Development of the Computer

In this section, we take a brief look at the development of the computer. By understanding its origins, you'll gain an appreciation for both the complexity and simplicity of today's computers.

After this section, you will be able to

- Describe the major milestones in the development of the modern computer

Many of us think only in terms of electronic computers, powered by electricity. (If you can't plug it in, is it a computer?) But as the definition in *Funk & Wagnalls Standard College Dictionary* makes clear, to "compute" is to "ascertain (an amount or number) by calculation or reckoning." In fact, the first computers were invented by the Chinese about 2500 years ago. They are called *abacuses* and are still used throughout Asia today.

The Abacus

The abacus, shown in Figure 1.1, is a calculator; its first recorded use was circa 500 B.C. The Chinese used it to add, subtract, multiply, and divide. However, the abacus was not unique to the continent of Asia; archeological excavations have revealed an Aztec abacus in use around 900 or 1000 A.D.

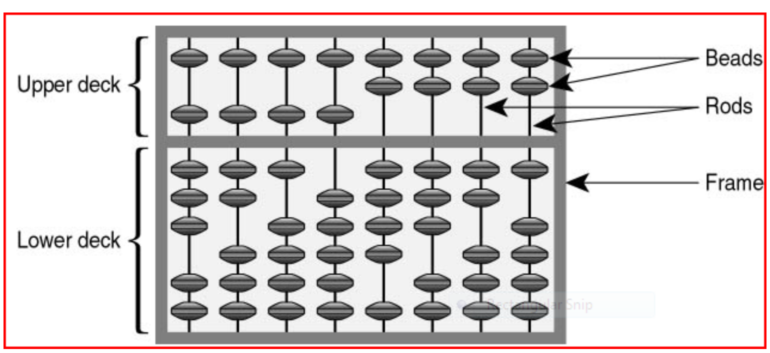

Figure 1.1 *The first computer*

The Analytical Engine (A Pre-Electronic Computer)

The first mechanical computer was the analytical engine, conceived and partially constructed by Charles Babbage in London, England, between 1822 and 1871. It was designed to receive instructions from punched cards, make calculations with the aid of a memory bank, and print out solutions to math problems. Although Babbage lavished the equivalent of $6,000 of his own money—and $17,000 of the British government's money—on this extraordinarily advanced machine, the precise work needed to engineer its thousands of moving parts was beyond the ability of the technology of the day to produce in large volume. It is doubtful whether Babbage's brilliant concept could have been realized using the available resources of his own century. If it had been, however, it seems likely that the analytical engine could have performed the same functions as many early electronic computers.

The First Electrically Driven Computer

The first computer designed expressly for data processing was patented on January 8, 1889, by Dr. Herman Hollerith of New York. The prototype model of this electrically operated tabulator was built for the U.S. Census Bureau to compute results of the 1890 census.

Using punched cards containing information submitted by respondents to the census questionnaire, the Hollerith machine made instant tabulations from electrical impulses actuated by each hole. It then printed out the processed data on tape. Dr. Hollerith left the Census Bureau in 1896 to establish the Tabulating Machine Company to manufacture and sell his equipment. The company eventually became IBM, and the 80-column punched card used by the company, shown in Figure 1.2, is still known as the Hollerith card.

