This article from Compton's Family Encyclopedia was contributed by Gary Masters, former managing editor, Microsoft Press; former technical editor and writer, Tandy Corporation; winner of the Southwest Technical Writer's Association Award for Excellence; and author of books about computers.

Generally, any device that can perform numerical calculations, even an adding machine, an abacus, or a slide rule, may be called a computer. Currently, however, the term usually refers to an electronic device that can use a list of instructions, called a program, to perform calculations or to store, manipulate, and retreive information.

TODAY'S WORLD OF COMPUTERS

Today's computers are marvels of miniaturization. Machines that once weighed 30 tons and occupied warehouse-size rooms now may weigh as little as 4 pounds (1.8 kilograms) and can be carried in a briefcase. The heart of today's computers are integrated circuits, sometimes called microchips, or simply chips. These tiny silicon wafers can contain hundreds of thousands of microscopic electronic components and are designed for many specific operations.

In 1953 there were only about 100 computers in use in the entire world. Today hundreds of millions of computers form the core of electronic products, and tens of millions more are used in homes, businesses, goverment offices, and universities for almost every conceivable purpose.

General-purpose computers, such as personal computers and business computers, are versatile because they can accept new sets of instructions. For example, with different sets of instructions the same general-purpose computer can be used as a word processor, an inventory spread sheet, or a video game. Some general-purpose computers are as small as pocket radios, but the smallest fully functional, self-contained, general-purpose computers are called laptop computers. These usually consist of a central processing unit (CPU), data-storage devices called disk drives, a liquid-crystal display (LCD), and a full-size keyboard, all housed in a single unit small enough to fit into a briefcase.

Most of the general-purpose computers known as personal, or desktop, computers can perform almost 5 million operations per second, and some can perform almost 35 million. These computers can be used not only for household management and personal entertainment, but also for most of the automated tasks required by small businesses, including word processing, generating mailing lists, and maintianing inventory, accounting, and payroll information.

Minicomputers are fast computers that have greater data-manipulating capabilities than do personal computers and that can be used simultaneously by many people. These machines are primarily used by larger businesses to handle extensive accounting, billing, and inventory records. Mainframes are large, extremely fast, multi-user computers that often contain complex arrays of processors, each designed to perform a specific function. Because they can handle huge data bases, can simultaneuosly accommodate scores of users, and can perform complex mathematical operations, they are the mainstay of industry, research, and university computer centers.

PARTS OF A DIGITAL COMPUTER SYSTEM

A digital computer is a complex system of four functionally different elements, a central processing unit, input devices, memory-storage devices, and output devices, linked by a communication network, or bus. These physical parts and all their physical components are called hardware.

Without a program, a computer is nothing but potential. Programs, also called software, are detailed sequences of instructions that direct the computer hardware to perform useful operations.

Hardware

The central procesing unit, or CPU, is the heart of a computer. In addition to performing arithmetic and logic operations on data, it times and controls the rest of the system. Mainframe CPUs sometimes consist of several linked microchips, each performing a separate task, but most other computers require only a single microprocessor as a CPU.

Most CPU chips and microprocessors have four functional sections:

(1) the arithmetic/logic unit, which performs arithmetic operations (such as addition and subtraction) and logic operations (such as testing a value to see if it is true or false);

(2) temporary storage locations, called registers, which hold data, instructions, or the results of calculations;

(3) the control section, which times and regulates all elements of the computer system and also translates patterns in the registers into computer activities (such as instructions to add, move, or compare data); and

(4) the internal bus, a network of communication lines that links internal CPU elements and offers several different data paths for input from and output to other elements of the computer system.

Input devices let users enter commands, data, or programs for processing by the CPU. Computer keyboards, which are much like typewriter keyboards, are the most common input devices. Information typed at the keyboard is translated into a series of binary numbers that the CPU can manipulate. Another common input device, the mouse, is a mechanical device with buttons on the top and a rolling ball in its base. To move the cursor on the display screen, the user moves the mouse around on a flat surface. The user selects operations, activates commands, or creates or changes images on the screen by pressing buttons on the mouse.

Other input devices include joysticks and trackballs. Light pens can be used to draw or to point to items or areas on the display screen. A sensitized digitizing pad translates images drawn on it with an electronic stylus or pen into a corresponding image on the display screen. Touch-sensitive display screens allow users to point to items or areas on the screen and to activate commands. Optical scanners "read" characters on a printed page and translate them into binary numbers that the CPU can use. Voice-recognition circuitry digitizes spoken words and enters them into the computer.

Memory-storage devices. Most digital computers store data both internally, in what is called main memory, and externally, on auxiliary storage units. As a computer processes data and instructions, it temporarily stores information internally, usually on silicon random-access memory, or RAM, chips, often called semiconductor memory. This kind of internal memory is also called read/write memory because computer programs constantly access and change the information stored there. Another type of internal memory consists of a series of read-only memory, or ROM, chips. The switches of ROM chips are set when they are manufactured and are unchangeable. The patterns on these chips correspond to commands and programs that the computer needs in order to boot up, or ready itself for operation, and to carry out basic operations.

