5th Revision

A Brief History of Computing Technology

and Related Sciences

Dr.E
W

Main information sources:

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IEEE spectrum

WIKIPEDIA The Free Encyclopedia

COMPUTER HISTORY MUSEUM

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Introduction

This is the 5th revision of my presentation from August 2009.

Computing technology is a wide subject that relates to all forms of information: numeric, textual, pictorial, and acoustic – even haptic information. Not to speak of such related subjects as mathematics, communication, data security, privacy, intelligence and crime, etc.

Historic facts are influenced by political, national, economic, psychological, etc. factors. Finding an absolute “truth” is close to impossible, and this presentation is no exception.

I claim no rights to the material. I did it for fun and the information is mostly borrowed from Wikipedia and other Internet sources.

Espoo, on the day of Mayan apocalypse

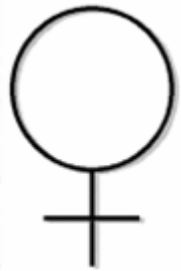
Johnny Heikell, www.heikell.fi

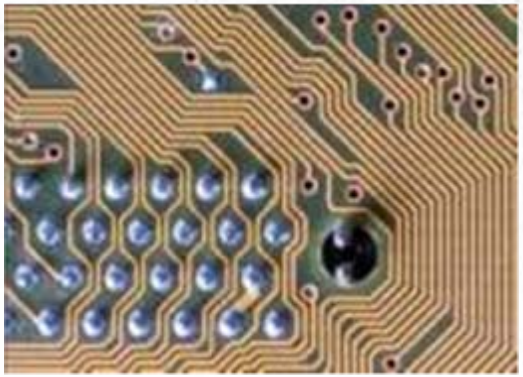
The Tally Stick

A tally (or tally stick) was an ancient memory aid device to record and document numbers, quantities, or even messages. Tally sticks first appear as notches carved on animal bones in the Upper Paleolithic. A notable example is the Ishango Bone (shown left), found in 1960 in the then Belgian Congo. It is believed to be over 20,000 years old. Older still – about 35,000 years – is the Lebombo bone from Swaziland. It has 29 cuts, believed to track the days of a lunar or menstrual cycle.

Image source: Wikipedia

Copper, Conductor of Choice





Copper has been known to man for some 10,000 years. The oldest copper objects (7th millennium BCE) are pearls, found at Ali Kosh in western Iran, and an awl and needles found at Canyönü-Tepesi in eastern Anatoly, Turkey. Copper is a good conductor and cheaper than silver, whose conductivity is better still. Except for specialized applications of novel materials – e.g. superconductors and nanotubes – copper will remain the conductor of choice for the foreseeable future.

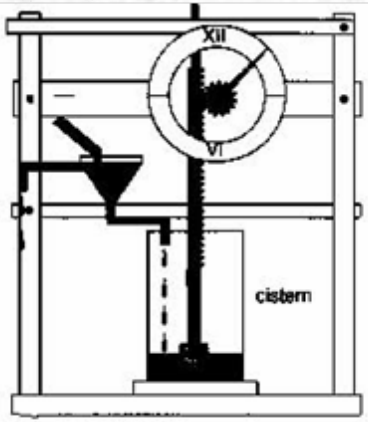
Image source: Wikipedia, Scientific American

Megalithic Structures

By the 5th millennium BCE the peoples in Nabta Playa, at the southwest corner of the western Egyptian desert, had fashioned one of the world's earliest known archeoastronomical devices (drawing). Research suggests that it may have been a prehistoric calendar that accurately marks the summer solstice. It was roughly contemporary to the Goseck circle in Germany and the Mnajdra megalithic temple complex in Malta, about 1000 years older than the comparable Stonehenge (photo).

Image source: Wikipedia

Measuring Time



There are unconfirmed claims that water clocks were used in China in 4000 BCE. The earliest confirmed time measuring devices – save for megalithic structures – are obelisks (left), which are known to have been used around 3500 BCE in Egyptian and Babylonian astronomy. Water clocks of various kinds (right) have been used since the Old Babylonian period (c. 2000 BCE – 1600 BCE). Not really clocks for computers, but good enough at the time.

Image source: Wikipedia

The Road to Latin Letters

Ελληνικό αλφάβητο

Predecessors of Sumerian cuneiform script (top) go back to the late 4th millennium BCE. They developed into the earliest cuneiforms around 3000 BCE. Cuneiform writing was gradually replaced by the Phoenician alphabet (middle) by 1050 BCE. From here rose the Greek alphabet (bottom), which has been in use since at least 730 BCE. And finally, the Latin/Roman alphabet – the most used alphabet in the world – developed from the Greek via an intermediary Etruscan form, but it was only after the Renaissance that it was fully developed.

Image source: Wikipedia

Warfare

Warfare has greatly contributed to the progress of computing technology; today we see the influence particularly in the development of cyber warfare. The earliest recorded instance in military history is a confrontation between Sumer (current Iraq) and Elam (current Iran), which occurred c. 2700 BCE near Basra. Iranians and Iraqis can therefore soon celebrate five millennia of mutual killings.

Image source: Unknown

The Cubit

The Cubit is the first known measure of length, used in the Egyptian Old Kingdom during construction of the Step Pyramid of Djoser around 2,600 BCE (top). The Sumerians also used the cubit at this time. It was most likely based on measuring one's forearm and remained in use to early modern times (15th to 18th centuries). The length varied throughout history. Best known is the Royal Cubit with a length of approx. 52.4 cm. The lower picture shows an Egyptian cubit.

Image source: Wikipedia

Imhotep, the First Engineer

Imhotep ("the one who comes in peace, is with peace") was an Egyptian polymath and engineer who lived around 2650-2600 BCE As one of the officials of Pharaoh Djoser, it was he who designed the Step Pyramid of Djoser (previous slide) at Saqqara in Egypt in 2630-2611 BCE. He may also have been behind the first use of columns in architecture.

Image source: Wikipedia

Hexadecimal Numbers

$$3BF0_{16} = 3x16^3 + 11x16^2 + 15x16^1 + 0x16^0 = 15{,}344_{10}$$

The hexadecimal numeral system (base-16 system) came into use in China under the Yellow Emperor (or Huangdi, pictured, ca. 2600 BCE). It was called the "market system" (市制) because it was used in markets. It remained in use in China until 1984. The term "hexadecimal" is believed to have been used for the first time in 1954.

Image source: Wikipedia

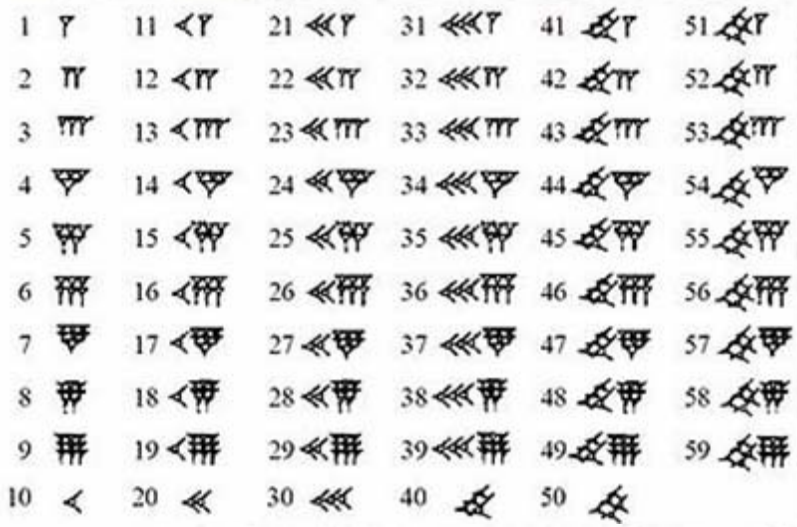
π, *the First Constant*

$$\pi = 4\sum_{k=0}^{\infty}\frac{(-1)^k}{2k+1} = \frac{4}{1} - \frac{4}{3} + \frac{4}{5} - \frac{4}{7} + \frac{4}{9} - \frac{4}{11} + \cdots$$

The Grate Pyramid in Giza was built in 2589-2566 BCE. Its perimeter is 1760 cubits and height 280 cubits, giving a ratio of 2π. This has been take as a proof that the Egyptians had knowledge of the most important mathematical constant already 45 centuries ago. The claim is not accepted by all scholars, but there are textual evidence that the ratio 256/81 ≈ 3.160 was known to the Egyptians around 1900 BCE.

Image source: Wikipedia

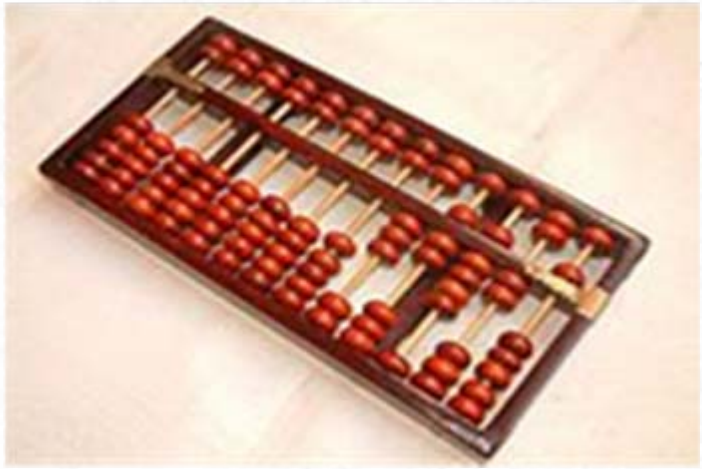
Sexagesimal Numbers



The sexagesimal numeral system (base-60 system) was invented by the Sumerians in the 3rd millennium BCE and later adopted by the Babylonians. A similar idea was incorporated in the sexagenry cycle of the Chinese calendar introduced in the second millennium BCE. We still retain the sexagesimal system in the 60-minute hour, 60-second minute, and the 360 degrees of the circle.

Image source: Wikipedia

The Abacus



Abacuses (plur. alt. Abaci) were in use centuries before the adoption of the written Hindu-Arabic numeral system and are still used by merchants, fishermen and clerks in some parts of the world. Its exact origins are unknown, but it is likely to have been invented by the Sumerians between 2700-2300 BCE.

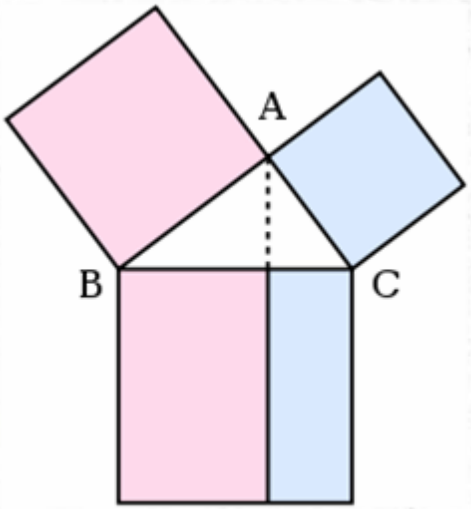
Image source: Wikipedia

Tackling Mathematical Problems

The earliest outlines of mathematical problems are given in the Akhim wooden tablets (or Cairo tablets) from around 1950 BCE. A set of algebraic and geometrical problems from Egypt are given in the Moscow Mathematical Papyrus, dating from about 1850 BCE. A fuller set of problems is presented in the Rhind papyrus from about 1650 BCE (portion shown), also from Egypt and on display at British Museum in London.

Image source: Wikipedia

Pythagorean Theorem



The Pythagorean Theorem is one of many instances in science when credit for a discovery or invention is given to the wrong person. The theorem, $a^2+b^2=c^2$, was one of the first mathematical problems that people attempted after basic arithmetic and geometry. It is discussed in the oldest writings on mathematics known to man, for instance by the Babylonians. A well known historic proof of the theorem is by Euclid (323–283 BCE) – a century before Pythagoras.

Image source: Wikipedia

Indian Mathematics

Indian mathematics emerged around 1200 BCE and remained influential until the 18th century CE The decimal number system in use today was first recorded by Indian mathematicians (save for earlier work by Archimedes). They made early contributions to the study of the concept of zero as a number, negative numbers, arithmetic, and algebra. Trigonometry was also advanced in India, and, in particular, the modern definitions of sine and cosine were developed there.

Image source: Wikipedia

Roman Numbers

I = 1
V = 5
X = 10
L = 50
C = 100
D = 500
M = 1000*

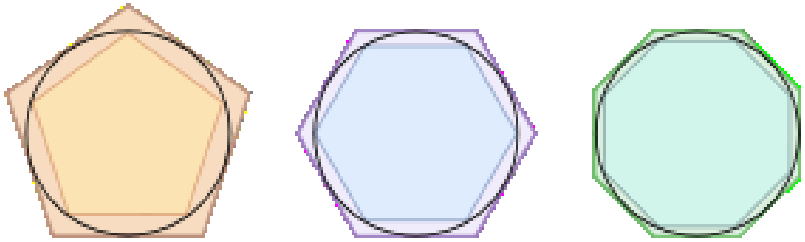
MCMXLVII = 1947

*) M was the highest number used in Roman numerals.

It is not known when Roman numerals developed, but they were preceded by similar Etruscan numerals that obviously developed from cutting tally sticks (e.g. the cutting for 12 made as IIIIVIIIIXII*). Roman numerals remained in use until the 14th century CE in Europe, when they were succeeded by Hindu-Arab numerals – a revolution started by Fibonacci (see later slide). Roman numerals can still be seen on official buildings where they mark the year of construction.*

Image source: Dr.EW

Precursor to Calculus



Was calculus invented by Newton or Leibnitz? The question has been disputed since the 18th century. However, the precursor to calculus was the method of exhaustion, the idea of which originated in the late 5th century BCE with the Greek Antiphon. The theory was later made rigorous by Eudoxus of Cnidus. (410 or 408 – 355 or 347 BCE). Later still it was used by Archimedes to calculate the area of a circle (picture) and to conclude that the area is proportional to the square of the radius.

