Computer History Hypermedia

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Click any heading to jump to that topic.

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*In **Windows 3.1**:* Click **Help**, then click **Always on Top** to remove the check mark.

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Computer History Hypermedia

The Pentium Pro Processor 1995

Credits

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Abacus 500 B.C.

The first calculation aids probably consisted of pebbles or notches carved in sticks. The abacus, a more sophisticated calculation aid consisting of beads strung on wires or rods, was used as early as 500 B.C. The abacus was widely used in China and Japan, where as late as the 1940s highly skilled users were able to perform calculations faster than operators using mechanical calculators.

Algebra and the Arabic Number System 830 A.D.

In 830 A.D., the Arab mathematician al-Khowarizmi wrote the book *Al-jabrwa'l muqabalah*. The word "algebra" was derived from the title of this book, which outlined the foundations of the arabic number system. For hundreds of years, the Arab world was mathematically more advanced than the western world. In 1120, Monk Adelard of Bath infiltrated the University of Cordoba in Spain and translated the book *Al-jabr* into English, introducing algebra to the western world. In 1202, an Italian named Leonardo Fibonacci wrote a book titled *Liber Abaci*, explaining the arabic number system. The book introduced questions such as: how many rabbits will be produced in a year beginning with a single pair, if, in every month, each pair bears a new pair, which becomes productive from the second month on?

Europeans gradually switched from Roman numerals to the more versatile arabic number system.

Logarithms 1614

In 1614, Scotsman John Napier invented the logarithm and constructed the first logarithm tables. These tables show the power to which a fixed number is raised to produce another number. For example, 2 to the second power is 4, 2 to the third power is 8, and so forth.. Logarithms proved to be an essential advance in the development of mechanical aids for multiplication and division because they allow you to multiply or divide numbers simply by adding or subtracting their logarithms. Sometime between 1614 and the time of his death in 1617, Napier produced and sold a device called Napier's Bones, which used logarithms to assist in multiplication. Logarithms were later used in the development of the slide rule.

The Slide Rule 1621

In 1620, Edmund Gunter plotted a logarithmic table on a ruler--the first step in the development of the modern slide rule.

In 1621, William Oughtred, an English clergyman, used ideas from Gunter's and Napier's work to invent the slide rule, a calculation device that would be used for over 300 years. A slide rule resembles two rulers marked with logarithmic scales rather than inches. To perform multiplication, division, and other complex mathematical calculations, the user slides the rules to indicate the input for the calculation. The result, or answer, is then read from the ruler. It is somewhat ironic, however, that the slide rule cannot be used for addition or subtraction.

The slide rule was one of the most successful calculation aids ever developed, and it remained an essential tool for university students, engineers, and scientists throughout the 1960s.

Schickard's Adding Machine 1623

In 1623, a German named Wilhelm Schickard built a machine that historians consider the first automatic adding machine. The device used a series of gears, each with 10 spokes. Each spoke represented one digit. To use the device, you would turn the gears to the numbers you wanted to input. Every time the gear completed a full circle, it moved the next gear to the left one notch, thereby "carrying the one."

Schickard's original machine was lost, but in 1960 German researchers reconstructed the machine from Shickard's sketches.

The Pascaline 1642

Between 1642 and 1644, a French teenager, Blaise Pascal, built the Pascaline, an adding machine very similar to Schickard's. Pascal advertised the device as being capable of performing "all the operations of arithmetic," but this was a bit of advertising hyperbole. To carry out multiplication, the operator performed a series of additions. To subtract, the operator needed to add the complement of the number being subtracted.. To divide, the operator carried out a series of subtractions. The Pascaline proved to be unreliable because of the sensitivity of its complex mechanical gears. Despite their unreliability, Pascal sold several of these adding machines. Because he was the only person who could fix them, he established a profitable service business.

The Leibniz Calculator 1673

In 1673, a German Baron, Gottfried Wilhelm von Leibniz, extended Pascal's design to produce a mechanical calculating device that could multiply and divide as well as add and subtract. The device contained an innovative component now known as the "Leibniz Wheel" that performed the calculations. The design principle of the Leibniz Wheel was used successfully in generations of calculating machines. During the 1800s, Charles Thomas of Alsace manufactured over 1500 mechanical calculating machines based on the Leibniz model.

Von Leibniz advocated the use of the binary number system in mechanical calculation devices, even though his device used the decimal system. In the 1940s, the binary number system became a cornerstone of modern computer design.

The Jacquard Loom and Punched Cards 1804

In the late 1800s, Joseph Jacquard invented a loom that used punched cards to control the weaving process. The punched cards controlled the movement of the loom to produce the woven pattern. To weave a different pattern, a new set of cards was inserted into the machine.

The punched card concept was later considered by Charles Babbage as an input device for his analytical engine. Herman Hollerith employed punched cards for input to his tabulating machine. In the 1950s and 1960s, IBM used punched cards to input programs and data to mainframe computers and the warning printed on the cards--"Do not fold, spindle, or mutilate"--worked its way into everyday conversation.

Babbage Engines 1822

In 1822, Englishman Charles Babbage proposed the Difference Engine, an extremely complex mechanical device designed to compute and print mathematical tables.

Babbage worked on the Difference Engine until 1833, but limited by the technology of the day, he was unable to produce a working version. Nevertheless, the Difference Engine and Babbage's later proposed device, known as the Analytical Engine, were both based on concepts remarkably similar to those on which modern computer systems are based. Babbage proposed to store the program and data for his engines on punched cards, an idea that probably came from the use of punched cards on the Jacquard loom. Augusta Ada, Countess of Lovelace, collaborated with Babbage on the development of his engines.

In 1854, a Swedish engineer named George Scheutz successfully completed a model of the Difference Engine. He brought to England, where he was awarded a Gold Medal from the British Royal Society. One of Scheutz's difference engines was purchased by an American. Another was used for many years to produce life expectancy tables for British insurance companies.