Auxiliary storage units suplement the main memory by holding parts of programs that are too large to fit into the random-access memory at one time. They also offer a more permenent and secure method for storing programs and data. Three auxiliary storage devices, floppy disks, hard disks, and magnetic tape, store data by magnetically rearranging metal particles. Floppy-disk drives (which "write" data on removable magnetic disks) can store from 360,000 to 1.44 million bytes of data on one disk and are used primarily in laptop and personal computers. Hard disk drives contain non removable magnetic media and are used with all types of computers. They access data very quickly and can store from 10 million bytes (10 megabytes) of data to a few hundred megabytes.

Magnetic-tape storage devices are usually used together with hard disk drives on large computer systems that handle high volumes of constantly changing data. The tape drives, which access data very slowly, regularly back up, or duplicate, the data in the hard disk drives to protect the system against loss of data during power failures or computer malefunctions.

Optical discs are non magnetic auxiliary storage devices that developed from compact-audio-disc technology. Data is encoded on a disc as a series of pits and flat spaces, called lands, the lengths of which correspond to different patterns of 0s and 1s. One removable 4.75-inch disc contains a spiral track more than 3 miles (4.8 kilometers) long, on which can be stored several billion bytes (gigabytes) of information. All of the text in an encyclopedia, for example, would fill only one fifth of one disc. Read-only optical discs, whose data can be read but not changed, are called CD-ROMs (compact disc-read-only memory).

Modems (modulator-demodulators) are input-output devices that allow computers to transfer data between each other. A modem on one computer translates digital pulses into analog signals (sound) and then transmits the signals through a telephone line or a communication network to another computer. A modem on the computer at the other end of the line reverses the process.

Printers generate hard copy, a printed version of information stored in one of the computer's memory systems. The principal types of printers are daisy-wheel, dot-matrix, ink-jet, and laser.

Software

A computer's operating system is the software that allows all of the dissimilar hardware and software systems to work together. It is often stored in a computer's ROM memory. An operating system consists of programs and routines that coordinate operations and processes, translate the data from different input and output devices, regulate data storage in memory, allocate tasks to different processors, and provide functions that help programmers write software.

Computers that use disk memory-storage systems are said to have disk operating systems (DOS). MS-DOS is the most popular microcomputer operating system. UNIX, a powerful operating system for larger computers, allows many users and many different programs to gain access to a computer's processor at the same time.

Programming. Software is written by professionals known as computer programmers. Most programmers in large corporations work in teams, with each person focusing on a specific aspect of the total project. (The eight programs that run each craft in the Space Shuttle program, for example, consist of a total of about half a million separate instructions and were written by hundreds of programmers.) For this reason, scientific and industrial software sometimes costs much more than do the computers on which the programs run.

Programming languages. On the first electronic computers, programmers had to reset switches and rewire computer panels in order to make changes in programs. Although programmers still must "set" (to 1) or "clear" (to 0) millions of switches in the microchips, they now use programming languages to tell the computer to make these changes.

HISTORY OF THE COMPUTER

The ideas and inventions of many mathematicians, scientists, and engineers paved the way for the development of the modern computer. In a sense, the computer actually has three birth dates, one as a mechanical computing device, in about 500 BC, another as a concept (1833), and the third as the modern electronic digital computer (1946).

Calculating Devices

The first mechanical calculator, a system of strings and moving beads called the abacus, was devised in Babylon around 500 BC. The abacus provided the fastest method of calculating until 1642, when the French scientist Blaise Pascal invented a calculator made of wheels and cogs. When a units wheel moved one revolution (past ten notches), it moved the tens wheel one notch; when the tens wheel moved one revolution, it moved the hundreds wheel one notch; and so on. Improvements on Pascal's mechanical calculator were made by such scientists and inventors as Gottfried Wilhelm Leibniz, W.T. Odhner, Dorr E. Felt, Frank S. Baldwin, and Jay R. Monroe.

Beyond the Adding Machine

The concept of the modern computer was first outlined in 1833 by the British mathematician Charles Babbage. His design of an "analytical engine" contained all of the necessary elements of a modern computer: input devices, a store (memory), a mill (computing unit), a control unit, and output devices. The design called for more than 50,000 moving parts in a steam-driven machine as large as a locomotive. Most of the actions of the analytical engine were to be executed through the use of perforated cards, an adaptation of a method that was already being used to control automatic silk-weaving machines called Jacquard looms. Although Babbage worked on the analytical engine for nearly 40 years, he never actually constructed a working machine.

In 1889 Herman Hollerith, an American inventor, patented a calculating machine that counted, collated, and sorted information stored on punched cards. When cards were placed in his machine, they pressed on a series of metal pins that corresponded to the network of potential perforations. When a pin found a hole (punched to represent age, occupation, and so on), it completed an electrical circuit and advanced the count for that catagory. His machine was first used to help sort statistical information for the 1890 United States census.

In 1896 Hollerith founded the Tabulating Machine Company to produce similar machines. In 1924, after a number of mergers, the company changed its name to International Business Machines Corporation (IBM). IBM made punch-card office machinery the dominant business information system until the late 1960s, when a new generation of computers rendered the punch card machines obsolete.