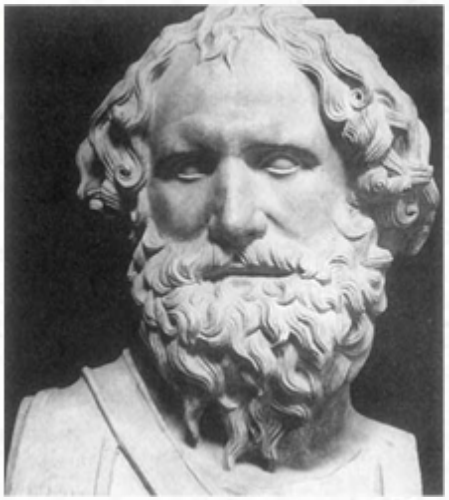
Image source: Wikipedia

Euclidian Geometry

Greek philosopher Euclide of Alexandria wrote around 300 BCE his supreme "The Elements." Little is known about Euclide, but The Elements is regarded as the most influential textbook ever written and a masterpiece in the application of logic to mathematics. The oldest surviving evidence of The Elements is a papyrus fragment (shown) found at Oxyrhynchus, Egypt, dated to around 100 CE. Euclidian geometry is the foundation on which today's computer aided design (CAD) programs rest.

Image source: Wikipedia

Archimedes & the Decimal System

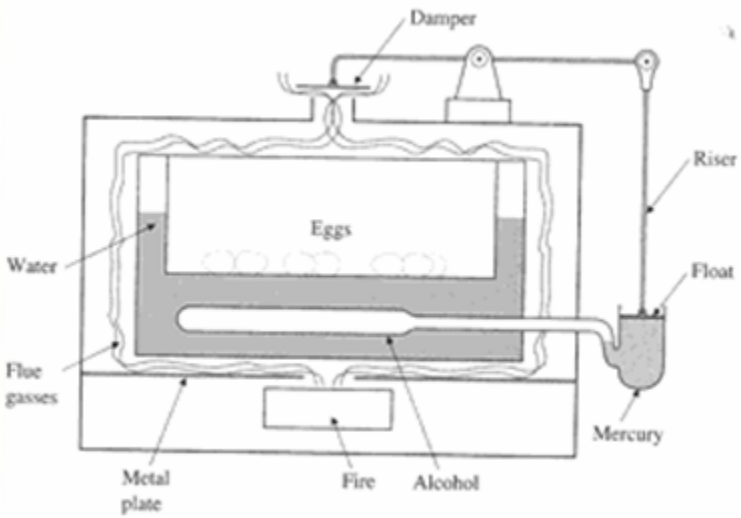


$$3095 = 3 \cdot 10^3 + 0 \cdot 10^2 + 9 \cdot 10^1 + 5 \cdot 10^0$$

The decimal system is perhaps 5,000 years old and was used by many cultures: by the Chinese, Egyptians, Minoans, etc. However, these were all non-positional decimal systems that required a large number of symbols. Archimedes (ca. 287-212 BCE, pictured) invented the simpler positional decimal system, but he did not grasp the importance of his discovery and the positional system came into use only through later work by Indian and Arab scholars (see earlier slide on Indian Mathematics).

Image source: Wikipedia

Feedback Control

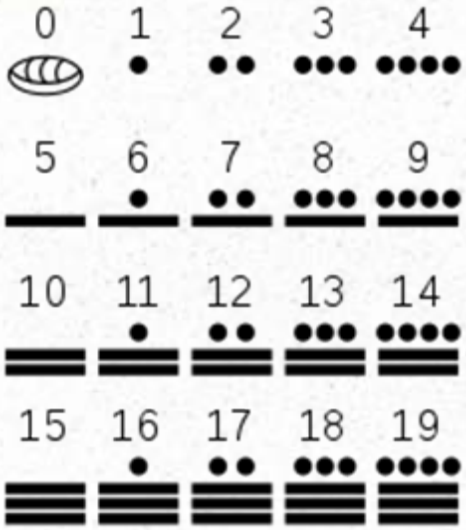


*) Literature gives different accounts on what (metal furnace or incubator) and when (1609-24) Drebbel invented

Feedback control originated in float valve regulators developed by the Greeks. They were used to control water clocks, oil lamps, water level in tanks, etc. The precise construction is not known since existing descriptions are vague and lack illustrations. The best known names in this field are Ktesibios and Philon (3rd century BCE) and Heron (1st century CE). The first European feedback control system after the Middle Ages was a temperature regulator for a chicken incubator that Cornelis Drebbel invented in around 1620 (pictured).*

Image source: Unknown

Vigesimal Numbers



The vigesimal numeral system (base-20 system) was independently invented around the world. The Mayan culture, for instance, used it with separate signs for 0, 1, and 5 (picture); the concept of zero was invented by them by 36 BCE. The vigesimal system can still today be found in linguistic numeral expressions, e.g. in the Danish "fem og halvfems" (95) *and its French counterpart "quatr-vingt-quinze."*

Image source: Wikipedia

Binary Numbers

पिङ्गल

Binary numbers, the mathematical cornerstone of modern computers, were first discussed by Indian writer Pingala, possibly in the 4th century BCE (some sources mention c. 200 BCE). In 1605 English statesman-philosopher Francis Bacon (picture left) discussed a system by which letters of the alphabet could be reduced to sequences of binary digits. The modern binary number system was fully documented in an article by German polymath Gottfried Leibniz (picture right) in the 17th century.

Image source: Wikipedia

The Differential Gear

The Chinese Book of Song (宋書), covering history in the 5th century BCE, asserts that the South Pointing Chariot (shown) used a differential gear. According to legend it was invented around 2000 BC, but the first reliable accounts are from the 3rd century CE. The differential gear would be used in all later mechanical computers, including the Antikythera mechanism from the 2nd century BCE (see below).

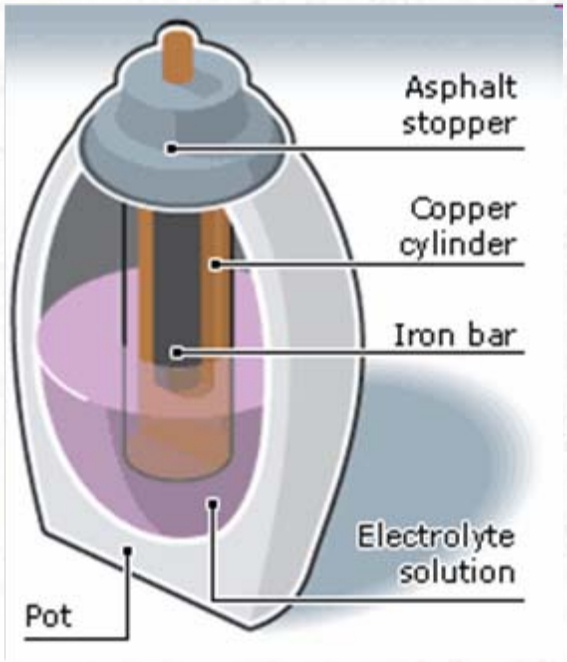
Image source: Wikipedia

The Astrolabe

An Astrolabe is a historical astronomical instrument used by classical astronomers, navigators, and astrologers. Its many uses include locating and predicting the positions of the Sun, Moon, planets, and stars; determining local time (given local latitude) and vice-versa; surveying; and triangulation. An early astrolabe was invented in the Hellenistic world by around 200 BCE and is often attributed to the astronomer Hipparchus (pictured).

Image source: Wikipedia

Baghdad Batteries



Around 1936, archaeologists uncovered near Baghdad a set of terracotta jars from around 200 BCE which each contained a rolled-up sheet of copper which housed an iron rod. Some assumed these to be ancient galvanic cells, and dubbed them the "Baghdad Batteries." A common food acid, such as lemon juice or vinegar, may have served as an electrolyte. If correct, the artifacts would predate Alessandro Volta's 1796 invention of the electrochemical cell by more than a millennium.

Image source: BBC

Antikythera Mechanism

The Antikythera mechanism (IPA: [□æntɪkɪˈ θɪərə], an-ti-ki-theer-uh), was an ancient mechanical calculator (also described as the first known mechanical computer) designed to calculate astronomical positions. It was discovered in the Antikythera wreck off the Greek island of Antikythera, between Kythera and Crete, in 1901. Subsequent investigation, particularly in 2006, dated it to about 150–100 BCE.

Image source: Wikipedia

A Not-so-Accurate Prediction

"I will ignore all ideas for new works and engines of war, the invention of which has reached its limits and for whose improvement I see no further hope."

Julius Frontinus, Chief Military Engineer to the Emperor Vespasian.
c. 70 CE

Birth of Cryptanalysis

Arab polymath al-Kindi (c. CE 801-873), known as "the Philosopher of the Arabs," described a method for solving monoalphabetic substitution ciphers by frequency analysis. It is based on the fact that in texts, letters occur with frequencies that are characteristic for the language in case. In English the letter e can constitute 12-13% of a newspaper text, while the frequency for q is only 0.1%. In Arabic, the letters a and l are most frequent, partly due to the definite article al-. Cryptanalysis of today rests solidly on mathematics and computer technology.

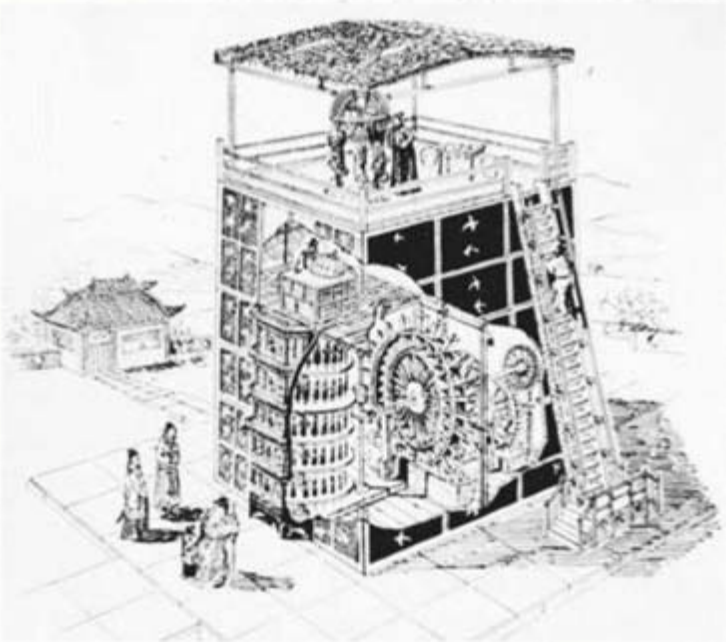
Image source: Wikipedia

The Name Bluetooth

Harald “Bluetooth” Gormsson was a Danish king who lived around 950 CE. He united dissonant Danish tribes and is believed to have been the first Viking king who converted to Christianity. His nickname was suggested for the present-day Bluetooth wireless standard by Jim Kardach, who at the time of his involvement in a related program was reading Frans Bengtsson’s book “The Long Ship.” The implication is that the Bluetooth standard unites different communication protocols.

Image source: Wikipedia

Su Sung's Astronomical Clock



Built in 1090 by Su Sung, Chinese diplomat and civil servant of the Song Dynasty, the water-powered clock was an impressive feat of mechanical engineering and the most complex piece of clockwork to that point in history. The machine was controlled by complicated gearing and counted out the hours and turned a bronze armillary sphere and a celestial globe in synchrony with the heavens. It fell into disrepair around 1200 for want of skilled mechanics, at the time when Chinese expertise in mechanical horology began to decline.

Image source: Unknown

Fibonacci & Decimal Numerals

0, 1, 1, 2, 3, 5, 8, 13, 21,…..

Italian mathematician Fibonacci (born Leonardo Bonacci but known under several names) was born in Pisa c.1170. Fibonacci received education in Northern Africa by Arab scholars and is the first Postclassical era European mathematician of note. It was through the influence of his book Liber Abaci (published in 1202) that Europe switched from Roman to Hindu-Arabic numerals. The Fibonacci sequence, $f_{k+2} = f_{k+1} + f_k$, was invented by Indian mathematicians centuries earlier and used as an example in Liber Abaci.

Image source: Wikipedia

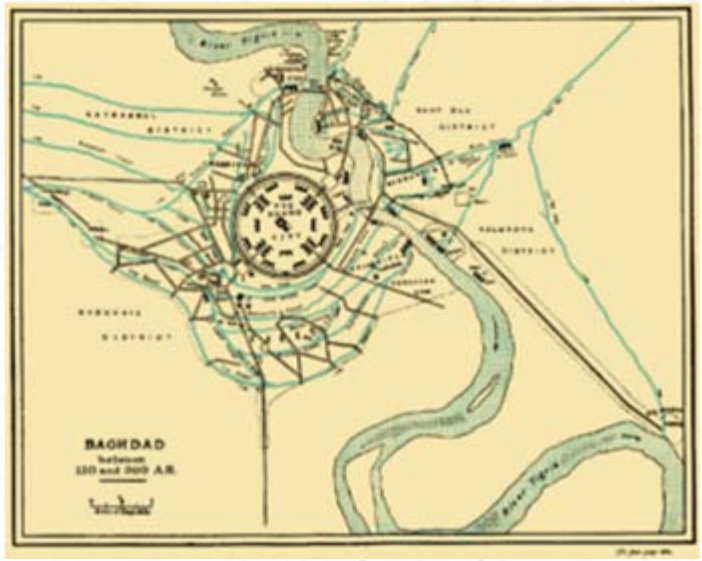
Al-Jazari's "Castle Clock"

The water clock, published by Arab polymath Ibn al-Razzaz al-Jazari in 1206, is considered as the first programmable analog device. The length of day and night could be reprogrammed to account for their changing length throughout the year.