Augusta Ada, Countess of Lovelace 1800s

Augusta Ada Byron, the daughter of the poet Lord Byron, collaborated with Babbage on the conceptual development of the Difference Engine and the Analytical Engine during the early 1800s. Together with Babbage, she created a program for the Analytical Engine to compute Bernoulli numbers and also pioneered the concept of subroutines. She has been called the first female programmer; and the Ada programming language, adopted by the U.S. Department of Defense, was named after Ada Lovelace in recognition of her role in the development of the computer.

George Boole 1850

In the mid-1800s, George Boole, an Irish mathematician, developed a system of symbolic logic known as Boolean algebra. Boolean logic, with the key words AND, OR, and NOT, became a fundamental component of modern computer architecture and a cornerstone of database query languages.

The Census and the Tabulating Machines 1890

In 1870, Charles W. Seaton, Chief Clerk of the U.S. Census, created a machine to assist with the 1870 census of over 40 million Americans. It didn't help enough. Tabulation of the 1880 census was not completed until 1887, just three years before the next census was to begin. Without a way to increase the speed of tabulation, it was likely that the 1890 census would not be completed before 1900.

The U.S. Census Bureau held a competition to determine the best way to tabulate the 1890 census. Herman Hollerith, founder of the company that later became IBM, won the competition with a design for a punch card tabulating device that used two devices: a card punch and a card reader. These devices served as prototypes for later developments in the computer industry; mainframe computers had card readers and card punch machines well into the 1980s.

The U.S. Census Bureau used punched cards to record data about individual families. Each area of the card represented a field such as "nationality." Within each area, the card could be punched to indicate a data item, such as "Irish." The card reader was used to tabulate or count the data from the cards.

One unique aspect of the card reader was that it used electricity to read the information from the punched cards. The card reader device contained an array of metal rods. When a card was inserted into the reader, the rods descended onto the card. Where the card was punched, the rods descended through the card and into a small cup of mercury, completing a circuit and advancing a dial to reflect the count. Electricity, of course, became the preferred power source for calculators and, later, for computers.

IBM Corporation: the Birth of a Legend 1924

IBM, the company whose name today is synonymous with computers, did not spring into business overnight, nor was its first product a computer.

In 1896, Hollerith incorporated The Tabulating Machine Company, the company that eventually became IBM.

In 1913, Thomas Watson assumed the presidency of Hollerith's company, then known as the Computing Tabulating Recording Company or CTR. Watson was an ambitious and dynamic leader. In 1924, Watson changed the name of CTR to International Business Machines, or IBM. Corporate songs helped maintain employee motivation. There was nothing better than a chorus of "ever onward IBM" to boost sales:

Our products are known
In every zone.
Our reputation sparkles like a gem.
We've fought our way through,
And new fields we're sure to conquer too,
For the ever onward IBM.

The motivational techniques paid off in huge dividends. In 1928, IBM was the fourth largest business machines company, with revenues of $19.7 million. The industry leader, Remington Rand, had revenues of $59.9 million. By 1945 IBM led the industry with revenues of $141.7 million, even though it had not yet produced a single computer.

When the computer era dawned in 1952, Watson, by then referred to as "the old man" when he was out of earshot, had been at the helm for almost 40 years. He was more interested in preserving the status quo than in innovation and expansion. He was not, therefore, interested in computers. In 1952 his son, Tom Watson, Jr., assumed the presidency of the company and a year later IBM entered the computer era and began its march to leadership of the computer industry.

Alan Turing and the Turing Machine 1937

In 1937, Alan Turing, a young English mathematician, published a paper describing a hypothetical device known as a Turing Machine. The Turing Machine demonstrated the theoretical limits and potential of computer systems. In the 1950s, Turing proposed the so-called Turing test of machine intelligence. According to the Turing test, a computer could be described as intelligent if it was able to convince a person that it was human.

John Atanasoff and the ABC Computer 1937

Between 1937 and 1942, an Iowa State University professor, John V. Atanasoff, and a graduate student, Clifford E. Berry, developed the prototype for an electronic computer. The major innovation of the ABC computer was its use of vacuum tubes instead of mechanical switches. Computers based on vacuum tubes are now known as first generation computers.

There has been significant controversy about whether the ABC or the later ENIAC should be considered the first general purpose electronic digital computer. In 1973, a U.S. court ruled that the patent on ENIAC was invalid, because parts of ENIAC had been derived from information obtained from Atanasoff. Atanasoff is now generally recognized as the inventor of the first electronic computer, even though he did not continue in the development of computer systems or apply for a patent on his design.

Konrad Zuse's Z-series 1938

Between 1938 and 1969, Konrad Zuse, a German engineering student, constructed a series of calculating machines, Z1 through Z22, which used electromagnetic relays and the binary number system. Although several of Zuse's machines were used to calculate the position of wings on guided missiles, the German military command believed that German aircraft were the best in the world and would not benefit from Zuse's machines. If the German military had supported Zuse's work, it is possible they would have had a significant effect on the outcome of World War II. Zuse, however, worked in the isolation of war-time and post-war Germany during the birth of the computer era. Without government support, progress was difficult, and Zuse is not widely noted as a contributor to the development of computers.

Vannevar Bush and the Memex 1939

Vannevar Bush, a student, and later a professor at M.I.T., worked on several significant projects, including one on analog calculating devices. Bush published a paper in the late 1930s that described a device called the "memex," which would store data and then retrieve it using a type of associative linking similar to human memory. This concept is similar to the way today's multimedia encyclopedias work, and is related to the technology that is the basis for this program; a technology called hypertext or hypermedia.

Harvard MARK I 1939

In 1939, Howard Aiken began work on the IBM Automatic Sequence Controlled Calculator, also known as the Harvard MARK I, because IBM later donated it to Harvard University. Some historians call this the first large scale automatic digital computer produced in the U.S.

The MARK I was 51 feet long, weighed about 5 tons, and was encased in steel and glass. Using punched cards as the primary input medium, the MARK I could subtract two 23-digit numbers in 3/10 of a second, multiply them in 4 seconds, or divide them in 10 seconds. The MARK I used electronic relays and was powered by a four horsepower motor. The MARK I was used for 16 years, primarily to produce mathematical tables. Aiken continued to develop computers through 1952 with the MARK II, MARK III, and MARK IV.

