UNITED ARAB REPUBLIC

THE INSTITUTE OF NATIONAL PLANNING

التخطيط القومي

Memo. No. 830

AN INTRODUCTION TO DIGITAL COMPUTERS

By

Mr. El Kafrawy M.

April 1968

CAIRO
3 MOHAMED MAZHAR - ZAMALEK

AN INTRODUCTION TO DIGITAL COMPUTERS

BY

EL KAFRAWY, M.

INSTITUTE OF NATIONAL PLANNING.

APRIL 2nd, 1968

Historical Notes:

To many scientists, engineers and researchers in U.A.R., the high speed digital computer is an unknown quantity. Till 1960, when the computer system had been installed in the INP, the chances of having an introduction to computing were slim. Today virtually researchers in this country have access to digital computers, (by the benefit of the training courses held in INP). Within the coming few years those without an introductory course in the use of computers (also university under-graduates-as in Alex. University) will be the exception.

The growth in the use of the digital computer has been tremendous. The first large scale digital computers appeared in 1963 while internationally in the early 1950.

In 1642 Blaise Pascal, a French mathematician, built the first operating digital computing machine but with a very limited use. In 1800, Charles Babbage of England, designed the modern digital computer, except that it was to be mechanical rather than electronic. He built what is termed a difference machine for the computation of tables of values. Many of the functions, for which tables are desired, in the fields of navigation, astronomy and surveying can be handled by such techniques. However, modern computers are very far from the difference machines. In the same time George Boole, an English mathematician, was laying the foundation for the Boolean Algebra(the algebra of logic) which is so necessary in the design of digital computers. In 1930, John von Neumann and modern mathematicians, started interest in the possibilities of machine computation. After words, Harvard and MIT, were the centers of building electromechanical digital computers. World war II demanded larger and faster computational facilities in the military technological advancements. By the end of the war, the logic for the construction of a general-purpose digital computer was fairly well specified.

The computing problems

They are falling into one of the following two classes:

1. Straightforward computations are those which have in the past been handled by slide rule or paper and pencil. They also include those for which the technique of solution has

required too much computation to tackle.
e.g. A set of n homogeneous linear equations in n variables, the differential equations, etc.

2. Iterative problems comprise a large area, mostly unexplored. The iteration with computer handling of problems are used in the mathematical statement of the physical problem for evaluating one or more of the variables.

The Digital Computer

The computer manufacturers through their use put such terminology:

1. Memory - for that part of the computer which stores information.
2. Nerve Center - for that part of the computer which controls its operation .
3. Brain - for that part of the computer which accomplishes arithmetic and logical operations.

The basic components of a computer are :

Storage

That part of a computer which most differentiates it from a calculator (desk-type, slide rule, adding machine) is its storage - or its memory.

STORAGE

A computer can store numbers, alphabetic characters and some special symbols. In any calculation, it is necessary to store the numbers which begin the calculations, intermediate results and - at least temporarily - final results. A desk calculator has a very limited ability to store data. The operator usually must enter each number as it is needed. On the other hand, the IBM 1620 computer for instance can store 20,000 digits (and in additional 20,000 or 40,000 digits) and call them out of storage whenever they are needed in a calculation.

The Stored Program

The ability to store large amounts of data that is to be used in or has been developed by calculations is only part of the function of storage. Equally significant is the fact that the computer also contains within storage the program for the calculations to be performed.

Data
STORAGE
Program

A program is made up of instructions which, when acted upon by the computer, cause it to go through the sequence of operations necessary to arrive at a meaningful result. A single instruction may:

1. Cause data to be brought into storage from some external source, such as a card reader.
2. Cause a specified arithmetic operation to be performed on selected numbers.
3. Constitute a logical test to determine what part of the program should be performed next.
4. Cause results to be sent from storage to a recording device, such as a typewriter.

After both the data to be operated upon and the program which describes the operations are in storage, the computer is free to proceed with a series of calculations at its own natural speed. For present-day machines, this may be from 50 to 500,000 additions per second.

ADDRESSES

To be able to select the item of data or the instruction to be operated upon next, the computer must be provided with a means of locating the desired information in storage. For this reason, storage is divided into units and each unit is identified by an address. Different computers are designed with different-size units of storage. The basic unit may vary from one decimal digit (as in the IBM 1620) to 36 binary digits (as in the IBM 7090).

Whatever the size of the basic unit, each is assigned a numerical address which identifies the location. Manipulation of the data stored in a location is accomplished through the use of the address corresponding to the location.