Analog electronic computers were a research subject before digital computers took over in the 1950s. The most famous analog computer, the Norden bombsight, was an optical/ mechanical device that served from World War II to the Vietnam War.

Image source: Wikipedia

The End of a Scientific Era



Europe was a scientific void in the Middle Ages (from 500/800 CE to about 1500 CE) – only biblical truths as interpreted by the Pope mattered. At the same time Arab science flourished, with Baghdad (map) being the main center of progress. That ended in 1258 when the Mongols invaded Baghdad and slaughtered its population. Arab science began to decline, but remained superior to European science until the Renaissance (beginning in Italy in the 14th century and spreading across Europe over the next two centuries).

Image source: Wikipedia

The Logarithm

Scottish mathematician John Napier, 8th Laird of of Merchistoun, published his major work "Mirifici Logarithmorum Canonis Descriptio" in 1614. In it he explained and presented tables for the natural logarithm. He derived the word from Greek λόγος (logos) meaning proportion, and ἀριθμός (arithmos) meaning number. His discovery was to have a profound impact on all areas of computing. One of the first practical results was the development of the slide rule.

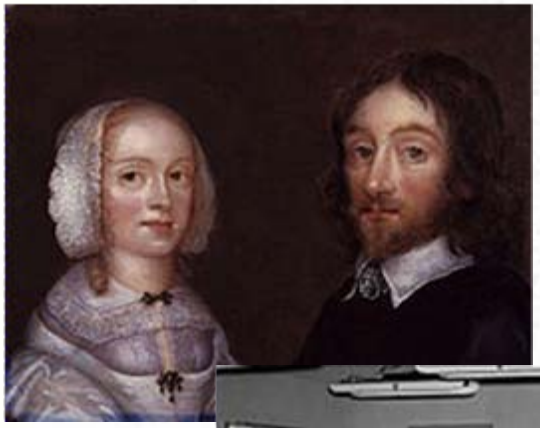
Image source: Wikipedia

Pascal's Mechanical Calculator

In 1642 the French mathematician, physicist, and religious philosopher Blaise Pascal was not yet 19 years old. In an effort to ease his father's endless, exhausting calculations, and recalculations, of taxes owed and paid, Pascal constructed a mechanical calculator capable of addition and subtraction. The device became known as Pascal's calculator or the Pascaline. Due to its high price the Pascaline became little more than a toy, and status symbol, for the very rich both in France and throughout Europe.

Image source: Wikipedia & Musée des Arts et Métiers

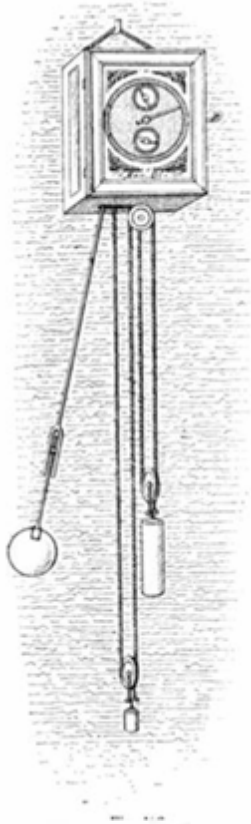
The Word "Computer"



The word "computer" is said to have been coined in 1646 by English author Sir Thomas Browne (pictured with his wife Dorothea). By computer, Browne meant "someone who performs the calculations needed to draw up a calendar." The term was used into the 1930s for a person with mathematical training who was employed by an engineering firm or observatory to perform calculations with the aid of tables. The bottom picture shows human computers in 1949.

Image source: Wikipedia

The Pendulum Clock



The pendulum clock was patented by Dutch scientist Christiaan Huygens in 1657. It is a resonant device with the pendulum swinging back and forth in a precise time interval dependent on its length, while it resists swinging at other rates. It was a breakthrough in timekeeping and remained the standard for timekeeping until the invention of the quartz clock in 1927.

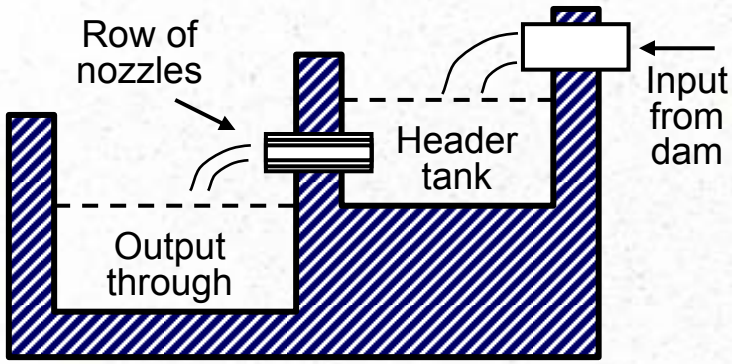
Image source: Wikipedia

The Slide Rule

Slide rules were developed in the 17th century by William Oughtred and others, based on the work on logarithms by John Napier. Oughtred's slide rule was circular, in 1850 Amedee Mannheim invented the linear slide rule that became familiar to generations of engineers. The slide rule disappeared quickly after the introduction of the HP-35 pocket calculator in 1972. HP-35 sold for $395 in 1972, equivalent of $1,700 in 2005. Five years later every college student could afford one.

Image source: Wikipedia

Earliest Data Conversion



Physical processes in the analog world must be converted before they can be computed digitally. The history of conversion goes back at least to the 17th century, and to Turkey under the Ottoman Empire. Systems for metering water from dams were built using manually controlled, binary-weighted nozzles to regulate the output flow. For instance, Sinan's system in 19th century Istanbul had eight binary-weighted nozzles, making it a hydraulic, 8-bit ADC with manual input and wet output.

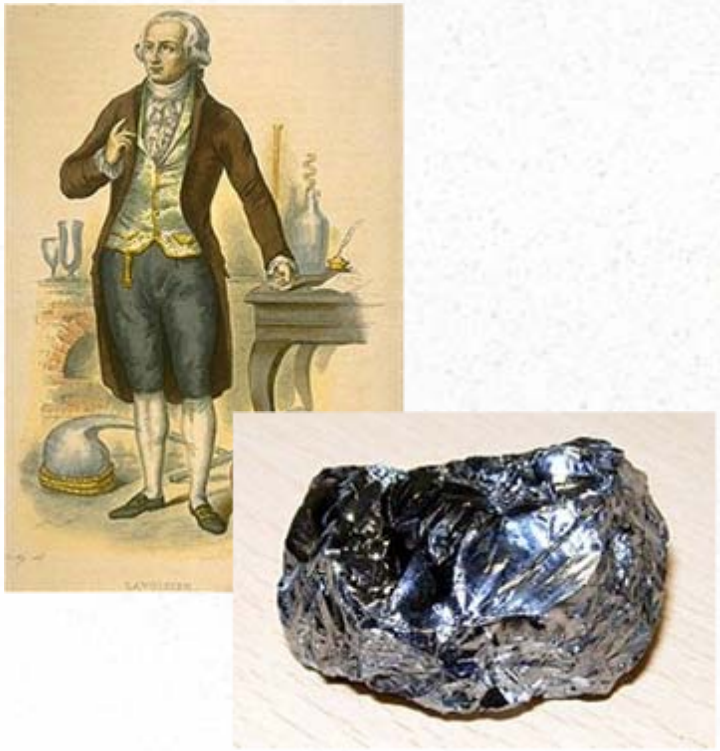
Image source: DrEW based on W. Kester

Octal Numbers

The octal numeral system (base-8 system) has been used by some native American tribes who counted not fingers, but the spaces between fingers. The octal system was first suggested in Europe around 1700 by Swedish religious mystic Emmanuel Swedenborg (pictured). The term "octal" was coined in 1801 by James Anderson. The octal system was common in computers of the 1960s, most notably the PDP-8, ICL 1900, and IBM mainframes. It lost out to the more practical hexadecimal system.

Image source: Wikipedia

Silicon



Silicon, the backbone element of electronics, was identified by French scientist Antoine Lavoisier (pictured) in 1787. Silicon in its crystalline form, however, was not prepared for another 31 years, then by another Frenchman, Henri Sainte-Claire Deville. It is on monocrystalline silicon substrates that most present-day integrated circuits are built.

Image source: Wikipedia

Volta's Battery

Italian physicist Alessandro Antonio Volta invented the battery in 1796. It is credited as the first electrochemical cell—save for the possibility that the "Baghdad Batteries" (see earlier slide) really are what they are assumed to be. Today, over two centuries later, battery technology is far from perfected. But where would our laptops, tablets and other portable electronic devices be without them?

Image source: Unknown

Time and Frequency Domains

$$F(s) = \mathcal{L}\{f(t)\} = \int_0^{\infty} e^{-st} f(t)\,dt.$$

$$S(f) = \int_{-\infty}^{\infty} s(t) \cdot e^{-i2\pi ft} dt.$$

Where would communications theory – and the whole IT sector – be without the ability to switch between time and frequency domain analysis? The tools we mostly use are Laplace and Fourier transforms (top and bottom respectively). Although they are named after French 18-century mathematicians P.-S. de Laplace and J. Fourier, the two played only a partial role in the development of these particular integral transforms.

Image source: Wikipedia

The Arithmometer

The Arithmometer, the first successful mechanical calculator, was patented in France by Tomas de Colmar in 1820 (some sources say 1815). It could not only add and subtract, but also perform long multiplication and division by using a movable accumulator for the result. However, it took until 1851 before all problems had been solved and production could commence. It was the only type of mechanical calculator in production until 1887, sold all over the world, and stayed in production until 1915.

Image source: Wikipedia

Babbage's Difference Engine

Starting in 1820, Charles Babbage built a mechanical calculator, called a difference engine, which was capable of holding and manipulating seven numbers of 31 decimal digits each. Babbage produced two designs for the difference engine and a further design for a more advanced mechanical programmable computer called an analytical engine. It had all the features of modern computers, except for ability to manipulate memory addresses. None of the designs were completed by Babbage.

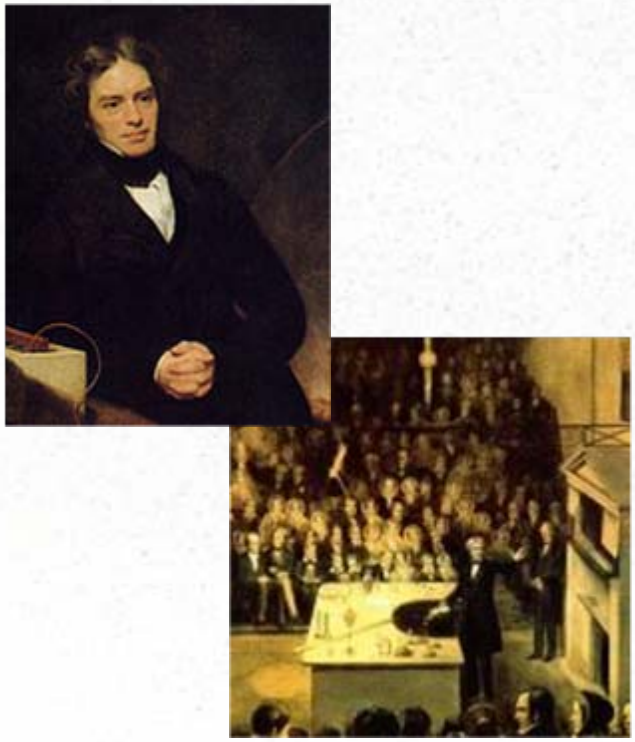
Image source: Wikipedia & Science Museum, London

Ohm's Law

German physicist and high-school teacher Georg Simon Ohm published in 1827 a book with the title "Die galvanische Kette, mathematisch bearbeitet." In it he outlines what we now know as Ohm's Law, $U = I \cdot R$. Despite its simplicity, it is a useful model in most practical problems in electrical engineering. The majority of electrical engineers never master the mathematically sophisticated Maxwell Equations.

Image source: Wikipedia

Prelude to Semiconductors I



While investigating the effect of temperature on "sulphurette of silver" (silver sulfide) in 1833, Michael Faraday found that electrical conductivity increased with increasing temperature. This effect, typical of semiconductors, is the opposite of that measured in metals such as copper, where conductivity decreases as temperature is increased. Pictures: Michael Faraday and delivering a Christmas Lecture in 1856.

Image source: Wikipedia & Computer History Museum

Lady Ada Lovelace

The daughter of poet Lord Byron, Lady Ada Lovelace (1815–52), acquired mathematical training usually denied to her gender. When she met Charles Babbage and learned about his computer design, she translated his work and wrote the world's first computer programs. A century later she would be honored by having the Ada programming language named after her.

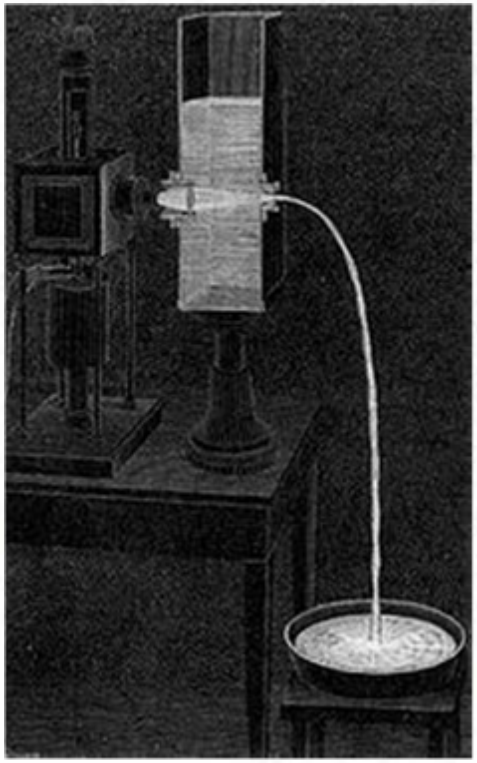
Image source: Wikipedia

Wire Communication

A prerequisite for distributed computing—and the Internet—is electromagnetic communication channels. Work on various aspects of electrical telegraphy was carried out by many inventors and scientists in the early 19th century. In 1832 Baron Pavel Schilling (image) set up an operational telegraph in his apartment in St Petersburg, Russia. The first commercial telegraph system was in use by the Great Western Railway in England in 1839.