COLOSSUS 1943

During World War II, Nazi Germany used ENIGMA, a mechanical coding machine, to create secret codes that were extremely difficult to break. In 1943, a team of British developers, which included Alan Turing, created COLOSSUS, an electronic device designed to decode ENIGMA messages. COLOSSUS contained 1,800 vacuum tubes, used binary arithmetic, and was capable of reading input at the rate of 5,000 characters (5K) per second. Eventually, 10 versions of COLOSSUS were built. COLOSSUS successfully broke the codes created by ENIGMA and gave the Allies a major advantage during World War II.

The Bug in the Machine 1945

In 1945, a malfunction in the Harvard MARK I was traced to a moth that had flown inside the machine and caused a short circuit. The log book shows the moth and the entry "First actual case of bug being found." Whether this is exactly what happened or whether the log entry is something of an afterthought, Grace Hopper recounts, "From then on, whenever anything went wrong with a computer, we said it had bugs in it."

ENIAC 1945

In 1943, a development team headed by John W. Mauchly and J. Presper Eckert started work on ENIAC, a gigantic general purpose electronic computer at the University of Pennsylvania. ENIAC was designed to calculate trajectory tables for the U.S. Army, but wasn't finished until November 1945, three months after the Japanese surrendered and World War II ended. Although it was completed a little late for World War II, ENIAC could calculate the trajectory of a missile in 30 seconds, a task which took a skilled person with a desk calculator over 20 hours. ENIAC was put to use performing calculations for development of the hydrogen bomb, and it was operated until 1955.

ENIAC was over 100 feet long, 10 feet high, and weighed 30 tons. It contained 17,468 vacuum tubes, 1,500 relays, 70,000 registers, 10,000 capacitors, and 6,000 switches. The thousands of vacuum tubes in ENIAC consumed 174,000 watts of power and were a continual source of problems. Although ENIAC contained only a few less than 18,000 tubes, approximately 19,000 replacement tubes were installed in the system in 1952 alone. ENIAC could perform 5,000 additions per second and was programmed by manually connecting cables and setting 6,000 switches. ENIAC's internal storage was limited to 20 numbers. It generally took about two days to 'program' ENIAC to perform a particular series of calculations. ENIAC had a variable clock rate that allowed it to perform approximately 100,000 instructions per second. ENIAC's estimated cost was $500,000, about 200% over budget.

The patent on ENIAC was declared invalid in 1973, when a Federal Judge ruled that many of the concepts used in the development of ENIAC were derived from Mauchly's contacts with Atanasoff, particularly Mauchly's five day visit to view the ABC machine in 1941.

Manchester Mark I 1946

In late 1946, a group of scientists in Manchester, England began building a computer. It was completed in 1948 and became the first fully electronic computer to store a program in memory. This was a major step forward in the computer industry. Prior to stored program computers, a program was read from paper tape one instruction at a time as each instruction was executed. Using a mechanical device to read instructions from paper tape was extremely slow. The execution time for programs with jumps or loops was also extremely slow while the processor waited for the tape to wind to the jump instruction or the beginning of a loop.

Programs stored in memory execute much faster than programs on tape because the program does not pause while instructions are located and read. The program is read into memory from tape or punched cards before program execution begins. As the program runs, instructions are transferred electronically to the processor.

With the success of the prototype Mark I, the British government commissioned the first commercial computer, the Ferranti Mark I, which was completed in 1951.

Transistors 1947

In 1947, the first transistors were demonstrated at AT&T's Bell Laboratories. Transistors were much smaller, cheaper, and more reliable than vacuum tubes. Starting in 1957, transistors replaced vacuum tubes as the basis for the second generation computers. The general public became aware of transistors in the early 1950s with their use in hearing aids and transistor radios.

EDSAC 1949

The Electronic Delay Storage Automatic Computer (EDSAC) was completed in 1949 in Cambridge, England. EDSAC incorporated many features developed from Mauchly's EDVAC project. EDSAC was significantly more powerful than the Manchester Mark I and was the first stored program computer with significant computing ability.

The Integrated Circuit 1959

In the early 1950s, an English engineer named G. W. A. Dummer envisioned electronic components created in a solid block, with no connecting wires. He believed that this so-called "solid circuit" would greatly reduce the size and cost of electronic devices. It was a good idea, but no one was able to build such a circuit at the time.

In 1959, Jack Kilby at Texas Instruments, and Robert Noyce, at Fairchild Semiconductor, independently developed the integrated circuit. The integrated circuit made it possible to pack the equivalent of thousands of vacuum tubes or transistors into a single miniature chip. The integrated circuit eventually became the basis for the third generation of computers and is considered one of the most significant technological developments of all time.

UNIVAC 1951

In 1951, Eckert and Mauchly completed the UNIVAC I computer for the Sperry Rand Corporation. UNIVAC was physically much smaller than ENIAC at 14.5 feet long, 7.5 feed wide, and 9 feet high, but it could read data at the rate of 7,200 characters per second and complete 2.25 million instruction cycles per second. UNIVAC had internal storage capacity of 12,000 characters, or 12K, and could use magnetic tape for storage and retrieval of data. The best official estimate of the cost to build UNIVAC is $930,000.

It's interesting to compare UNIVAC's speed of 2.25 million instruction cycles per second to that of a microcomputer. The original IBM PC could perform 4.77 million instruction cycles per second, while a Pentium computer can complete 66 to 100 million instruction cycles per second. Modern personal computers have an internal memory capacity of 4 to 16 million characters, compared to UNIVAC's capacity of only 12,000 characters.

Forty-six UNIVAC computers were delivered to customers between 1951 and 1958, making it the first all-purpose commercial electronic digital computer system.

Grace Hopper wrote the first compiler for use with UNIVAC in 1951. It did not, however, live up to the promise of a 1955 UNIVAC news release, which stated, "Automatic programming, tried and tested since 1950, eliminates communication with the computer in special code or language." The compiler still required the programmer to use a programming language.

