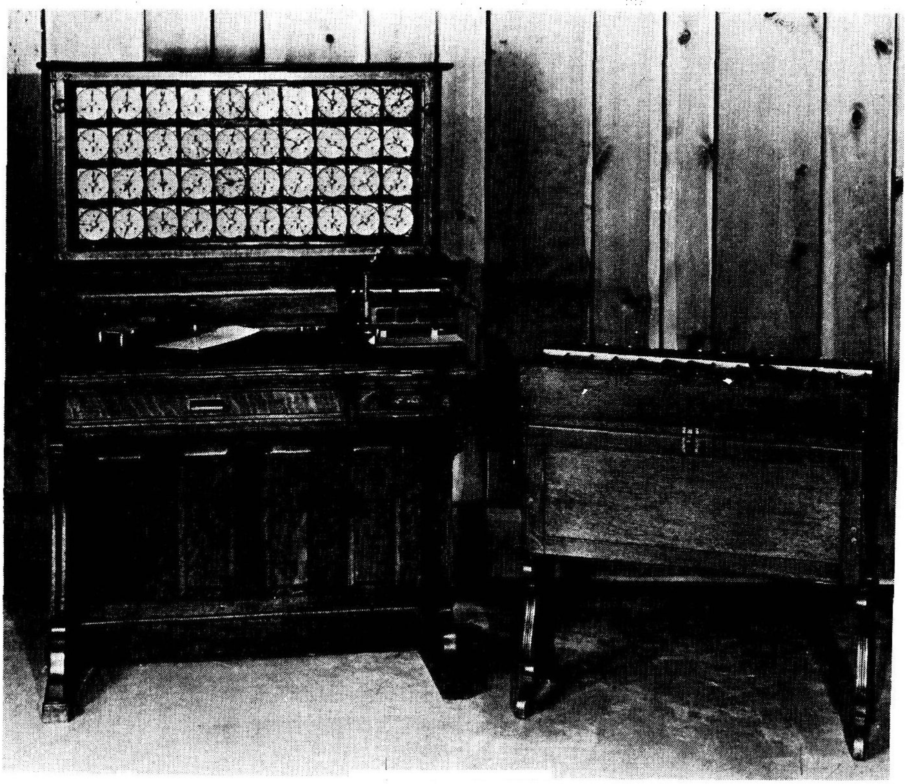

Figure 1-6. First Census Tabulator