Stamp image source: Wikipedia

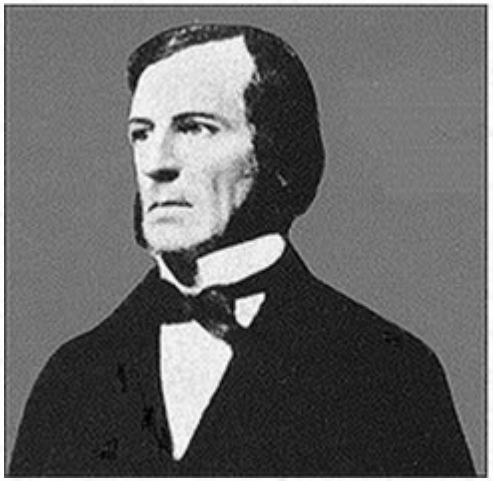
Guiding Light



The principle of guiding light through optical refraction was first demonstrated by Daniel Colladon and Jacques Babinet in Paris in the early 1840s. It is the principle behind fiber optics and fiber optic communications. The illustration shows a "light fountain," light in a parabolic liquid stream, from an article by Colladon in 1884.

Image source: Wikipedia

Boolean Logic



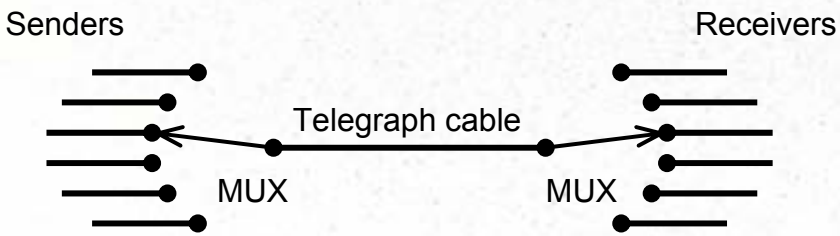
Boolean logic (or Boolean algebra), the basis of modern computer logic, was invented by English philosopher-mathematician George Boole in the 1840s. To engineers, the fundamental Boolean operations are

$A \cdot B$ = AND (A AND B)
$A + B$ = OR (A OR B)
$A \oplus B$ = XOR (EXCLUSIVE A OR B)
$\overline{A}$ = NOT (NOT A)

Despite the solid logic behind it, the Boolean equation 1 + 1 = 1 continues to confuse rookies.

Image source: Wikipedia

Time Division Multiplexing



TDM – "Shut up and let me talk!" – is one method used in modern digital communication to increase the efficiency of communication channels. TDM was employed already in the 1850s by American inventor and telegraph company supervisor Moses G. Farmer (top). The idea was to interlace samples from different telegraphy sources – allocate them time slots – and convey them over a single telegraph cable (bottom). As far as is known, Farmer used a basic duplex system.

Image source: Unknown

Weather Forecasting

The first weather forecast was published in The Times on August 1, 1861. Its originator was admiral Robert FitzRoy (pictured), better know as captain of the Beagle on which Charles Darwin made his famous voyage. In 1904, Norwegian scientist Vilhelm Bjerknes argued that it should be possible to forecast weather from calculations based upon natural laws. Today such calculations are performed by supercomputers. They provide simulated predictions that must be interpreted by trained meteorologists.

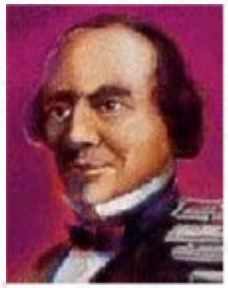
Image source: Wikipedia

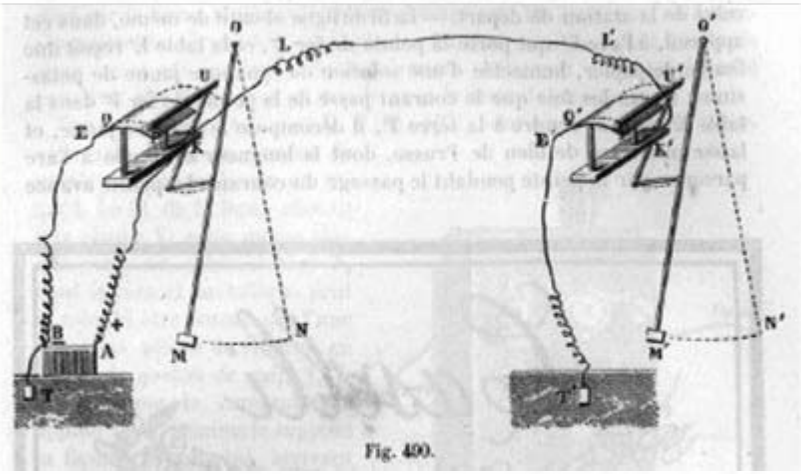
Transatlantic Telegraph Cable

In 1858, US President Buchanan and Queen Victoria were able to exchange telegraph messages of congratulation over the newly laid transatlantic cable. It run from Ireland to Newfoundland (top), but signal quality deteriorated quickly and the cable was destroyed the following month due to testing with excessive voltage. A lasting cable was laid in 1866 by the famous SS Great Eastern (bottom). Undersea cables are still the backbone of transatlantic Internet traffic.

Image sources: Wikipedia

The Pantelegraph





Italian physicist-inventor Giovanni Caselli demonstrated in 1860 his Pantelegraph, the first practical facsimile machine, on a telegraph line between Paris and Amiens. Earlier patents on methods for transmitting still pictures had been granted to Scottish physicist Alexander Bain in 1843 and English physicist Frederic Bakewell in 1848, but their inventions were not practical. The inventions used line-by-line scanning, as computerized scanners still do.

Image sources: Unknown

Maxwell's Equations

*Scottish mathematician James Clarke Maxwell worked for a decade on the problem of how to state the relations between electric and magnetic phenomena in a mathematical way. In 1864 he was ready to publish his now famous set of equations:**

$$\nabla \cdot D = \rho \quad \text{(Gauss's law)}$$

$$\nabla \cdot B = 0 \quad \text{(Gauss's law for magnetism)}$$

$$\nabla \times E = \frac{\partial B}{\partial t} \quad \text{(Faraday's law)}$$

$$\nabla \times H = J + \frac{\partial D}{\partial t} \quad \text{(Ampère's law)}$$

*) Maxwell published eight equations. Heaviside grouped them into four in 1884

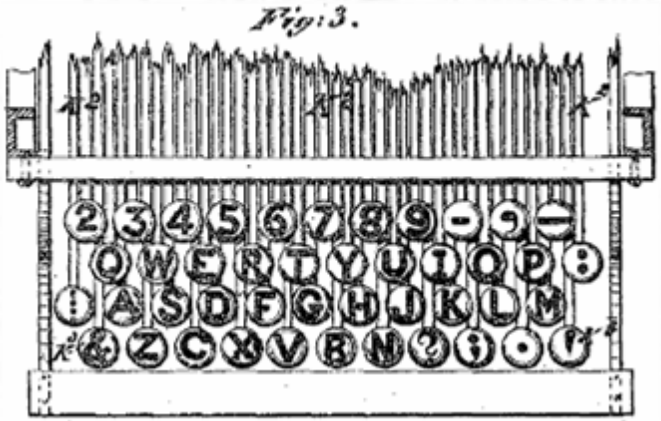
Image source: Wikipedia

The Birth of Spam

On a May evening in 1864, several British politicians were delivered a telegram – a most unusual occurrence at such a late hour – from a dentistry, advising that their dental practice would be open from 10am to 5pm until October. It was the first case of what today is called spam, bulk delivery of unsolicited electronic messages. Computer-age spam saw daylight in 1978 when Gary Thuerk of DEC sent an advertisement to 393 recipients on ARPANET. In neither case the recipients were amused by the spam, but it generated sales to the sender.

Image source: Unknown

The QWERTY Keyboard



The QWERTY keyboard that is still used in computers, is based on a layout (shown) that was developed for the Sholes and Glidden typewriter in 1873. It was sold the same year to E. Remington & Sons, an arms manufacturer seeking to diversify. The use and adoption of the QWERTY keyboard is often viewed as one of the most important case studies in open standards because of the widespread, collective adoption and use of the product, particularly in the United States.

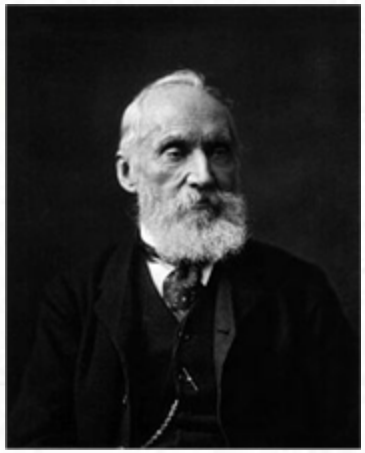
Image source: Wikipedia

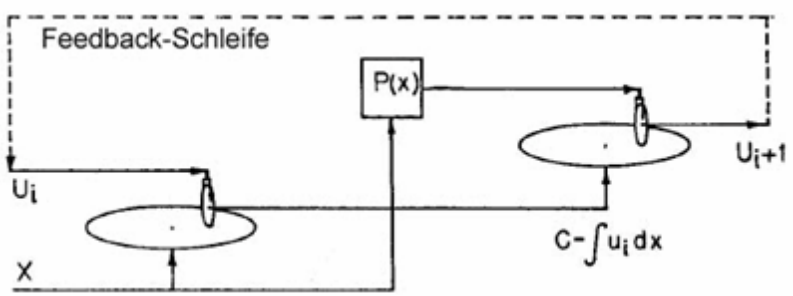
Prelude to Semiconductors II

In 1874 Ferdinand Braun, then a 24-year old graduate of the University of Berlin, probed a galena crystal (lead sulfide) with the point of a thin metal wire and noted that current flowed freely in one direction only. The invention found no useful application until the advent of radio, in which it was used to detect signals in crystal radios ("cat's-whisker" detector). For his invention Braun shared the 1909 Nobel Prize with Guglielmo Marconi.

Image source: Wikipedia

Feedback in Computing





Analog mechanisms for computing integrals and differential equations were a popular topic in the 19th century. Lord Kelvin (top) studied the subject in the 1870s and found that differential equations can in principle be solved using integrators with feedback loops (bottom). A practical calculator could not however be built at the time.

Incidentally, Lord Kelvin was also critical to the success of the earlier mentioned transatlantic cable projects.

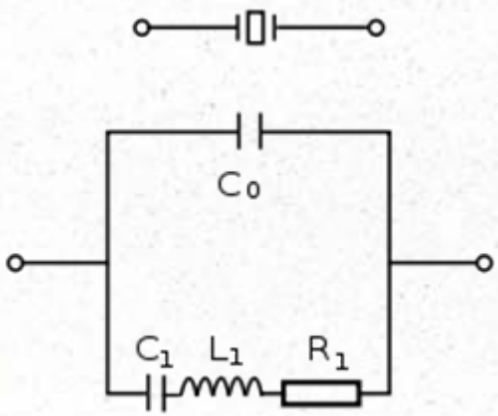
Image source: Wikipedia/Unknown

The Gray Code

Ordinary digital values have a weakness in that errors may occur when several bits change at once. The Gray code is an improved solution where only one bit changes at any time. It was invented by Elisha Gray in 1878 (pictured) and was originally called "reflected binary." The invention was forgotten until Frank Gray – unrelated to Elisha Gray but usually mentioned as the inventor – re-invented it some 60 years later.

Image source: Wikipedia

Piezoelectric Properties of Quartz



French physicist-brothers Jacques and Pierre Curie observed piezoelectric properties of quartz in 1880. It led to a crystal oscillator being built by Walter G. Cady in 1921 and to the first quartz crystal clock being built at Bell Telephone Laboratories in 1927 (the picture shows the schematic symbol and equivalent circuit of a crystal oscillator). Today crystal oscillators are timekeepers in computers, cell phones, and wrist watches alike.

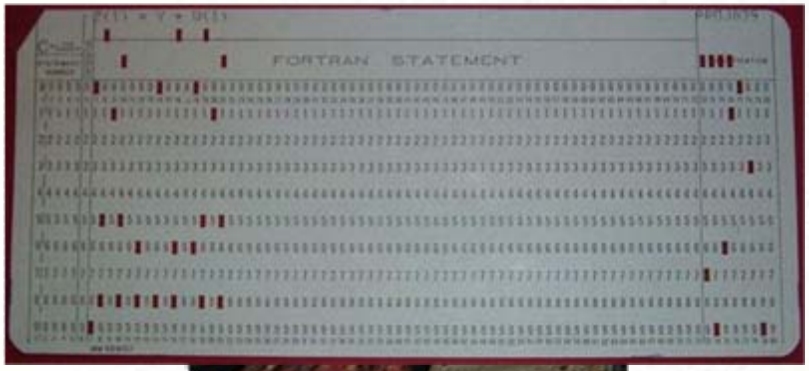
Image source: Wikipedia

The Automatic Tabulating Machine

Herman Hollerith developed the automatic tabulating machine in the 1880s. The machine was used by government agencies involved with vital statistics such as agricultural statistics, by insurance companies, and by other businesses. Hollerith later sold his patent to IBM, which for a long time would dominate the market for tabulators, calculators, and other office machines. The image shows an IBM advertisement from the 1930s.