In 1952, UNIVAC was programmed to predict the winner of the presidential elections and was featured on the CBS Evening News with Walter Cronkite. By mid-evening, UNIVAC predicted that Eisenhower would win a landslide victory over Stevenson. However, most analysts believed Stevenson would win, so the UNIVAC operators became convinced that UNIVAC was wrong. The operators refused to tell CBS what UNIVAC predicted, while they attempted to modify the program to force UNIVAC to predict the "correct" winner. But, as results continued to come in, it became clear that Eisenhower would indeed win by a landslide as UNIVAC had predicted. UNIVAC was eventually credited with correctly predicting the election results, but the morning's newspaper headlines were not favorable. The computer was referred to as a "giant brain" and more than one reporter thought it necessary to mention "Big Brother," the tyrant of George Orwell's novel, *1984*.

EDVAC 1952

In 1944, while the ENIAC project was still in the early stages, Eckert and Mauchly started work on the Electronic Discrete Variable Computer, or EDVAC. EDVAC was designed as a stored program computer, with both program instructions and data stored in a single storage device. EDVAC could have been the first stored program computer, but it wasn't completed until 1952, four years after the Manchester Mark I became the first computer to run a stored program.

John von Neumann, a highly respected Hungarian professor teaching at Princeton University, became interested in the ENIAC and EDVAC projects and helped Eckert and Mauchly refine their design. Von Neumann eventually wrote a paper describing the stored program concept, the idea of keeping both the program and data in the computer's memory. An early draft of this paper listed von Neumann as the only author. Because of this paper, von Neumann was for years incorrectly thought of as the sole developer of the stored program concept.

First IBM Mainframe Computers 1952

In 1952, IBM announced the 701, an electronic computer designed to compete with UNIVAC. In 1955, IBM began delivery of the 704, an enhanced computer system first featuring 4K of RAM and later expanded to 32K. Between 1955 and 1960, IBM produced one hundred twenty-three model 704 computer systems.

FORTRAN 1956

Between 1954 and 1956, John Backus headed a team of IBM programmers who developed the FORTRAN programming language. FORTRAN was designed for scientific applications. Its name is derived from FORMula TRANslation. FORTRAN was the first widely used high-level computer programming language. It featured English-like command words--such as READ, FORMAT, and PRINT--in addition to control structures - such as IF..THEN..ELSE branching, FOR..NEXT, and DO..CONTINUE loops.

Transistorized Computers 1957

In 1957 and 1958, the first transistor-based computer systems were introduced by UNIVAC and Philco Corporation. In 1960, IBM introduced the IBM 1401, which became the most successful transistorized computer. Most historians refer to these as second generation computers because they were built using a significantly different architecture than the first generation vacuum tube computers.

The second generation computers were smaller, faster, more reliable, less expensive, and more powerful than the first generation systems. However, by the mid-1960s the second generation computers were made obsolete by the introduction of third generation systems based on integrated circuits.

Hypertext 1960

Hypertext is a method of storing data that allows you to retrieve it in a non-linear fashion. Hypertext offers features first proposed by Vannevar Bush for the Memex machine. Just as in this program, hypertext allows you to click words or key phrases to get additional information, search for key words, and jump from one topic to a related topic.

The first system of non-linear text retrieval was developed by Doug Engelbart at the Stanford Research Institute. In 1960 Ted Nelson coined the word "hypertext" and began development of project Xanadu, a blueprint for a world-wide publishing and text retrieval system. In spite of Nelson's dynamic personality, project Xanadu did not reach fruition, and the hypertext concept was not popularized until 1987, when Apple Computer, Inc. introduced Hypercard for the Macintosh computer. By 1995, the World Wide Web had become the most popular feature of the Internet, making world-wide hypertext a reality.

COBOL 1960

In April 1959, a team of five computer programmers, including Grace Hopper, met to begin developing a "common business language" for digital computers. The specifications were completed in 1960, and COBOL (COmmon Business Oriented Language) was born. COBOL remains one of the most prevalent computer languages used on large computer systems. Millions of lines of COBOL programs have been written since 1960 and are still in use.

BASIC 1964

In 1964, John Kemeny and Thomas Kurtz of Dartmouth College developed the first version of BASIC (Beginners All-purpose Symbolic Instruction Code), which became the most popular computer programming language in the world. BASIC is a high-level language designed to teach computer programming. As with other high-level languages, it uses English-like commands and provides control structures for sequencing, branching, and looping.

BASIC was first used on mainframe computers. BASIC was also included with most early microcomputers, such as those from Apple and IBM , which accounts in part for its popularity. Early versions of BASIC were limited and did not encourage structured programming. The dreaded GOTO command was overused by novice programmers, who created thousands of "spaghetti code" programs with indecipherable logic. However, the BASIC language has continued to evolve into advanced programming environments, such as Microsoft's Visual BASIC, which provide programmers with sophisticated tools to easily create software with graphical user interfaces.

IBM 360 and 370 Computers 1964

In 1964, IBM introduced the IBM 360/40, the first of a series of mainframe computers that was to dominate computing in the 1960s. The IBM 360/40 was based on ceramic modules rather than true integrated circuits, and can be considered as an intermediate stage between first and second generation computers.

The first computer system based on integrated circuits was the Spectra, released by RCA in 1965. The first IBM computers based on integrated circuits were the IBM 370 series, released in the early 1970s.

Computers based on integrated circuits are known as third generation computers.

DEC PDP-8 Minicomputer 1965

In 1965, Digital Equipment Corporation (DEC) brought out the DEC PDP-8, the first minicomputer. The PDP-8 was about the size of a refrigerator, cost $18,000, and contained only 4K of memory. Minicomputers were less powerful than mainframes, but intentionally so. The price of a minicomputer was 10 times less than that of a mainframe, so it was cost-effective for many dedicated applications that previously were financially prohibitive to manage, such as maintaining inventory, controlling machine tools, and keeping personnel and payroll records.

Object-Oriented Languages: Simula and SmallTalk 1968

Simula, the first object-oriented programming language, was developed in 1968. It was followed by SmallTalk, developed at Xerox PARC in 1983.