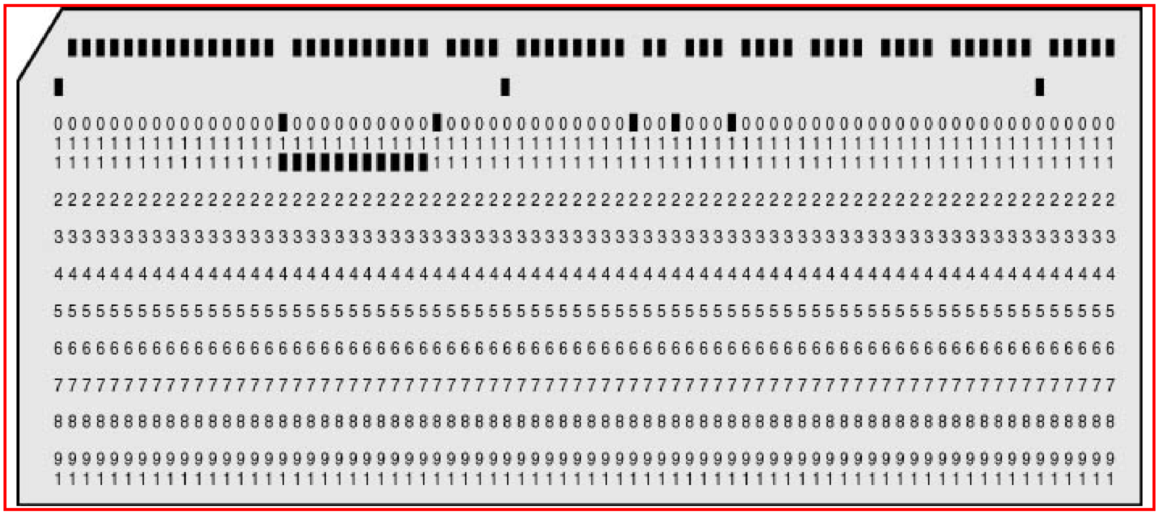

Figure 1.2 *Typical 80-column punched card*

The Digital Electronic Computer

The first modern digital computer, the ABC (Atanasoff–Berry Computer), was built in a basement on the Iowa State University campus in Ames, Iowa, between 1939 and 1942. The development team was led by John Atanasoff, a professor of physics and mathematics, and Clifford Berry, a graduate student. This machine utilized concepts still in use today: binary arithmetic, parallel processing, regenerative memory, separate memory, and computer functions. When completed, it weighed 750 pounds and could store 3000 bits (.4 KB) of data.

The technology developed for the ABC machine was passed from Atanasoff to John W. Mauchly, who, together with engineer John Presper Eckert, developed the first large-scale digital computer, ENIAC (Electronic Numerical Integrator and Computer). It was built at the University of Pennsylvania's Moore School of Electrical Engineering. Begun as a classified military project, ENIAC was designed to prepare firing and bombing tables for the U.S. Army and Navy. When finally assembled in 1945, ENIAC consisted of 30 separate units, plus a power supply and forced-air cooling. It weighed 30 tons, and used 19,000 vacuum tubes, 1500 relays, and hundreds of thousands of resistors, capacitors, and inductors. It required 200 kilowatts of electrical power to operate.

Although programming ENIAC was a mammoth task requiring manual switches and cable connections, it became the workhorse for the solution of scientific problems from 1949 to 1952. ENIAC is considered the prototype for most of today's computers.

Another computer history milestone is the Colossus I, an early digital computer built at a secret British government research establishment at Bletchley Park, Buckinghamshire, England, under the direction of Professor Max Newman. Colossus I was designed for a single purpose: cryptanalysis, or code breaking. Using punched paper tape input, it scanned and analyzed 5000 characters per second. Colossus became operational in December 1943 and proved to be an important technological aid to the Allied victory in World War II. It enabled the British to break the otherwise impenetrable German "Enigma" codes.

The 1960s and 1970s marked the golden era of the mainframe computer. Using the technology pioneered with ABC, ENIAC, and Colossus, large computers that served many users (with accompanying large-scale support) came to dominate the industry.

As these highlights show, the concept of the computer has indeed been with us for quite a while. The following table provides an overview of the evolution of modern computers—it is a timeline of important events.

Year	Events
1971	The 4004—the first 4-bit microprocessor—is introduced by Intel. It boasts 2000 transistors with a clock speed of up to 1 megahertz (MHz).
1972	The first 8-bit microprocessor—the 8008—is released.
1974	The 8080 microprocessor is developed. This improved version of the 8008 becomes the standard from which future processors will be designed.
1975	Digital Research introduces CP/M—an operating system for the 8080. The combination of software and hardware becomes the basis for the standard computer.
1976	Zilog introduces the Z80—a low-cost microprocessor (equivalent to the 8080). The Apple I comes into existence, although it is not yet in widespread use.
1977	The Apple II and the Commodore PET computers, both of which use a 6502 processor, are introduced. These two products become the basis for the home computer. Apple's popularity begins to grow.
1978	Intel introduces a 16-bit processor, the 8086, and a companion math coprocessor, the 8087. Intel also introduces the 8088. It is similar to the 8086, but it transmits 8 bits at a time.
1980	Motorola introduces the 68000—a 16-bit processor important to the development of Apple and Atari computers. Motorola's 68000 becomes the processor of choice for Apple.
1981	The IBM personal computer (PC) is born; it contains a 4.7-MHz 8088 processor and 64 kilobytes (KB) of RAM (random access memory), and is equipped with a version of MS-DOS 1.0 (three files and some utilities).