Image source: IBM

Punched Cards

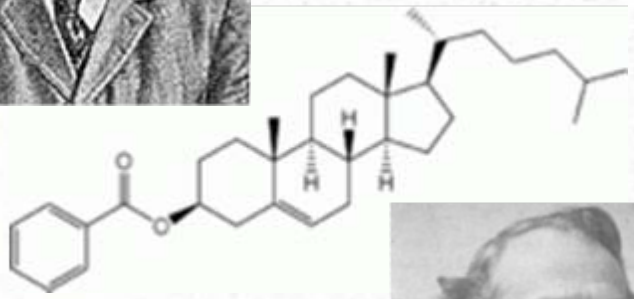


A part of Hollerith's invention was the punched card for storing data (top). It built on a French solution for controlling textile looms from around 1725 (bottom). Later generations—up to the 1980s—would become familiar with the punched card as a computer data storage/input medium that contained one row of Fortran code. The shown card represents the statement

$$Z(1) = Y + W(1)$$

Image source: Wikipedia

Liquid Crystals

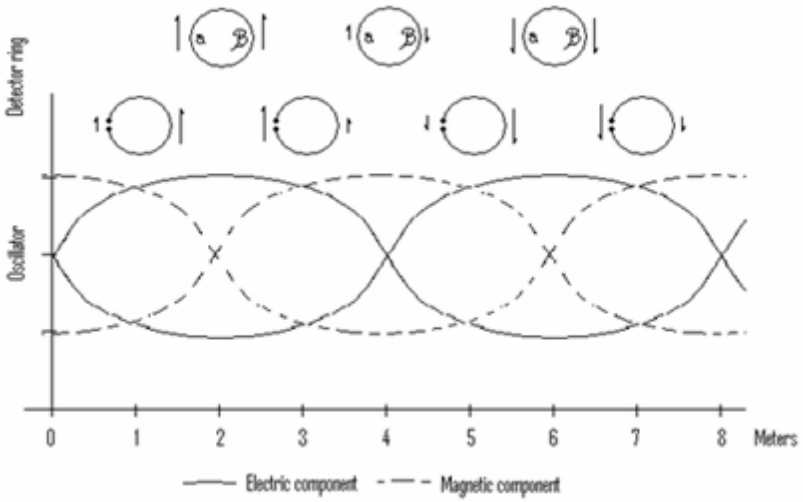


In 1888, Austrian botanical physiologist Friedrich Reinitzer (top) observed a reversible optical phenomenon in a derivative cholesteryl benzoate. German physicist Otto Lehmann (bottom) examined the cloudy fluid, and reported seeing crystallites. Substances of this type would later be named "liquid crystals" and can now be found in most flat-screen displays.

Image source: Wikipedia

Electromagnetic Radiation

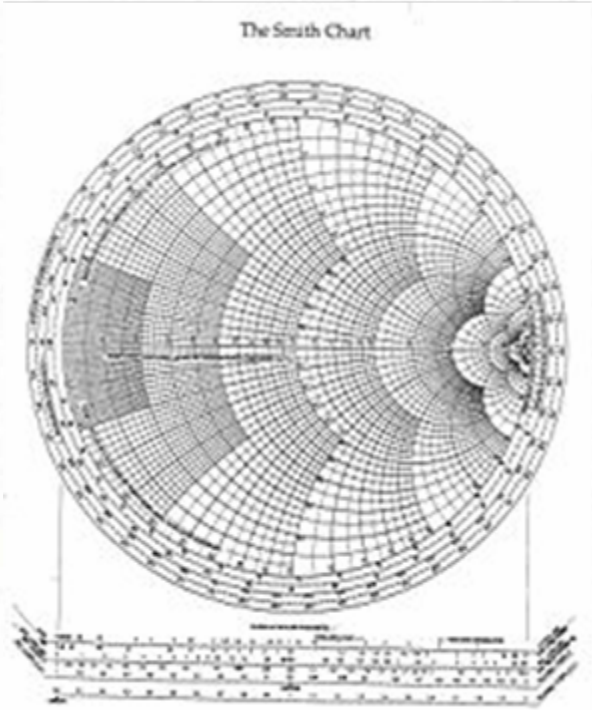
Transverse free space electromagnetic wave



31-year old German physicist Heinrich Hertz published in 1888 a paper with the title "Über Strahlen elektrischer Kraft." In essence, the experiments that Hertz had done confirmed earlier ideas by Faraday, as well as Maxwell's theoretical framework. Hertz's work was to have profound influence on future research in electromagnetics, and is the cornerstone on which radio engineering – and therefore wireless communication – rests.

Image source: Wikipedia

Nomograms



French mathematicians Massau and Ocagne invented nomograms in 1889. Nomograms, for instance the shown Smith Chart, are graphical calculating constructs that provide approximate results. Despite being handy, the use of nomograms has virtually come to a halt in the computer age.

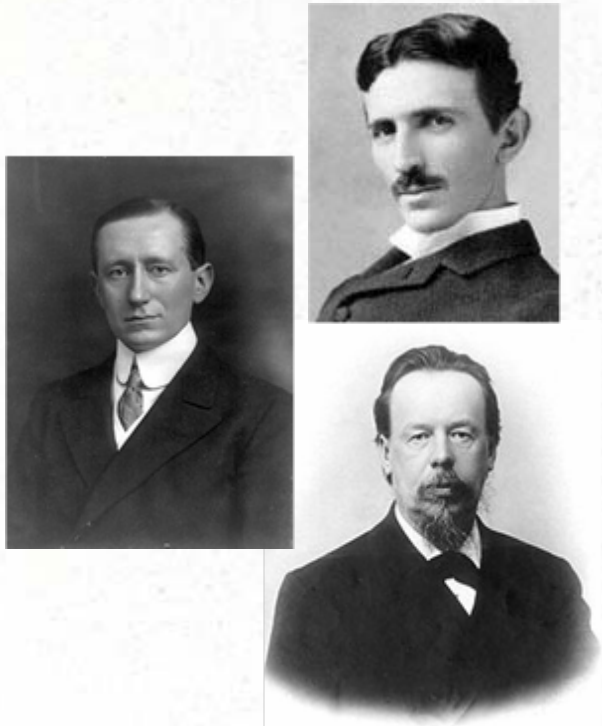
Image source: Wikipedia

Prelude to Semiconductors III

Indian polymath Sir J.C. Bose built a crystal detector – "cat's whisker" – around 1895, but did not patent it (G.W. Pickard received a US patent for it a decade later). It consisted of a pointed metal wire that touched a semiconducting crystal (e.g. pyrite FeS_2 or lead) to form a nonlinear element. It was the first form of semi-conductor diodes (save for Braun's invention two decades earlier). Sir Nevill Mott, Nobel Laureate in 1977, remarked that "J.C. Bose was at least 60 years ahead of his time" and "In fact, he … anticipated the existence of P-type and N-type semiconductors."

Image source: Wikipedia

1895, Year of the Radio

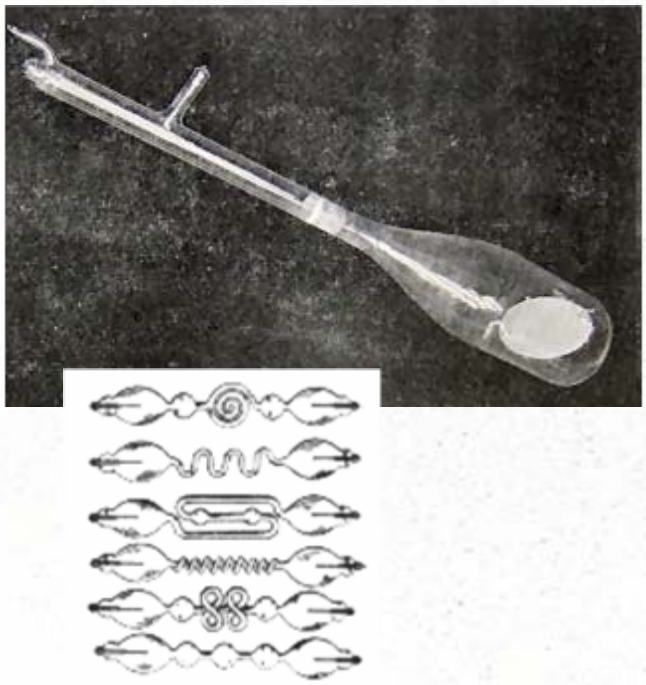


*) Popov is claimed to have done the same in 1894

Who invented the radio? Was it Nikolai Tesla (top), who carried out the first laboratory tests in 1894? Or should the honor go to one of the three men who in 1895 independently gave outdoor demonstrations of radio systems: Indian J.C. Bose (previous slide), Italian G. Marconi (middle), and Russian A.S. Popov (bottom)? Marconi is usually and unfairly given the credit – he was good at marketing himself – but the truth is that numerous individuals made the invention at the same time.*

Image source: Wikipedia

Braun's Cathode Ray Tube



Geissler Tubes. p. 897.

CRTs as we know them were developed by German physicist Karl Ferdinand Braun in 1897 (top). It is therefore also known as the "Braun tube" ("Braunsche Röhre" in German). A century later CRTs would form the bulk of computer display devices. The history, however, begins in 1857 when physicist and glassblower Heinrich Geissler built gas discharge tubes (bottom), and continues with cold cathode tubes by English physicist William Crookes and others around 1869-1875.

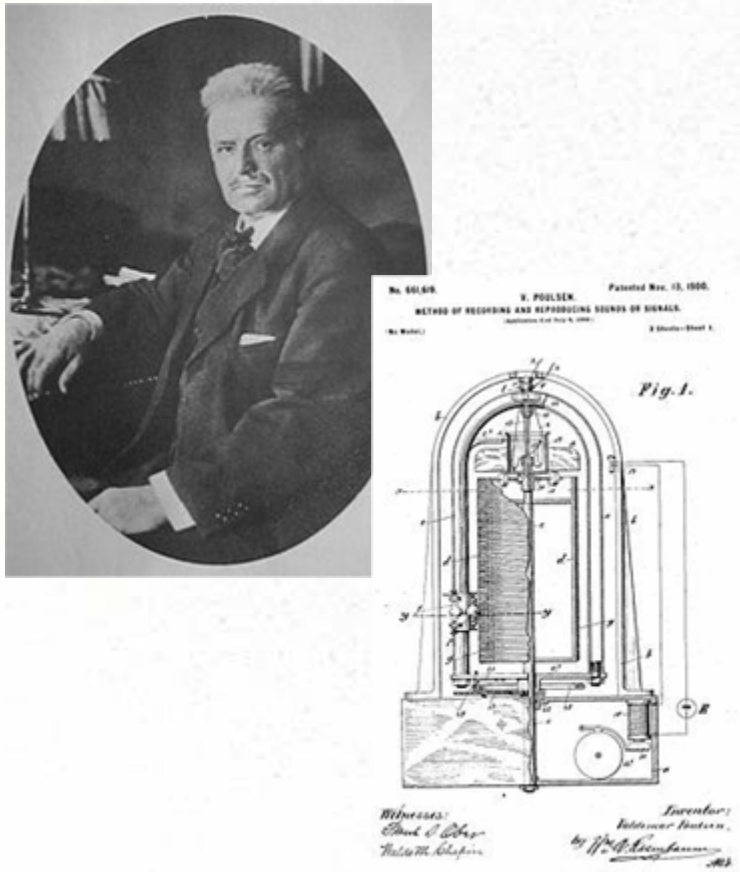
Image source: Wikipedia & The Cathode Ray Tube Site

Discovery of the Electron

The discovery of the electron was announced by British physicist J.J. Thomson in 1897. He had used three different experiments to reach his conclusions on the electron, one of which was based on Braun's cathode ray tube. Thomson was awarded the Nobel Prize in 1906. His son George Paget Thomson received the Nobel Prize in 1937 for proving wavelike properties of electrons.

Image source: Wikipedia

Birth of Magnetic Recording



Danish engineer Valdemar Poulsen (left) demonstrated in 1898 a magnetic wire recorder called "telegraphone," and for which he obtained a US patent in 1900 (right). Poulsen had the chance to record the voice of Austro-Hungarian Emperor Franz Joseph during the Paris World Fair in 1900; believed to be the oldest surviving voice recording. However, it was only with Fritz Pfleumer's invention of magnetic tape recording (see later slide) that recording became practical.

Image source: Wikipedia

The Ni-Cd Battery

The nickel-cadmium (Ni-Cd) battery, the dominating type of rechargeable batteries in mobile applications in the up to the 1990s, was invented in 1899 by Swedish engineer and inventor Waldemar Jungner. The lithium battery, which developed into the presently popular Li-Ion battery, was proposed in the 1970s by American chemist M.Stanley Whittingham while working for Exxon. A related discovery was made in the 1970s by J.O. Besenhard at TU Munich in Germany.

Image source: Wikipedia

A Not-so-Accurate Prediction

”Everything that can be invented has been invented.”

Charles H. Duell, Commissioner, U.S. Office of Patents, 1899

The Photon

$E = h \cdot v$

In 1900, German physicist Max Planck suggested that the energy in electromagnetic waves could only be released in "packets;" he called these quanta (sing. quantum). Five years later Albert Einstein extended the idea by suggesting that EM waves could only exist in these discrete wave-packets. The term photon was coined in 1926 by Gilbert Lewis. We rely on photons to convey data in both optical and radio communication. The picture shows Planck and Einstein in Berlin in 1929.