Object-oriented programming languages provide programmers with tools to create programs that consist of objects. An object might contain data and the instructions for processing that data or interacting with other objects. Objects can be grouped into a "class" with other objects that have similar characteristics. For example, the class "window" might contain objects that are essentially rectangular areas on the screen. A text box can be defined as a special sub-class, or type, of "window" that can contain text. A picture box can be defined as another sub-class, or type, of "window" that can contain a picture or graphical image. An object-oriented version of the language C, known as C++, has rapidly gained favor as an object-oriented programming environment.

The Internet 1969

In the late 1960s, the U.S. Department of Defense began research into computer networks. In 1969, an experimental 4-node network was completed; and by the mid 1980s, the ARPANET (Advanced Research Project Agency Network) had expanded to include almost 1,000 computers around the world.

In 1983, ARPANET was split into two interconnected networks, ARPANET and MILNET, and the Internet (meaning "interconnected network") was born. Access to the Internet was at first allowed only to military researchers and defense contractors. Then in 1986, the National Science Foundation network (NSFNET) connected to the Internet and provided more general access.

The NSFNET was constructed in the early 1980s to provide access to five supercomputer centers that were available to civilians for scholarly research. Providing access to the supercomputers presented a problem, because researchers at organizations throughout the country--such as colleges, universities, and corporations--wanted access to the supercomputers without traveling to a supercomputer site. The most cost-effective way to connect hundreds of organizations to the network was to encourage each organization to connect to another organization somewhere nearby, forming a chain of networks that ended at a supercomputer center. It was a somewhat haphazard plan, but it worked. When NSFNET joined the Internet in 1986, the size of the Internet doubled.

Internet connections are currently available at almost every college campus in the U.S. and in almost every country of the world, from Argentina to Zimbabwe. A wide variety of computer services are available through the Internet, the most popular of which are electronic mail and the World Wide Web.

Intel 1969

Robert Noyce, one of the engineers who developed the integrated circuit, founded Intel, the company that was to become the industry leader in the design and production of integrated circuits. In 1969, Intel was a fledgling company scrambling for business, but within two years an Intel engineer named Ted Hoff created the first microprocessor by putting memory, an ALU, a control unit, and input/output pathways in a single silicon circuit. Intel processors such as the 8008 and 8080, were essential to development of the early microcomputers.

IBM used Intel's 8088 microprocessor in its IBM PC microcomputer and Intel processors became the mainstay of the microcomputer industry. Intel has since produced many successors to the 8088 including the 80286, 80386, 80486, and Pentium processors.

Pascal 1971

Pascal, named after Blaise Pascal, is a programming language that was developed in the early 1970s by Niklaus Wirth. Wirth designed the Pascal language for use as a tool for teaching programming students how to write well-structured programs. Pascal requires a programmer to declare variables at the beginning of the program by specifying the variable name and the data type, such as "price: real," which indicates that the variable "price" is a "real" number. The language does not include the notorious GOTO command, so sequential control is managed by functions and procedures.

The Microprocessor 1971

In 1971, Ted Hoff developed the Intel 4004, the first general purpose microprocessor. The microprocessor dramatically changed the computer industry, enabling the development of fourth generation computer systems that were faster, smaller, and less expensive than third generation computers.

The 4004 was less than 1/16" long and 1/2" wide, but it matched the computing power of ENIAC . The 4004 packed 2,300 transistors on a single silicon chip and was able to perform 60,000 instructions per second. This was impressive at the time, but today seems very limited compared to a modern processor such as the Intel Pentium, which contains over 3.1 million transistors and can perform over 100 million instructions per second.

In 1972, Intel released the 8008, the first commercial 8-bit microprocessor. The 8008 was followed in 1973 by the 8080 microprocessor, which was 20 times faster than the original 4004.

Many hobbyists used the 8008 to create their own microcomputers, such as the Mark-8, developed by Jonathan A. Titus and featured in the July 1974 issue of Radio-Electronics. Individuals at IBM, DEC, Xerox, and Hewlett-Packard proposed microcomputer projects, but their companies decided not to pursue a commercial microcomputer at that time.

In 1974, Motorola released the 6800 8-bit microprocessor. Ex-Motorola engineers later created the 6502, an 8-bit microprocessor that was to be used in the Apple II and Commodore computers.

In 1976, Intel released the 8085, a further enhancement of the 8080. Soon after, Zilog introduced the Z80 microprocessor, an enhanced 8080 microprocessor that was used in many early microcomputer systems.

Both Intel and Motorola continued development of an advanced line of microprocessors. The Intel line grew to include a variety of 16, 32, and 64-bit processors, the most popular of which are listed in the following table:

Processor	Release Date	Word Size
8086	1978	16
8088	1978	8/16
80286	1982	16
80386	1985	32
80486	1989	32
Pentium	1993	64

The Intel 80x86 processors were primarily used in IBM PC and IBM-compatible computer systems.

The Motorola line grew to include the 16-bit 68000, and a full line of 32-bit microprocessors including the 68020, 68030, and 68040, which were primarily used in the Apple Macintosh computers. In the early 1990s, Motorola developed the 64-bit RISC PowerPC processor, which was licensed by both Apple and IBM.

The CP/M Operating System 1971

In the early 1970s, Gary Kildall wrote PL/1, the first programming language for the 4004, while working for Intel. As part of the PL/1 project, Kildall created an operating system, which eventually became CP/M, the first microcomputer operating system, and the operating system used in most early microcomputers.

Kildall was approached by IBM in regards to licensing CP/M for the upcoming IBM PC computer, but before an agreement could be reached, IBM arranged to license the MS-DOS operating system from Microsoft Corporation, launching Microsoft on the road to success.

The UNIX Operating System 1971

The UNIX operating system was developed at Bell Labs during the 1970s by Ken Thomson and Dennis Ritchie. UNIX was originally designed for minicomputers, but is now also available for microcomputers and mainframes. Many versions of UNIX exist, such as AIX from IBM, XENIX from Microsoft, and ULTRIX from Digital Equipment Corporation, but these other versions are essentially the same operating system adapted for different computers.