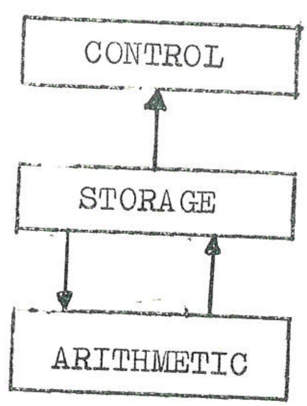
CONTROL UNIT

The control unit of a computer provides the means whereby the stored program causes the desired operations to be performed in the sequence specified. The control unit reads an instruction from storage, examines it, sets up the circuit conditions to perform the operation , and, when the operation is completed, reads the next instruction from storage and repeats these steps.

Generally, the first operation to be performed is manually entered into the control unit by the machine operator. Thereafter the action of the computer is completely controlled by the program in storage as interpreted by the control unit. An instruction which tells the computer to stop can be the last one in the program.

ARITHMETIC UNIT

This component contains the circuitry which performs arithmetic on numbers taken from storage. It usually includes a limited amount of storage in which to hold the operands involved in the arithmetic.



The two basic types of computers - analog and digital have different ways of accomplishing arithmetic. The analog computer performs arithmetic by measuring, the digitial computer by applying a set of rules to the numbers involved.

BINARY ARITHMETIC

A problem in computer design that the programmer may have recognized by now is that to store and manipulate decimal digits requires some device capable of assuming ten stable and unique states - one state to represent each of the digits 0 to 9. While such devices are available (the notched wheels in a desk calculator are an example), they lack the speed of operation and small size necessary for a computer. Furthermore, they don't fit into an electronic system.

The computer designer has at his disposal, therefore, a number of devices and techniques for operating in a number system with the base 2 - the binary number system. The rules for arithmetic are also much simpler in the binary number system than in the decimal system (base 10) which we are accustomed to using.

ADDITION TABLES

	0	1
0	0	1
1	1	10

MULTIPLICATION TABLES

	0	1
0	0	0
1	0	1

As a result, there are two basic types of digital computers: one which operates entirely in the binary number system and another which codes decimal digits as binary numbers. For the latter, the decimal digits appear as their binary equivalents:

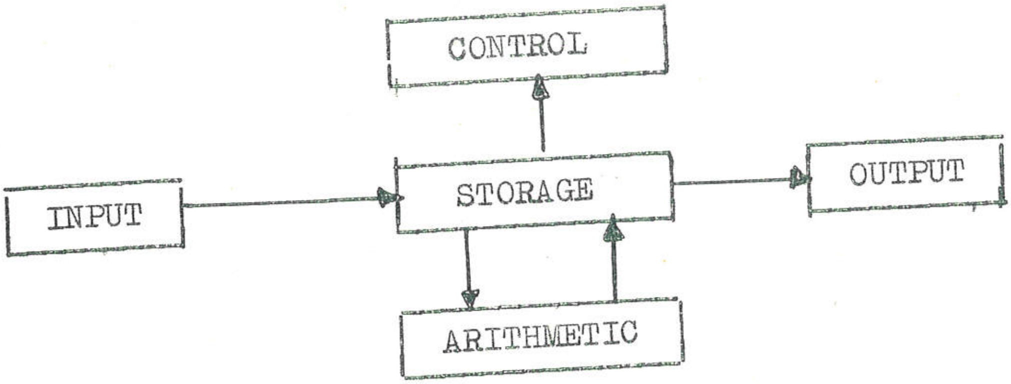
DECIMAL	0	1	2	3	4	5	6	7	8	9
BINARY	0	1	10	11	100	101	110	111	1000	1001

As far as the user is concerned, it is not necessary to be familiar with the binary nature of the computer. The computer is capable of translating the programmer's language to its own before starting a program and performs the reverse operation when communicating its results to the programmer.

INPUT AND OUTPUT

So far, the methods for getting data and programs into the computer and for getting the results out have been ignored. Every computer must have a means for communicating with the outside world.

Typical input devices are punched card readers, paper tape readers and manual keyboards. Card and paper tape punches, typewriters and printers are typical output devices. Magnetic tapes and magnetic disks provide a means of storing data



externally from the computer in a form which allows rapid re-entry.

The use of input-output devices is under control of the stored program. For example, an instruction to read a card will cause the reader to start up, feed and read one card and transmit what has been read into storage.

SUMMARY

Thus there are five basic components of a computer:

1. A place to store data and instructions in such a way that each item can be located when needed.
2. A means of controlling the overall action of the system.
3. Devices for performing arithmetic and other operations required in manipulating the data to obtain desired results.
4. A way of getting information into the computer.
5. A way of getting results out of the computer.