Image source: Wikipedia

Prelude to Hacking

In June 1903 Marconi wanted to demonstrate what he claimed to be secure radio transmissions in Morse. As it turned out, the demonstration was overshadowed by insulting messages on the receiving equipment minutes before the demonstration was due to start. The messages originated in strong radio pulses, beamed into the theater and interfering with the equipment. The culprit was Nevil Maskelyne (shown), a British music hall magician who for personal reasons wanted to humiliate Marconi.

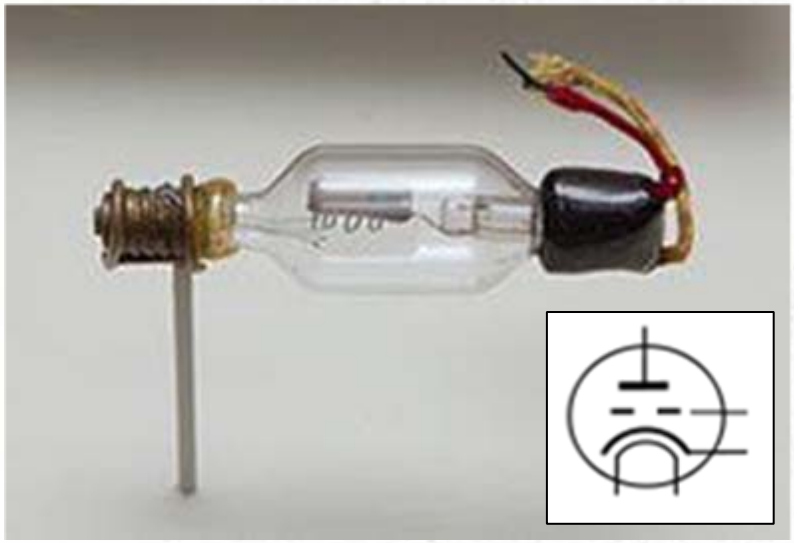
Image source: New Scientist

The Emergence of Electronics

In 1904 John Ambrose Fleming of University College London investigated the Edison effect, electrical conduction within a glass bulb from an incandescent filament to a metal plate, and used it to rectify high frequency oscillations and thus detect wireless signals. The same year Fleming patented the device, later known as the "Fleming valve." It was the first working vacuum diode.

Image source: IEEE

The Triode



*) It was independently developed by Austrian physicist Robert von Leiben

After reading Fleming's 1905 paper on his oscillation valve, American engineer Lee DeForest in 1906 created a three-element vacuum tube, the triode "Audion," by adding a modulation grid to the diode. It could act as an amplifier and oscillator as well as detector. However, it was not a true vacuum triode since it was not capable of linear amplification. It was a 2-element device with the signal applied to a wire wrapped around the glass envelope (the picture shows an improved version from 1908).*

Image source: Wikipedia

Mobile Communication

PASSENGER ON VESSEL COMMUNICATING WITH LAND.

In 1908, a patent for a wireless telephone was issued to Nathan B. Stubblefield, an inventor and melon farmer in Kentucky. The concept of cells for mobile phone base stations was invented in 1947 by Bell Labs engineers at AT&T and further developed by Bell Labs during the 1960s. It was the start of mobile/ cellular communication as we now know it today.

Image source: Scientific American (May 1902)

Color Photography

R G B

Russian aristocrat Sergei Mikhailovich Prokudin-Gorskii (Russian: Серге́й Миха́йлович Проку́дин-Го́рский, top picture) was a pioneer in color photography. Starting 1909, he documented Russia in some 10,000 color photographs. Each image was caught three times – with red, blue and green filters. Projected together, the triple image appeared in full color (bottom). Today we can enjoy a part of his work as the result of a digitization program that the Library of Congress initiated in 2004.

Image source: Wikipedia

IBM

The company that we know as IBM was formed in 1911 as the Computing Tabulating Recording Company (CTR) by the merger of four companies: the Tabulating Machine Company, the International Time Recording Company, the Computing Scale Corporation, and the Bundy Manufacturing Company. It took the name International Business Machines in 1924 and would dominate the computer business from the 1950s to the 1980s.

Image source: Wikipedia

Bernstein and Bézier

Curves in computer graphics are typically based on the so-called Bézier curves (as in the shown case of Adobe Illustrator, top). The mathematical foundation is Bernstein polynomials, developed by Russian mathematician Sergei Natanovich Bernstein (Сергей Натанович Бернштейн, below) around 1912. Pierre Bézier was a French engineer who in the 1960s popularized the use of such curves and was honored by having his name attached to them.

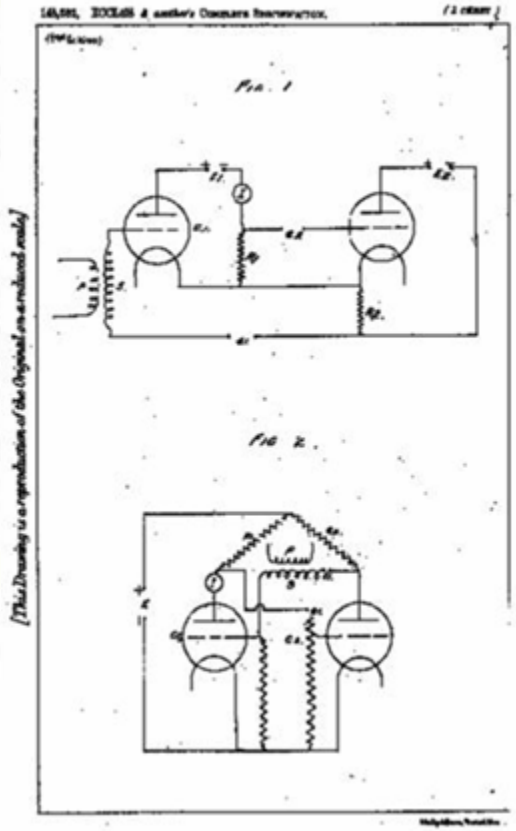
Image source: Wikipedia

TEMPEST

World War I showed that single-wire telephone systems were security risks. Further hints of sensitive EM and acoustic signals leaking (radiating/ conducting) from communication equipment were observed during WW II. In the late 1960s or early 70s, the problem was given the codename TEMPEST (later also called Emission Security, EMSEC) by the US National Security Agency. Still today specifications for attenuation of red (plain) signals leaking to the black (encrypted) environment are deemed classified military information.

Image source: Wikipedia

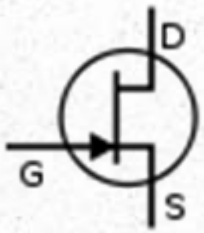
The “Flip-Flop” Circuit



The “flip-flop” circuit was invented by British physicists W. H. Eccles and R. W. Jordan in 1918, for which they were awarded British Patent 148,582 in 1920. The ability of the circuit to switch smoothly between two (binary) states would form the basis of computer arithmetic logic units. The drawing left is from the patent.

Image source: Wikipedia

The Field-Effect Transistor



Austro-Hungarian-American physicist and inventor Julius E. Lilienfeld (he was born in Lemberg, now Lviv in Ukraine) filed a Canadian patent in 1925 for "Method and Apparatus for Controlling Electric Currents," in which he proposed a three-electrode structure using copper-sulfide semiconductor material. Today this device would be called a field-effect transistor, but it was only in 1959 that a successful MOSFET device was achieved by Khang and Atalla at Bell Labs.

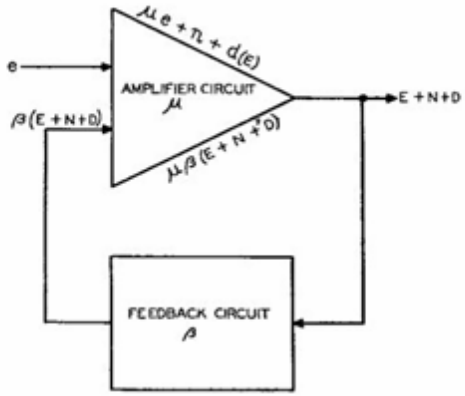
Image source: Wikipedia

Light Emitting Diodes

Russian scientist and inventor Oleg Vladimirovich Losev (Russian: Олег Владимирович Лосев) worked as a radio technician when he noticed that crystal diodes used in radio receivers emitted light when current was passed through them. Losev published details in a Russian journal of the first-ever light-emitting diode in 1927. His observations of LEDs languished for half a century before being recognized in the late 20th and early 21st century. Today LEDs are the most common light source in LCD displays.

Image source: Wikipedia

The Feedback Amplifier



Negative feedback amplifiers are analog circuits but needed e.g. when weak electric signals have to be amplified before being digitized for computation. The feedback amplifier was invented in August 1927 by Harold S. Black (shown), an engineer at Bell Laboratories, while he traveled on a ferry across the Hudson River. Questions regarding the stability of such feedback loops were worked out by Black's colleague Harry Nyquist in 1932. The schematic is from an article by Black from 1934.

Image source: IEEE

Bandwidth & Sampling

There are numerous names associated with developing the theory of bandwidth limitations and sampling rates: Nyquist, Küpfmüller, Whittaker, Kotelnikov, and Shannon, to name a few. Swedish-American Harry Nyquist (pictured) can be mentioned because he was early, although his contribution was limited. In 1928 Nyquist published a paper in which he showed that up to 2B independent pulse samples can be sent through a system of bandwidth B; but he did not consider the problem of sampling and reconstruction of continuous signals.

Image source: Wikipedia

Magnetic Tape Recording

German engineer Fritz Pfleumer (picture) filed in 1928 a patent for the audio tape recorder. Pfleumer used very thin paper which he coated with iron oxide powder using lacquer as glue. The first reliable tape recorder was produced by German electronics company AEG in 1935. Development shifted to the US after the war, where 3M developed a high-quality tape using red oxide on a plastic backing by 1947. Entertainer Bing Crosby invested $50,000 of his own money in the later leading tape recorder company Ampex.

Image source: Wikipedia

Teleprinters

Teleprinters (Teletype, Telefax, Telex) were electro-mechanical typewriters that came into use used for long-distance communication in the 1920s (although their development began already in the 19th century) and remained until the Internet took over. Teleprinters also served as input/ output devices in many early computers. The pictures show a British teleprinter from the 1930s (top) and a Siemens Fehrnschriber 100 from the early 1960s (bottom).

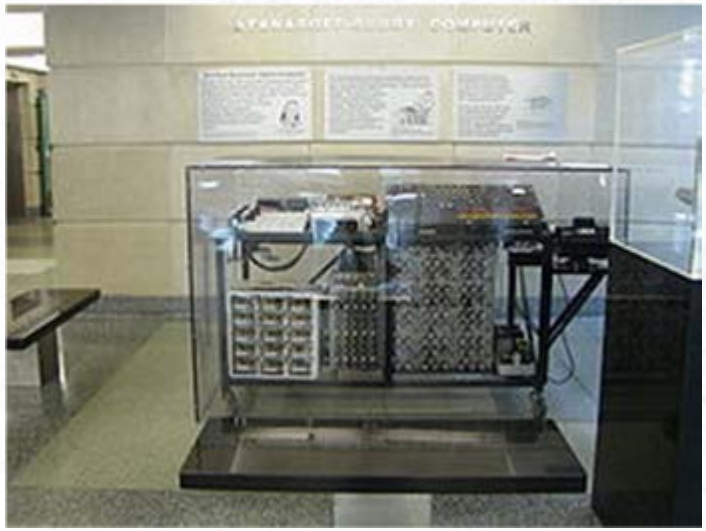
Image source: Wikipedia

The Turing Machine

In 1936, British mathematician Alan Turing published a paper that proved influential in computing and computer science in two ways. Its main purpose was to prove that there were problems (the halting problem) that could not be solved by any sequential process. In doing so, Turing provided a definition of a universal computer which executes a program stored on tape. This construct came to be called a Turing machine.

Image source: Wikipedia

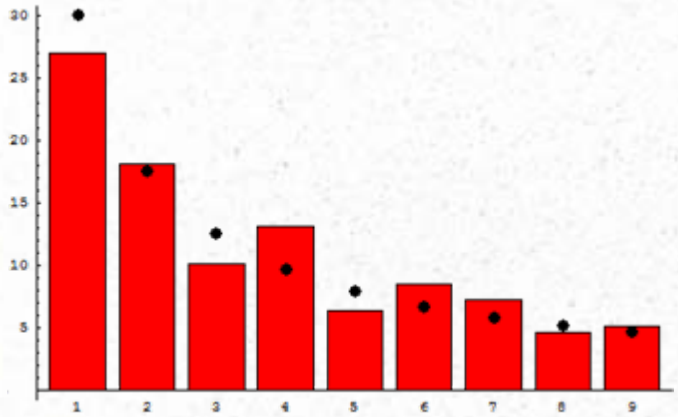
The Atanasoff-Berry "Computer"



The Atanasoff-Berry Computer (ABC) was a non-programmable electronic computing device, designed to solve linear equations. It did however pioneer some important elements of modern computing. The device was conceived in 1937 by J.V. Atanasoff of Iowa State University and built by him and graduate student Clifford Berry. It was successfully tested in 1942. The development was discontinued and its existence became known only through a lawsuit case in the 1960s, at which it was ruled to be the first US made computer.

Image source: Wikipedia

*Benford's Law**



*) The law was stated already in 1881 by Simon Newcomb

Physicist Frank Benford presented his counterintuitive finding in 1938. It has also become known as the first-digit law and states that in lists of numbers from many (but not all) real-life sources of data, the leading digit is distributed in a non-uniform way. The first digit is 1 about 30% of the time, while it is 9 only about 5% of the time. This logarithmic law has been found to apply in such cases as population distribution (shown), electricity bills, lengths of rivers, physical and mathematical constants, etc.