UNIX features a command-line user interface, but you can purchase add-on software that provides a graphical user interface with direct object manipulation and pull-down menus. UNIX also supports multi-tasking, which means that more than one program can run on a single computer at the same time. UNIX is also a multi-user operating system, which means that many users can simultaneously run programs from terminals attached to a single computer.

Ethernet 1973

Ethernet was created by Robert Metcalfe at Xerox PARC during 1973. In 1979, he brought together Xerox, DEC, and Intel to establish Ethernet as a standard for local area networks. The original Ethernet was designed to offer 10 Megabit per second performance using thick Ethernet cabling. Later versions included the 10Base2, which used coax cabling and a bus topology, and finally 10BaseT, which used less expensive twisted pair cabling. 10BaseT was approved as an Ethernet standard in 1990 and it has quickly become the most popular microcomputer network.

In 1992, Grand Junction Networks Inc. proposed FastEthernet, a 100 Megabit per second Ethernet variation. Since then, several options have been proposed to provide increased Ethernet capability, including FastEthernet, full duplex Ethernet, and switched Ethernet.

C 1974

C was developed in the early 1970s at AT&T's Bell Laboratories in conjunction with the development of the UNIX operating system. The language became popular with programmers who wrote system software and eventually it entered widespread use for applications programming. The C language is an interesting hybrid language that provides high-level commands but also allows a programmer to deal directly with the basic functions of the computer in a way similar to an assembly language.

The original C language was extended in the early 1980s to handle objects. This object-oriented version is called C++. The latest versions of C++ by Microsoft and Borland have incorporated further enhancements to produce visual programming environments for the development of programs with graphical user interfaces.

Xerox PARC 1974

In the 1960s, Xerox established the Palo Alto Research Center, known as PARC. By 1974, engineers at PARC had created the Alto, an advanced personal computer featuring high-resolution graphics, a graphical user interface, a mouse, disk drives, an Ethernet network connection, and software. The Alto was dramatically more powerful than the Altair and the other early microcomputers. The Alto was installed in a number of government offices such as the White House, the Executive Office Building, and the Senate. The Alto was never released as a commercial product and was far too expensive to be purchased for individual use, but it can be considered the first personal computer.

Xerox did eventually release the Xerox Star, a sophisticated computer utilizing much of the Alto technology. But neither the Star, priced at $16,595, nor the later Xerox 820, a less-expensive microcomputer based on the Z80 processor, failed to achieve market success.

Although the Alto was not brought to market, it did have a significant effect on the computer industry. In 1979, Steve Jobs from Apple Computer visited PARC and observed the high-resolution graphics, graphical user interface, and mouse that were later incorporated in the Apple Lisa and Macintosh computers.

MITS Altair: The First Microcomputer 1975

In 1975, Ed Roberts and the MITS (Micro Instrument and Telemetry Systems) company announced the Altair, the first commercial microcomputer. The Altair was based on the Intel 8080 processor and sold for $650 fully assembled or $395 for a kit.

The Altair was definitely a computer for the hobbyist. It came unassembled in a box containing a processor and 256 bytes of memory--not 256K, just 256 *bytes*. It had no keyboard, no monitor, and no permanent storage device. To program the computer, it was necessary to flip individual switches on the front of the computer. Output consisted of flashing lights, and the only programming language that could be used with the Altair was 8080 machine language.

Arrangements had been made to feature the Altair on the cover of *Popular Electronics*. Unfortunately, the first and only working Altair was lost in shipment on the way to the magazine's editorial office. Since it was too late to back out, MITS assembled an empty box with some flashing lights and shipped it to *Popular Electronics*, where it was photographed for the cover of the January 1975 issue.

Microsoft 1975

In 1975, Bill Gates and Paul Allen developed the first version of microcomputer BASIC for the Altair. Gates, who later became one of the most influential people in the microcomputer industry, dropped out of Harvard University to work on the project.

The BASIC for the Altair was quite successful, earning Gates and Allan $200,000 in royalties. The two formed a corporation called Microsoft. The Altair BASIC was just a hint of the success that awaited them.

Microsoft created the operating system PC-DOS, or MS-DOS, which was sold with nearly every IBM-compatible computer between 1982 and 1994. Gates leveraged the earnings from DOS to build a software empire that now includes computer programming languages, applications software, and the Windows operating systems. "Billion Dollar Bill," as Gates is called by the computer industry press, has amassed a personal fortune as well as considerable influence in the microcomputer industry.

Electric Pencil: the First Microcomputer Word Processing Program 1976

In 1976, Michael Shrayer completed Electric Pencil, the first microcomputer word processing program. The first version of the Electric Pencil was written for the Altair, but eventually Shrayer wrote 78 versions of the program for different microcomputer systems. Electric Pencil was followed in 1979 by WordStar, the word processing program that dominated the microcomputer market until the release of the IBM PC. Many of the editing command keys used today are based on the WordStar, including CTRL-Y to delete a line, CTRL-T to delete a word, CTRL-S to move left, and CTRL-D to move right.

ARCNET Introduced 1977

In 1977, ARCNET, a network protocol, was introduced. Although ARCNET was not accepted as a network standard until 1992, it became reasonably popular due to its easy installation and low cost. The original ARCNET featured a 2 megabit per second transmission speed, although eventually a 20 megabit per second and a 100 megabit per second version were introduced.

TRS-80, Commodore PET, Apple: the First Popular Microcomputers

In 1977, Radio Shack entered the microcomputer market with the TRS-80. In the same year, Commodore released the Commodore PET.

Also in 1977, Steve Jobs and Steve Wozniak founded Apple Computer Corporation and released the Apple I, a kit containing a motherboard with 4K of RAM that sold for $666.66. The Apple I later became the basis for the extremely successful Apple II computer.

Apple II 1978

In 1978, Apple released the Apple II computer, a fully assembled computer featuring high-resolution color graphics, expansion slots, and a reasonably priced disk drive. The Apple II sold for $1,195 with a 1.07 Mhz 6502 processor, and 16K of RAM. You had to purchase an optional disk drive or cassette tape and a monitor in order to use the system, but the Apple II was an instant success. The floppy disk drive, developed in 1978, soon became the preferred storage device on the Apple II and most other popular microcomputers.