	Available mass-storage devices include a 5.25-inch floppy drive and a cassette tape drive.
1982	Intel completes development of the 80286—a 16-bit processor with 150,000 transistors. MS-DOS 1.1 now supports double-sided floppy disks that hold 360 KB of data.
1983	IBM introduces the XT computer with a 10-MB hard disk drive. MS-DOS 2.0 arrives; it features a tree-like structure and native support for hard disk drive operations.
1984	The first computer with an 80286 chip—the IBM AT—enters the market. It is a 6-MHz machine with a 20-MB hard disk drive and a high-density, 1.2-MB 5.25-inch floppy disk drive. Apple introduces the Macintosh computer, marking the first widespread use of the graphical user interface and mouse.
1985	MS-DOS 3.2, which supports networks, is released.
1986	The first Intel 80386-based computer is introduced by Compaq; it features a 32-bit processor with expanded multitasking capability (even though no PC operating system yet fully supports the feature).
1987	MS-DOS 3.3 arrives, allowing use of 1.44-MB 3.5-inch floppy disk drives and hard disk drives larger than 32 MB.
1988	IBM introduces the PS/2 computer series. A complete departure from previous machines, its proprietary design does not support the hardware and software available on IBM PCs or clones. Microsoft (with the help of IBM) develops OS/2 (Operating System 2), which allows 32-bit operations, genuine multitasking, and full MS-DOS

	compatibility. Microsoft releases MS-DOS 4.0.
1989	Intel introduces the 80486 processor; it contains an on-board math coprocessor and an internal cache controller (offering 2.5 times the performance of a 386 processor with a supporting coprocessor).
1991	MS-DOS 5.0 offers a significantly improved DOS shell.
1992	The Intel i586 processor, the first Pentium, is introduced, offering 2.5 times the performance of a 486. Microsoft introduces Windows 3.1, vastly expanding the use of a graphical user interface in the mass market. IBM expands OS/2.
1993	MS-DOS 6.0 arrives. The term "multimedia" (the inclusion of CD-ROM drives, sound cards, speakers, and so forth, as standard equipment on new personal computers) comes into use.
1994	Intel delivers the first 100-MHz processor. Compaq Computer Corporation becomes the largest producer of computers.
1995	Windows 95, code-named Chicago, is introduced by Microsoft. It features 32-bit architecture. The Internet, having expanded far beyond its beginnings as a network serving government and university institutions, is now in everyday use by the rapidly growing proportion of the population with access to a modem. Computer prices drop as performance increases. IBM purchases Lotus (maker of the popular Lotus1-2-3 spreadsheet).
1995-1996	Software manufacturers scramble to make their products compatible with Windows 95.
1997	Microprocessor speeds exceed the 200-MHz mark. Hard disk drive and

	memory prices fall as basic system configuration sizes continue to increase. CD-ROM drives and Internet connections have become standard equipment for computers.
1998	PC performance continues to soar and prices continue to fall. Central processing unit (CPU) speeds exceed 450 MHz, and motherboard bus speeds reach 100 MHz Entry-level machines are priced near the $500 mark. Universal serial bus (USB) is introduced. Windows 98 becomes the standard operating system for most new personal computers. Computer prices drop well under $1,000, increasing computer sales to the home market.
1999	Processor speeds exceed 1 gigahertz (GHz). E-commerce grows dramatically as the Internet expands.
2000	Microsoft releases Windows 2000 and the basic PC becomes a commodity item in discount stores. Broadband connections such as DSL and cable begin to take hold, making Internet access easier and faster than over the telephone line.

The following paragraphs summarize the major developments that occurred in each of these generations.

First-Generation Computers

The first generation of computers generally runs from 1945 to 1956. During this time, the first vacuum tube computer, the ENIAC, was invented. The first commercial computer was called the UNIVAC, and it was used by the

U.S. Census Bureau. It was also used to predict President Eisenhower's victory in the 1952 presidential election (Baker, 2003).

Second-Generation Computers

During this period, 1956 to 1963, computers were run by transistors. These computers were known for their ability to accept instructions for a specific function that could be stored within the computer's memory. This is also the period when COBOL and FORTRAN were used for computer operations. The entire software industry began in this generation.