Image source: Wikipedia

Curta "Pepper Grinder"

Austrian-born Curt Herzstark (the name means Strongheart) received patents in 1939 for what would become known as the Curta mechanical calculator. After some dramatic events, including Herzstark's two-year stint in the Buchenwald concentration camp due to his Jewish background, Curta was put into production in Lichtenstein in 1947. It remained in production until 1972, when the competition from electronic calculators became too strong.

Image source: Unknown

The First General Purpose Computer

Konrad Zuse's Z3, which used over 2000 relays and was completed in 1941, was the world's first working programmable, fully automatic computing machine. It only lacked conditional branching of the attributes normally used as criteria in defining a computer. It had a clock frequency of ~5–10 Hz, and word length of 22 bits. Calculations on the computer were performed in full binary floating point arithmetic.

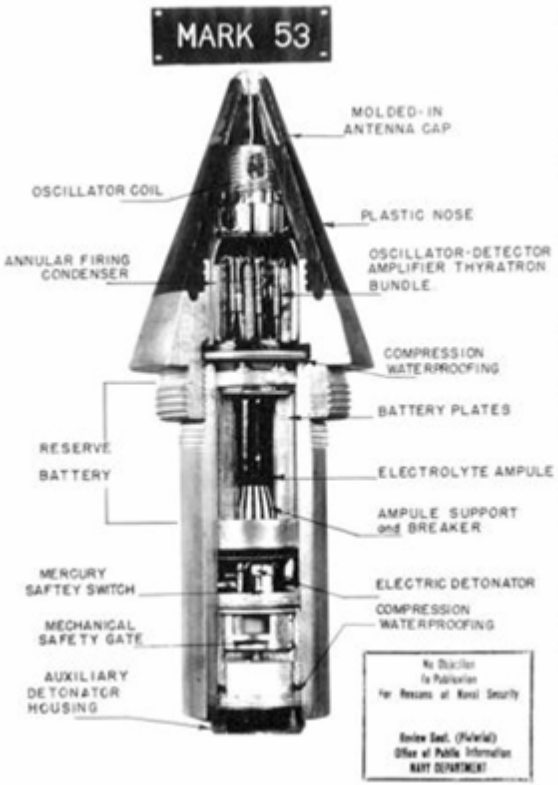
Image source: Wikipedia & Deutsches Museum

A Not-so-Accurate Prediction

” I think there is a world market for maybe five computers.”

Thomas Watson, chairman of IBM, 1943 (misquoted)

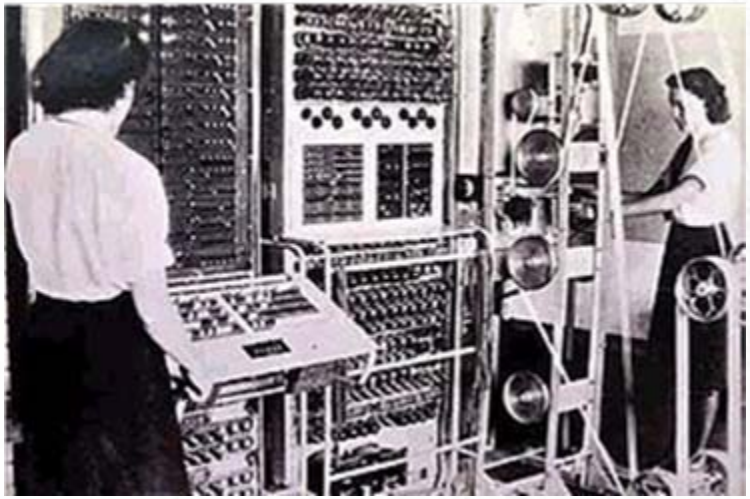
Miniaturization



Improving the effectiveness of anti-aircraft artillery was a major challenge during WWII. With mechanical contact fuzes artillery shells were effective only when they scored a direct hit on the target. Better effectiveness could be achieved if the shells could be brought to explode also with near-misses, in the vicinity of the aircraft. This required electronic proximity fuzes with miniaturized components that allowed them to be crammed into the limited space (and to withstand accelerations of more than 10,000 g).

Image source: Wikipedia

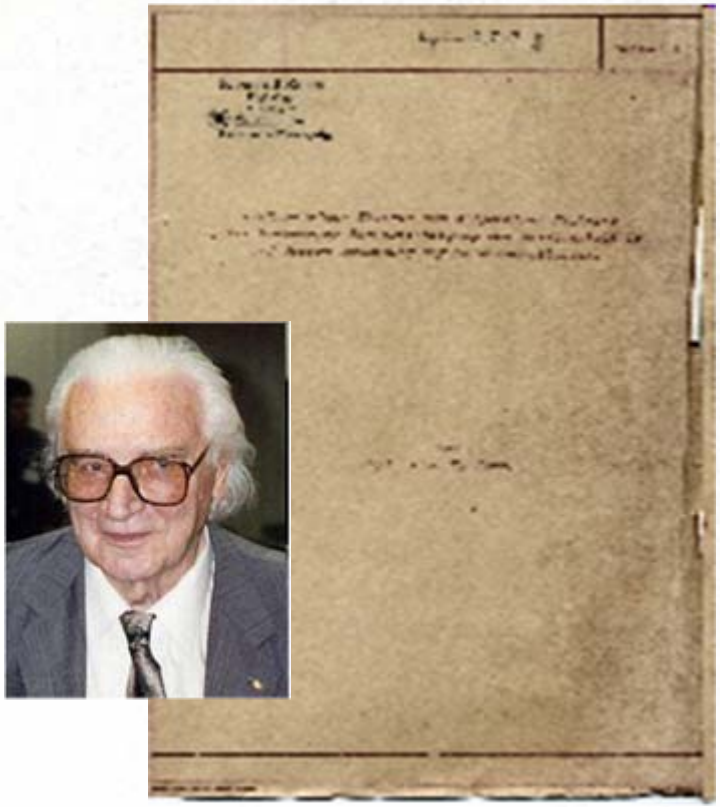
The Colossus Computer



The Colossus machines (both Mark 1 and Mark 2 were completed in 1944), designed by mathematician Max Newman and built by engineer Tommy Flowers, were electronic computing devices used by British codebreakers to read encrypted German messages during World War II (encrypted using the Lorenz SZ 40/42 cipher machine). These were the world's first programmable, digital, electronic, computing devices. They used vacuum tubes (2400 tubes in the more advanced Colossus Mark 2) to perform calculations.

Image source: Wikipedia & Public record office, London

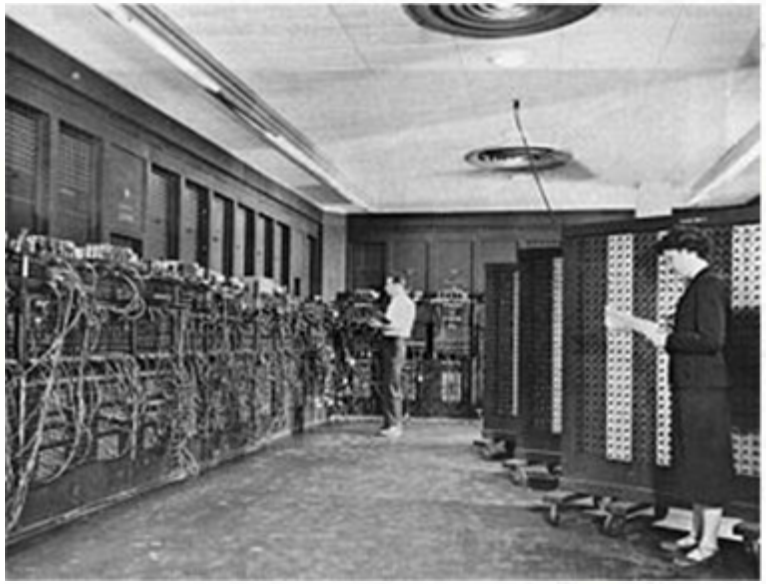
Plankalkül, a Programming Language Ahead of its Time



Zuse's main contribution to computer history may not be the hardware that he built but "Plankalkül," a programming language that he developed during World War II but published fully only in 1972. It was far in advance of its time in many ways, with features that would arrive with programming languages of the 1960s.

Image source: Wikipedia & TU Berlin

ENIAC, the First General-Purpose Electronic Computer



ENIAC (1946), short for Electronic Numerical Integrator And Computer, was the first general-purpose electronic computer. It was the first Turing-complete, digital computer capable of being reprogrammed (via a plugboard) to solve a full range of computing problems. ENIAC was designed and built to calculate artillery firing tables for the U.S. Army's Ballistic Research Laboratory. It had about 19,000 vacuum tubes and could perform 5,000 arithmetic operations per second.

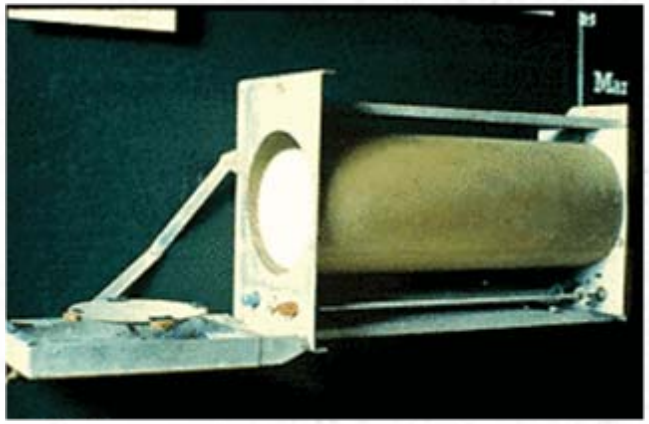
Image source: Wikipedia & US Army

Early Memory Solutions

The basic computing process consists of moving, manipulating and storing data. In Konrad Zuse's Z3 computer 1,800 of the total 2,400 relays were reserved for the memory, the remaining 600 relays formed the calculating unit. Zuse punched holes in discarded movie films to store external data.

Punched cards, punched tapes and similar media serve the dual role of being data and command input tools, while also fulfilling the role of external storage devices—memories—for the same.

The Williams Tube Memory



A memory device based on a modified CRT tube was developed in 1946-47 by British physicist Freddie Williams (and improved by engineer Tom Kilburn). It was for a time popular among early computer manufacturers as a fast dynamic random-access memory. For instance, the IBM 701 that emerged in 1952 used 72 3" Williams tubes with a capacity of 1024 bits each, to give a total memory of 2048 words with 36-bit length.

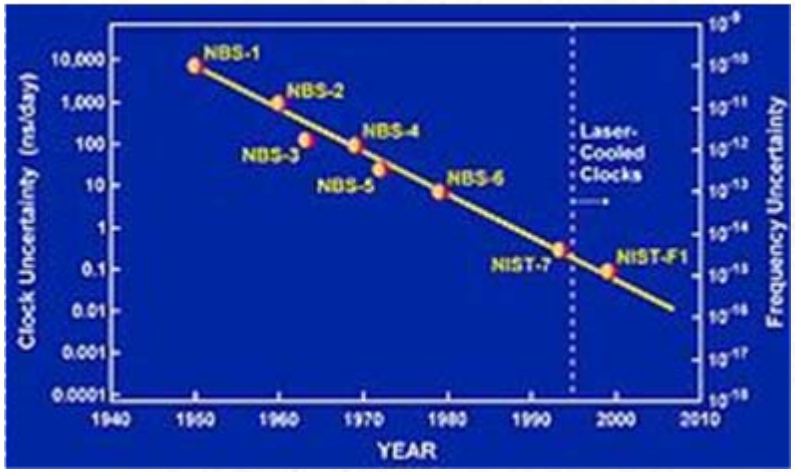
Image source: Unknown

Enters the Transistor

John Bardeen and Walter Brattain invented the germanium point-contact transistor in December 1947 at Bell Telephone Laboratories. (William Shockely made improvements to the invention before it was announced in June 1948.) A virtually similar device, called "transistron," was developed independently at the same time by two German wartime radar researchers, Herbert Mataré and Heinrich Welker, at a Westinghouse subsidiary in Paris, France.

Photo by: Michael Riordan/Bell Labs

The Atomic Clock



Harold Lyons and his colleagues at the US National Bureau of Standards constructed the first atomic clock in 1948. It was based on the 23,870 MHz oscillation of the ammonia molecule and was stable to one part in a hundred million—no more than ordinary quartz clocks. Later atomic clocks have been based on hydrogen, cesium and rubidium, and the accuracy has improved roughly by an order of magnitude each decade, as shown in the picture.

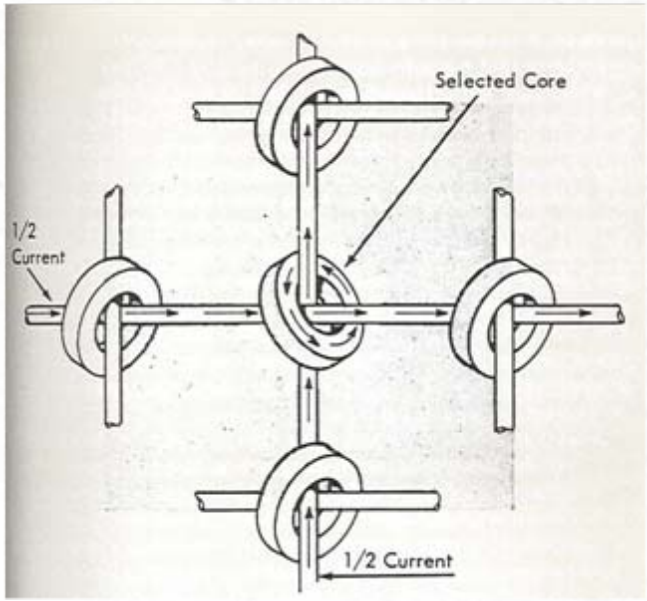
Image source: Wikipedia

A Not-so-Accurate Prediction

”Computers in the future may weigh no more than 1.5 tons.”