The Apple II was followed by the Apple III, a relatively unsuccessful computer intended to replace the Apple II line. The Apple II series remained the mainstay of Apple Computer until the release of the Macintosh in 1984.

Apple became the fastest growing company in U.S. American history. Annual sales rose from $775,000 in 1977 to $335 million in 1981. When Apple went public, Steve Job's shares were worth $165 million and Steve Wozniak's shares were worth $88 million.

VisiCalc: the First Electronic Spreadsheet Program 1978

In 1978, VisiCalc, the first electronic spreadsheet program, was created by Dan Bricklin and Bob Frankston. VisiCalc was initially available only for the Apple II. Thousands of business people and professionals purchased the Apple II computer because at the time the only way to use an electronic spreadsheet was to purchase VisiCalc and an Apple II. Therefore, VisiCalc was a major factor in the success of Apple Computer, Inc.

IBM PC 1981

In 1981, IBM began marketing what it called a "personal computer," or PC, based on the 8088 microprocessor. The IBM PC was not the most technologically advanced microcomputer, but it had a number of advantages, one of which was the backing and name recognition of IBM. The IBM PC quickly became the top selling microcomputer system, far surpassing IBM's expectations. Some 35,000 IBM PCs were sold in 1981 and about 800,000 were sold in 1983.

The IBM PC was designed so the processor could access 640K of RAM, which at that time was considered an extremely large amount of memory. This 640K limitation later became a major nuisance for designers and users of IBM-compatible computers as graphical user interfaces resulted in software that required many megabytes of memory.

The IBM PC was soon followed by the PC XT, which featured a 10 Megabyte hard disk drive, at that time considered a gigantic storage device. Hard disk drives soon became required equipment for most serious microcomputer users.

Within months of the release of the IBM PC, dozens of companies developed IBM-compatible computers that could run the same software and use the same expansion cards as the IBM PC. Many of the early companies eventually failed, but some became major forces in the IBM-compatible computer market, such as Compaq, which released the 28 pound Compaq portable computer in 1983. Microsoft licensed its MS-DOS operating system to virtually every manufacturer of IBM-compatible computers and soon became a major force in operating systems.

Osborne I 1981

In 1981, Adam Osborne and the Osborne Computer Corporation introduced the Osborne I, the first portable computer system. The Osborne I components were arranged in a suitcase size unit designed to be carried (with difficulty--it weighed almost 30 pounds). The computer had a miniature display screen, dual floppy disk drives, a Z80 processor, 64K of RAM, and the CP/M operating system. The Osborne I came complete with software, including a word processor, spreadsheet, BASIC, and an operating system. Retail value of the software alone was over $2,000, but you could buy the Osborne I with software for only $1795.00, making the Osborne I an almost irresistible deal. Despite its price, the Osborne, like other CP/M machines, was soon swamped by a tidal wave of IBM PCs and IBM PC compatible computers.

Apple Macintosh 1984

In 1979, Steve Jobs visited Xerox PARC (Palo Alto Research Center), the birthplace of many important microcomputer developments, including the mouse and the first graphical user interface. Although Xerox seemed unable to turn its inventions into marketable products, Jobs recognized their potential and incorporated many Xerox developments into later Apple computer models.

In 1983, Apple introduced the Lisa, the first commercial microcomputer with a graphical user interface featuring windows, menus, and icons. At $10,000 per workstation however, the Lisa proved too expensive for general acceptance.

Many of the design features from Lisa reappeared in the Apple Macintosh, released in 1984. The $2495 Macintosh featured a graphical user interface that made programs easier to use than those available on the character-based IBM PC. The first Mac proved a little under-powered for graphical applications with its 7.83 MHz 68000 processor, a single 400K 3.5" floppy disk drive, 64K of ROM, and 128K of RAM. Later versions of the Mac featured faster processors, hard disk storage, and increased RAM capacity.

The Mac became the computer of choice for graphical applications such as desktop publishing. In fact, it can be said that the Mac--in combination with the Apple Laserwriter printer, the low-cost AppleTalk network built in to every Mac, and Aldus PageMaker, the first desktop publishing program--created the desktop publishing market.

Like most microcomputers of that time, the original Macintosh could run only one program at a time. In 1987, Multifinder was introduced, an ingenious piece of software that allowed the Mac to run multiple programs at the same time, making the Macintosh the first popular computer with multi-tasking capability. Also in 1987, Hypercard, the first popular hypertext program, introduced the concept of hypertext links. The Macintosh line was continually expanded and upgraded, and the Macintosh computer continues to be the primary alternative to the IBM-compatible computers.

Lotus 1-2-3 1983

In 1983, the first version of Lotus 1-2-3 was released. Lotus 1-2-3 was an enhanced spreadsheet program that included graphics and data management features as well as the spreadsheet capabilities pioneered by VisiCalc. Lotus 1-2-3's enhanced features proved very popular, and 1-2-3 quickly became the dominant spreadsheet program for IBM-compatible computers.

Lotus 1-2-3 is often considered the first integrated software program because it combined features from spreadsheet programs, graphics programs, and database programs. Later, integrated software programs, such as Symphony, Frameworks, and Microsoft Works, incorporated a broader set of features.

IBM AT 1984

In 1984, IBM introduced the IBM AT, based on the Intel 80286 processor. The AT featured a 16-bit expansion bus which was backwardly compatible with the earlier 8-bit bus in the IBM PC. This bus eventually became known as the ISA, or Industry Standard Architecture bus, and was used in computer systems well into the 1990s.

Industry watchers predicted that 80286 computers would be used primarily for file servers or other heavy duty applications, because individual users didn't need that much power on their desk. However, individual users expressed their desire for speed by buying 80286 computers as soon as they could get them.

Token Ring Introduced 1985

IBM introduced its first network, the IBM PC network, in 1984. The IBM PC Network, which operated at 2 Megabits, never became very popular.