Third-Generation Computers

This computer generation ran from 1964 to 1971, and it is characterized by the use of integrated circuits to replace the transistors from the previous generation. As a result of this invention, computers became smaller, faster, and more powerful.

Fourth-Generation Computers

This generation is placed in the 1971 to 1999 time category. Again, computers became smaller and faster, and the Intel chip was responsible for most of the changes taking place in this 29-year period. Because of the rapid miniaturization that took place with the chip, the CPU, memory, and input/output controls could now be placed on a single chip. Computers were becoming faster and faster; and they were being used in everyday items such as microwave ovens, televisions, and automobiles.

Fifth-Generation Computers

According to Allen, the turn of the century marks this generation, and it will be associated with artificial intelligence, spoken word instructions, and superconductor technology, which allows electricity to flow with little or no resistance.

Computer Communication

In this section, we examine the fundamentals of electronic communication and explore how computer communication differs from human communication.

After this lesson, you will be able to

- Understand how a computer transmits and receives information
- Explain the principles of computer language

Early Forms of Communication

Humans communicate primarily through words, both spoken and written. From ancient times until about 150 years ago, messages were either verbal or written in form. Getting a message to a distant recipient was often slow, and sometimes the message (or the messenger) got lost in the process.

As time and technology progressed, people developed devices to help them communicate faster over greater distances. Items such as lanterns, mirrors, and flags were used to send messages quickly over an extended visual range.

All "out of earshot" communications have one thing in common: They require some type of "code" to convert human language to a form of information that can be packaged and sent to the remote location. It might be a set of letters in an alphabet, a series of analog pulses over a telephone line, or a sequence of binary numbers in a computer. On the receiving end, this code needs to be converted back to language that people can understand.

Obstacles to effective communications include differences in languages and in how the speaker and listener give meaning to words. Language between people is made up of more than words. Gestures, emphasis, body language, and social concepts have an impact on how we interpret interpersonal communications. Most of these elements have no bearing on human–machine interactions. There are other issues we must understand to be able deal and interact with computers.

Dots and Dashes, Bits and Bytes

Telegraphs and early radio communication used codes for transmissions. The most common, Morse code (named after its creator, Samuel F. B. Morse), is based on assigning a series of pulses to represent each letter of the alphabet. These pulses are sent over a wire in a series. The operator on the receiving end converts the code back into letters and words. Morse code remained in official use for messages at sea almost until the end of the twentieth century—it was officially retired in late 1999.

Morse used a code in which any single transmitted value had two possible states: a dot or a dash. By combining the dots and dashes into groups, an operator was able to represent letters and, by stringing them together, words. That form of on–off notation can also be used to provide two numbers, 0 and 1, The value 0 represents no signal, or off, and the value 1 represents a signal, or on, state.

This type of number language is called *binary notation* because it uses only two digits, usually 0 and 1.

The Binary Language of Computers

The binary math terms that follow are fundamental to understanding PC technology.

Bits

A *bit* is the smallest unit of information that is recognized by a computer: a single on or off event.

Bytes

A *byte* is a group of 8 bits. A byte is required to represent one character of information. Pressing one key on a keyboard is equivalent to sending 1 byte of information to the computer's central processing unit (CPU). A byte is the standard unit by which memory is measured in a computer—values are expressed in terms of kilobytes (KB) or megabytes (MB). The table that follows lists units of computer memory and their values.

Memory Unit	**Value**
Bit	Smallest unit of information; shorthand term for binary digit
Nibble	4 bits (half of a byte)
Byte	8 bits (equal to one character)
Word	16 bits on most personal computers (longer words possible on larger computers)
Kilobyte (KB)	1024 bytes
Megabyte (MB)	1,048,576 bytes (approximately 1 million bytes or 1024 KB)
Gigabyte (GB)	1,073,741,824 bytes (approximately 1 billion bytes or 1024 MB)

The Binary System

The binary system of numbers uses the base of 2 (0 and 1). As described earlier, a bit can exist in only two states, on or off. When bits are represented visually:

- 0 equals off.
- 1 equals on.

The following is 1 *byte* of information in which all 8 *bits* are set to 0. In the binary system, this sequence of eight 0s represents a single character—the number 0.