In the late 1920s and 1930s, several new types of calculators were constructed. Vannevar Bush, an American engineer, developed the differential analyzer, the first calculator capable of solving differential equations. His machine calculated with decimal numbers and therefore required hundreds of gears and shafts to represent the various movements and relationships of the ten digits. In 1939 the American physicists John V. Atanasoff and Clifford Berry produced the prototype of a computer based on the binary numbering system. Atanasoff reasoned that binary numbers were better suited to computing than were decimal numbers because the two digits 1 and 0 could easily be represented by electrical circuits, which were either on or off. Furthermore, George Boole, a British mathematician, had already devised a complete system of binary algebra that might be applied to computer circuits.

Electronic Digital Computers

The modern computer grew out of intense research efforts mounted during World War II. As early as 1941 the German inventor Konrad Zuse produced an operational computer, the Z3, that was used in aircraft and missile design. The German goverment refused to help him refine the machine, however, and the computer never achieved its full potential.

A Harvard mathematician named Howard Aiken directed the development of the Harvard-IBM Automatic Sequence Controlled Calculator, later known as the Mark I, an electronic computer that used 3,304 electromechanical relays as on-off switches. Completed in 1944, its primary function was to create ballistics tables to make Navy artillery more accurate.

The first fully electronic computer, which used vacuum tubes rather than mechanical relays, was so secret that its existence was not revealed until decades after it was built. Invented by the English mathematician Alan Turing and in operation by 1943, the Colossus was the computer that British cryptographers used to break secret German military codes.

Because Colossus was designed for only one task, the distinction as the first modern general-purpose electronic computer properly belongs to ENIAC (Electronic Numerical Integrator and Calculator). Designed by two American engineers, John W. Mauchly and J. Presper Eckert, Jr., ENIAC went into service at the University of Pennsylvania in 1946. Its construction was an enormous feat of engineering, the 30-ton machine contained 17,468 vacuum tubes linked by 500 miles (800 kilometers) of wiring. ENIAC performed 100,000 operations per second.

The invention of the transistor in 1948 brought about a revolution in computer development. Hot, unreliable vacuum tubes were replaced by small germanium (later silicon) transistors that generated little heat yet functioned perfectly as switches or amplifiers.

The breakthrough in computer miniaturization came in 1958, when Jack Kilby, an American engineer, designed the first true integrated circuit. His prototype consisted of a germanium wafer that included transistors, resistors, and capacitors, the major components of electronic circuitry. Using less expensive silicon chips, engineers succeeded in putting more and more electronic components on each chip. The development of large-scale integration (LSI) made it possible to cram hundreds of components on a chip; very-large-scale integration (VLSI) increased that number to hundreds of thousands; and engineers project that ultra-large-scale integration (ULSI) techniques will allow as many as 10 million components to be placed on a microchip the size of a fingernail.

Another revolution in microchip technology occurred in 1971 when the American engineer Marcian E. Hoff combined the basic elements of a computer on one tiny silicon chip, which he called a microprocessor. This microprocessor, the Intel 4004, and the hundreds of variations that followed are the dedicated computers that operate thousands of modern products and form the heart of almost every general-purpose electronic computer.

PC Revolution

By the mid-1970s, microchips and microprocessors had drastically reduced the cost of the thousands of electronic components required in a computer. The first affordable desktop computer designed specifically for personal use was called the Altair 8800 and was sold by Micro Instrumentation Telemetry Systems in 1974. In 1977 Tandy Corporation became the first major electronics firm to produce a personal computer. They added a keyboard and CRT to their computer and offered a means of storing programs on a cassette recorder. Soon afterward, a small company named Apple Computer, founded by engineer Stephen Wozniak and entrepreneur Steven Jobs, began producing a superior computer.

IBM introduced its Personal Computer, or PC, in 1981. As a result of competition from the makers of clones (computers that worked exactly like an IBM-PC), the price of personal computers fell drastically. Today's personal computer is 200 times faster than ENIAC, 3,000 times lighter, and several million dollars cheaper.

BIBLIOGRAPHY

Asimov, Isaac. How Did We Find Out About Computers? (Walker, 1984).

Augarten, Stan. Bit by Bit: An Illustrated History of Computers (Ticknor & Fields, 1984).

Curran, Susan and Curnow, Ray. Overcoming Computer Illiteracy: A Friendly Introduction to Computers (Penguin, 1984).

Freedman, Alan. The Computer Glossary: The Complete Illustrated Desk Reference, 4th ed. (AMACOM, 1989).

Norback, Judith. The Complete Computer Career Guide (TAB, 1987).

Silverman, Gordon and Turkiew, D.B. Computers and Computer Languages (McGraw, 1988).

Time-Life Books. Computer Basics; Software; Computer Images; Computer Security; Input-Output (Time-Life, 1985; 1985; 1986; 1986; 1986).

Woram, John. The PC Configuration Handbook: A Complete Guide to Assembling, Enhancing and Maintaining Your PC (Bantam, 1987).