In 1985, IBM introduced the 4 Megabit per second Token Ring network, which was followed by a 16 Megabit per second version. Although Token Ring featured a somewhat higher transmission rate than Ethernet, it did not become as popular as Ethernet, due in large part to the high cost of Token Ring network interface cards.

Hypercard 1987

In 1987, Apple introduced a product called HyperCard, which was based on some of the earlier work on hypertext. HyperCard was a solution to a problem--the Macintosh computer was hard to program, so users were discouraged from building customized applications. The data stored in HyperCard appeared to the user as a card stack and could be manipulated using a natural-language programming script called HyperTalk. Combined with the Macintosh graphical user interface, HyperCard provided users with an easy-to-use and customizable environment and spawned hundreds of card stacks that are still used as teaching tools in schools and universities.

Microsoft Windows 1987

In 1985, Microsoft announced Windows 1.0, a multi-tasking, graphical user interface for the IBM PC and IBM-compatible computers. There were very few Windows applications, and they ran very slowly on the early PC and AT computers, so acceptance was limited. Microsoft continued to refine Windows and was finally successful with the release of Windows 3.0 in 1990.

In 1993, Microsoft released Windows NT, an advanced operating system capable of running programs designed for Window 3.1, DOS, and special Windows NT programs. Acceptance of Windows NT was slow due to the lack of software specifically written for NT and to the expensive hardware required for satisfactory performance.

In 1995, Microsoft released Windows 95, a 32-bit operating system designed to replace Windows 3.1 in the home and business market. Windows 95 features an improved user interface, a high level of compatibility with existing software and hardware, and improved support for multimedia hardware. Unlike Windows NT, Windows 95 was designed to perform reasonably well on existing computer systems without expensive hardware upgrades.

OS/2 1988

In 1988, IBM and Microsoft released OS/2, a sophisticated multi-tasking operating system with a graphical user interface. Acceptance of OS/2 was slow, due to the hardware requirements of the operating system and the lack of software specifically written for OS/2. Microsoft eventually abandoned OS/2 in favor of more sophisticated versions of Windows, but IBM continued development of OS/2 as an alternative to DOS and Windows.

BSOC: the First Optical Computer 1993

In 1993, Harry F. Jordan and Vincent P. Heuring of the University of Colorado demonstrated an optical computer system that stored and manipulated instructions and data as pulses of light. Although the BSOC (bit-serial optical computer) is a limited prototype, it represents a fundamental advance in computer systems. In the BSOC, data is not stored in relays, switches, or traditional RAM, but is constantly zooming around the fiber optic pathways of the BSOC. Since operation of the BSOC depends on the time it takes for light to travel from one processor to the next, reducing the size of the processor by half will double its speed. Plans are underway for an enhanced optical processor that will operate at 20 Gigahertz, or 20,000 Megahertz--200 times as fast as current microprocessors.

RISC processors 1994

During the early 1990s, RISC (Reduced Instruction Set Computing) processors emerged as alternatives to the more common CISC (Complex Instruction Set Computing) processors. RISC processors are optimized to perform a fairly small number of instructions at very high speeds, as opposed to CISC processors which can perform far more complex operations, but operate at a slower rate. Many industry analysts believe that the CISC architecture, as used in the Intel 80x86 and the Motorola 68000 series, may not be able to compete with future high speed RISC designs.

In 1992, DEC introduced the Alpha processor, a 64-bit RISC chip designed to be used in a series of Alpha systems ranging from personal computers to mainframes. Alpha processors were available at 133 Mhz, 150 Mhz, 200 Mhz, and 275 Mhz, making the Alpha processor the fastest single-chip microprocessor. Although the Alpha is not compatible with the Intel 80x86 processors and cannot run IBM-compatible or Windows software directly, DEC and Microsoft have created a version of Windows NT for the Alpha processor. With Windows NT, Alpha systems can run industry standard Windows and DOS programs, as well as software specifically written for the Alpha systems.

In 1994, Apple and IBM announced the PowerPC microcomputers based on the Motorola 64-bit RISC PowerPC microprocessor. PowerPCs are designed to run software specifically written for the PowerPC, and through emulation, can also run software designed for the Apple Macintosh and the IBM PC. Apple and IBM are both using the PowerPC processor in their new microcomputer systems.

The World Wide Web Enters the Mainstream 1995

By 1995, the World Wide Web had entered the mainstream of American culture. The Web quickly became the most popular service on the Internet, with millions of users and thousands of new home pages every month.

Today, there seems to be a Web page for everything, from the Roy Rogers and Dale Evans home page (*http://www.royrogers.com*) to Haitian art (*http://www.egallery.com/egallery/*) to the Federal Government (*http://www.fedworld.gov*) to Route 66 (*http://www.cs.kuleuven.ac.be/~swa/route66/main.html*). Web URLs (Uniform Resource Locators) used to locate information on the Web, now appear everywhere from business cards, to print ads, to television commercials.

Windows 95 1995

Microsoft released Windows 95 on August 24th, 1995. Intended as the primary replacement for the popular Windows 3.1, Windows 95 offered a mix of 16-bit and 32-bit operations. The 16-bit operations ensured a high degree of compatibility with existing DOS and Windows 3.1 applications, but made Windows 95 somewhat less robust than true 32-bit operating systems such as Windows NT.

In addition to increased 32-bit operations, Windows 95 added support for long filenames, a simplified user interface, integrated network support, and the ability to automatically add and configure new hardware.

The Pentium Pro Processor 1995

The Pentium Pro, also known as the P6, is the latest in the Intel line of microprocessors. While it can run 16-bit software such as DOS and Windows 3.1, the Pentium Pro is optimized specifically for use with 32-bit operating systems. When used with Windows 3.1, the Pentium Pro offers performance roughly equal to an equivalent Pentium processor. Running Windows 95, with a mix of 16-bit and 32-bit code, the Pentium Pro operates from 20 to 30 percent faster than an equivalent Pentium processor. When used with a true 32-bit operating system such as Windows NT, the Pentium Pro operates up to 50 percent faster than the equivalent Pentium.

Because of its higher cost and modest performance gains under the most popular operating systems, the Pentium Pro is typically used in file servers and high-end workstations running 32-bit operating systems.

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