0 0 0 0 0 0 0 0

The binary system is one of several numerical systems that can be used for counting. It is similar to the decimal system, which we use to calculate everyday numbers and values. The prefix *dec* in the term *decimal system* comes from the Latin word for 10 and denotes a base of 10, which means the decimal system is based on the 10 numbers 0 through 9. The binary system has a base of 2, the numbers 0 and 1.

Counting in Binary Notation

There are some similarities in counting with binary notation and the decimal system we all learned in grade school. In the decimal system, the rightmost whole number (the number to the left of the decimal point) is the "digits" column. Numbers written there have a value of 0 to 9. The number to the left of the digits column (if present) is valued from 10 to 90—the "10s" column. The factor of each additional row is 10 in the decimal system of notation. To get the total value of a number, we add together all columns in both systems: 111 is the sum of 100 + 10 + 1.

NOTE

A *factor* is an item that is multiplied in a multiplication problem. For example, 2 and 3 are factors in the problem 2 × 3.

Binary notation uses the same system of right-to-left columns of ascending values, but each row has only two (0 or 1) instead of 10 (0–9) possible values. Thus, in the binary system, the first row to the right can be only 0 or 1; the next row to the left can be 2 or 3 (if a number exists in that position). The columns that follow have values of 4, then 8, then 16, and so on, each column doubling the possible value of the one to its right. The factor used in the binary system is 2, and—just as in the decimal system—0 is a number counted in that tally. Examples of bytes of information (eight rows) follow.

Byte—Example A

The value of this byte is 0 because all bits are off (0 = off).

0	0	0	0	0	0	0	0	8	bits
128	64	32	16	8	4	2	1	#	values

Byte—Example B

In this example, two of the bits are turned on (1 = on). The total value of this byte is determined by adding the values associated with the bit positions that are on. This byte represents the number 5 (4 + 1).

0	0	0	0	0	1	0	1	8	bits
128	64	32	16	8	4	2	1	#	values

Byte—Example C

In this example, two different bits are turned on to represent the number 9 (8 + 1).

0	0	0	0	1	0	0	1	8	bits
128	64	32	16	8	4	2	1	#	values

The mathematically inclined will quickly realize that 255 is the largest value that can be represented by a single byte. (Keep in mind that we start with 0 and go to 255, which corresponds to a possible 256 places on a number line.) Because computers use binary numbers and humans use decimal numbers, technicians must be able to perform simple conversions. The following table shows decimal numbers and their binary equivalents (0_9). You will need to know this information. The best way to prepare is to learn how to add in binary numbers rather than merely memorizing the values.

Decimal Number	**Binary Equivalent**
0	0000
1	0001
2	0010
3	0011
4	0100
5	0101
6	0110
7	0111
8	1000
9	1001

Numbers are fine for calculating, but today's computers must handle text, sound, streaming video, images, and animation as well. To handle all of that, standard codes are used to translate between binary machine language and the type of data being represented and presented to the human user. The binary system is still used to transfer values, but those values have a secondary meaning that is handled by the code. The first common, code-based language was developed to handle text characters and serves as a good example that lets us examine some other core concepts as well.

Parallel and Serial Devices

The telegraph and the individual wires in our PCs are serial devices. This means that only one element of code can be sent at a time. Like a one-lane tunnel, there is only room for one person to pass through at one time. All electronic communications are—at some level—serial, because a single wire can have only two states: on or off.

To speed things up, we can add more wires. This allows simultaneous transmission of signals. Or, to continue our analogy, it's like adding another set of tunnels next to the first one: We still have only one person per tunnel, but we can get more people through because they are traveling in parallel. That is the difference between parallel and serial data transmission. In PC technology, we often string eight wires in a parallel set, allowing 8 bits to be sent at once. Figure 1.3 illustrates serial and parallel communication.

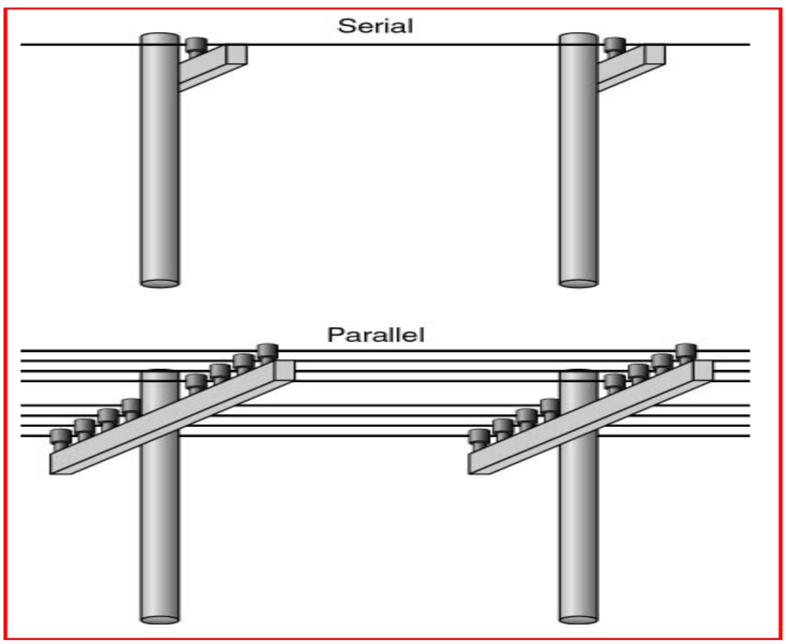

Figure 1.3 *Serial and parallel communication*

ASCII Code

The standard code for handling text characters on most modern computers is called *ASCII* (American Standard Code for Information Interchange). The basic ASCII standard consists of 128 codes representing the English alphabet, punctuation, and certain control characters. Most systems today recognize 256 codes: the original 128 and an additional 128 codes called the *extended character set*.

Remember that a byte represents one character of information; 4 bytes are needed to represent a string of four characters. The following 4 bytes represent the text string 12AB (using ASCII code):

00110001	00110010	01000001	01000010
1	2	A	B

The following illustrates how the binary language spells the word *binary*:

B	I	N	A	R	Y
01000010	01001001	01001110	01000001	01010010	01011001

NOTE

It is very important to understand that in computer processing, the "space" is a significant character. All items in a code must be set out for the machine to process. Like any other character, the space has a binary value that must be included in the data stream. In computing, the absence or presence of a space is critical and sometimes causes confusion or frustration among new users. Uppercase and lowercase letters also have different values. Some operating systems (for example, UNIX) distinguish between them for commands, whereas others (for example, MS-DOS) translate the uppercase and lowercase into the same word no matter how it is cased.

The following table is a partial representation of the ASCII character set. Even in present-day computing, laden with multimedia and sophisticated programming, ASCII retains an honored and important position.

Symbol	**Binary 1 Byte**	**Decimal**	**Symbol**	**Binary 1 Byte**	**Decimal**
0	00110000	48	V	01010110	86
1	00110001	49	W	01010111	87
2	00110010	50	X	01011000	88
3	00110011	51	Y	01011001	89
4	00110100	52	Z	01011010	90
5	00110101	53	a	01100001	97
6	00110110	54	b	01100010	98
7	00110111	55	c	01100011	99
8	00111000	56	d	01100100	100
9	00111001	57	e	01100101	101
A	01000001	65	f	01100110	102
B	01000010	66	g	01100111	103
C	01000011	67	h	01101000	104
D	01000100	68	i	01101001	105
E	01000101	69	j	01101010	106
F	01000110	70	k	01101011	107
G	01000111	71	l	01101100	108
H	01001000	72	m	01101101	109
I	01001001	73	n	01101110	110

J	01001010	74	o	01101111	111
K	01001011	75	p	01110000	112
L	01001100	76	q	01110001	113
M	01001101	77	r	01110010	114
N	01001110	78	s	01110011	115
O	01001111	79	t	01110100	116
P	01010000	80	u	01110101	117
Q	01010001	81	v	01110110	118
R	01010010	82	w	01110111	119
S	01010011	83	x	01111000	120
T	01010100	84	y	01111001	121
U	01010101	85	z	01111010	122

NOTE All letters have a separate ASCII value for uppercase and lowercase. The capital letter "A" is 65, and the lowercase "a" is 97.

Keep in mind that computers are machines, and they do not really "perceive" numbers as anything other than electrical charges setting a switch on or off. Like binary numbers, electrical charges can exist in only two states—positive or negative. Computers interpret the presence of a charge as 1 and the absence of a charge as 0. This technology allows a computer to process information.