Popular Mechanics, 1949

Magnetic-Core Memories



Two key inventions led to the development of magnetic core memory in 1951, which enabled the development of computers as we know them. The first, by An Wang at Harvard University, was the write-after-read cycle, which solved the puzzle of how to use a storage medium in which the act of reading was also an act of erasure. The second, by Jay Forrester at MIT, was the coincident-current system, which enabled a small number of wires to control a large number of cores.

Image source: Columbia University

The Line Printer

The first line printer was the Potter Flying Typewriter in 1952. The Time magazine on 10 March 1952 described it thus: "Instead of working laboriously, one character at a time, it prints whole lines at once, 300 lines per minute, on a paper band. It takes its information from the coded magnetic tape that races out of the computer…. ” The picture shows an IBM 1403 line printer, introduced in 1959.

Image source: Columbia University

A Computerized Superspy

The National Security Agency (NSA) was formed in secret in 1952 and given responsibility for all American communications intelligence. Headquartered north of Washington DC (picture), it is believed to employ more mathematicians and computer power than any other organization in the world. It intercepts all kinds of electronic signals with land-, sea-, air-, and space based sensors. Very little moves on the Internet without being intercepted by NSA.

Image source: Wikipedia

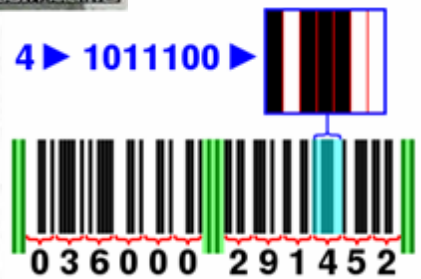
The First Compiler

*) Known as “Amazing Grace” and “Grandma Cobol” she retired involuntarily from the US Navy in 1986 at the age of 79 years, nine months and five days

Grace Hopper, best know for the COBOL language, developed the first compiler, called A-0 (Arithmetic Language version 0), in 1952. It was a tape collection of all subroutines that she had developed, each numbered so that the computer could find them. She had difficulties convincing people that it would work, because the conventional wisdom was that computers could only do arithmetic and not programs.*

Image source: Wikipedia

The Barcode

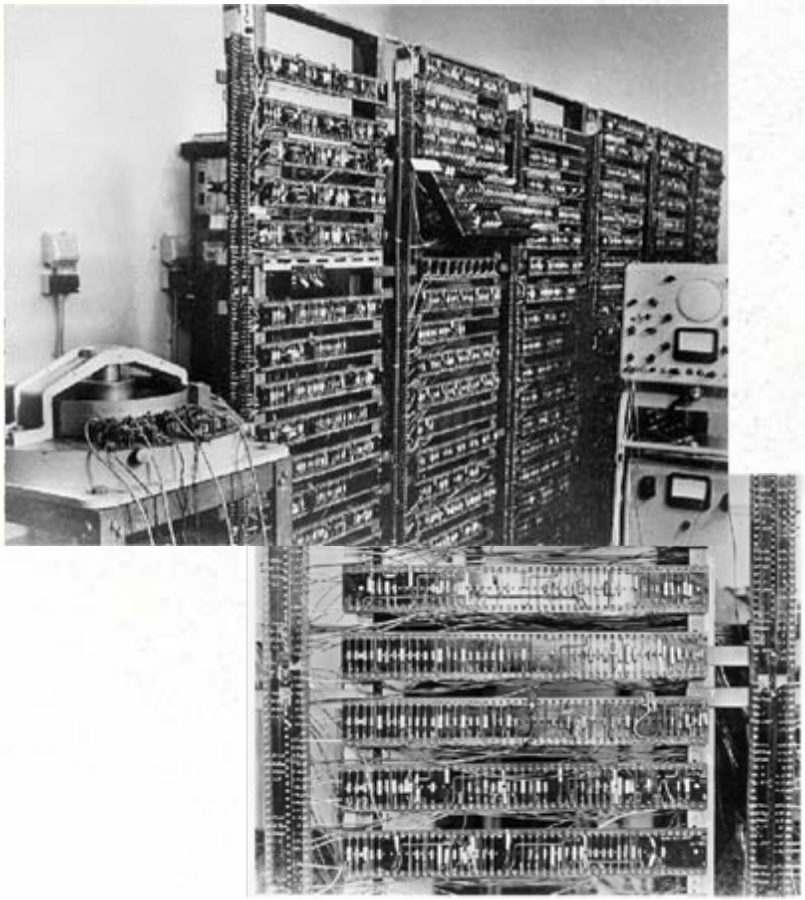


*) Their solution was the circular “bullseye” barcode that was developed into the UPC form by George J Laurer at IBM

Stretch out the dots and dashes of the Morse code to lines, and the result is the barcode. This was the idea that Norman Joseph Woodland (top) got in the late 1940s, and for which he and university classmate Bernard Silver received a US patent in 1952. The invention was ahead of its time and it took until 1974 before it was first used in a supermarket – to scan a packet of chewing gum. Today the barcode (the later developed Universal Product Code is shown in the lower image) is scanned some 5 billion times a day.*

Image source: BBC/Wikipedia

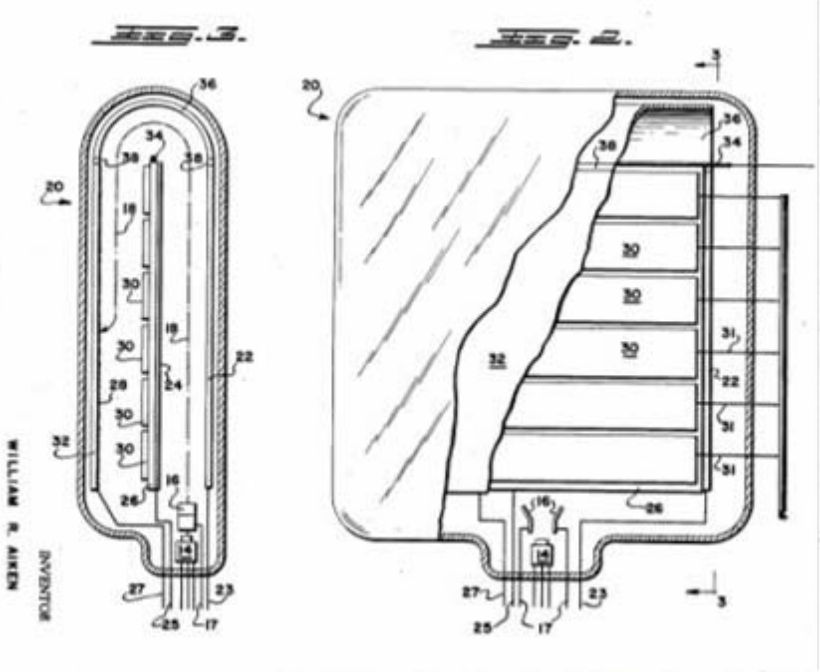
The First Transistor Computer



The experimental Transistor Computer at the University of Manchester was first operational in November 1953 and is believed to be the first transistor computer to come into operation. There were two versions: The prototype, operational in 1953, and the full-size version that was commissioned in April 1955. The latter had a total of 200 point-contact transistors and 1300 point diodes and consumed 150 watts of power. There were considerable reliability problems and the average error free run time was only 1.5 hours in 1955.

Image source: University of Manchester

Flattening Displays

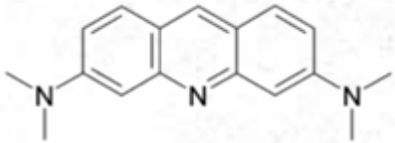


By the 1950s, CRT displays were common in computers – and even more so in television sets. The tubes, however, were bulky and replacements were sought. In 1958 Kaiser Electronics received a patent for a flat CRT display, commonly called Aiken Tube after its inventor (pictured). Although flat CRTs promised improvement, they never saw widespread use. An alternative solution arrived in the 1960s with electroluminescent displays on the control computer of the Apollo moon shuttle.

Image source: US Patent 2,837,691

The Beginnings of OLEDs

Nancy-Université



André Bernanose and coworkers discovered electroluminescence in organic materials (acridine orange) at Nancy-Université in 1953. It was the first step toward organic light-emitting diodes. OLEDs are expected to displace liquid crystals as the technology of choice in flat-screen displays, particularly in portable devices. They also allow flexible, paper-like displays to be made.

Image source: Wikipedia

The Silicon Transistor

Bell Labs chemist Morris Tanenbaum fabricated the first silicon transistor in January 1954. However, Bell Labs did not pursue the process further, thinking it unattractive for commercial production. This allowed Gordon Teal of Texas Instruments to claim credit for the breakthrough several months later.

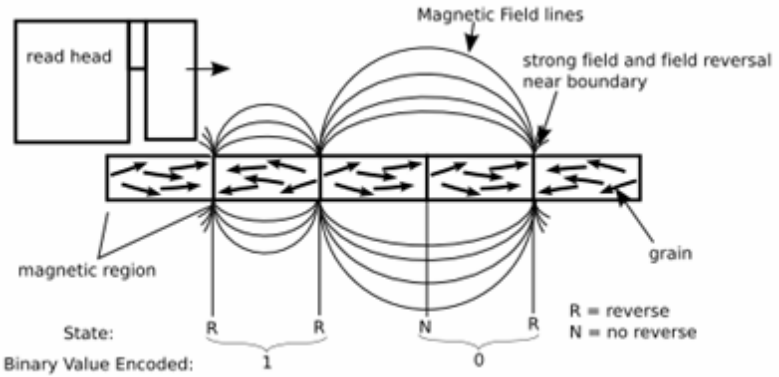
Image source: Computer History Museum

Exits the Ge Transistor

Germanium has such attractive features as low junction forward voltage and high electron mobility. However, it lost out to silicon as the semiconductor of choice due to its disadvantages:

- *Limited maximum temperature*
- *Relatively high leakage current*
- *Unable to withstand high voltages*
- *Less suitable for fabrication of integrated circuits*

Magnetic Mass Storage Devices



The magnetic hard disk, a non-volatile memory, was invented in 1954 by an IBM team. It has developed immensely over the years and is still the major non-volatile memory type. In 1980 the maximum capacity of a hard disk was just 1 MB, today the 1 TB barrier has been reached. The size has shrunk from 8 inches in 1979 to 1 inch or less in 2009.

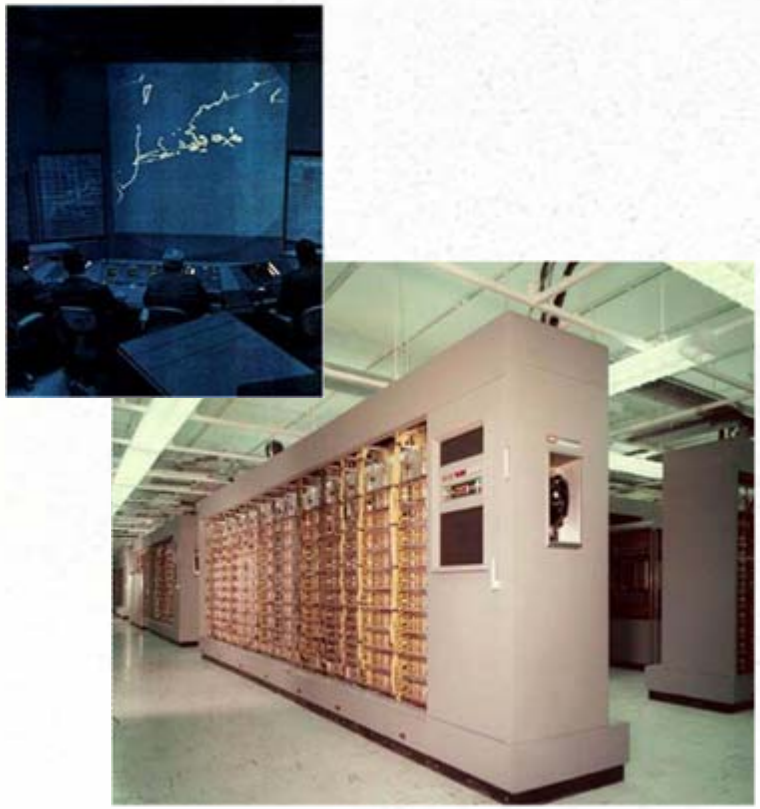
Image source: Wikipedia

A Commercial ADC

The first commercial analog-to-digital converter – as far as is known – was put on the market by Epsco Engineering in 1954. This "Datrac" (shown) was a 50 ksps vacuum-tube device that dissipated 500 W and was mounted in a 19" rack, but it was advanced in having a sample-and-hold function. It sold for $8,000 to $9,000. Epsco had been formed by Bernhard M. Gordon, who had worked on the UNIVAC computer and seen the need for ADCs.

Image source: Analogic Corp.

SAGE, the Ultimate Tube Machine



The Semi-Automatic Ground Environment (SAGE) was an automated control system for intercepting and *tracking enemy bomber aircraft used by NORAD (North American Air Defense Command) from the late 1950s into the 1980s. Each SAGE computer used 55,000 vacuum tubes, about 2,000 m² of floor space, weighed 275 tons and used up to 3 MW of power. By the time it was fully operational the Soviet bomber threat had been replaced by the Soviet missile threat, for which SAGE was entirely inadequate.*

Image source: Wikipedia & USAF

Fortran

THE FORTRAN
AUTOMATIC CODING SYSTEM
FOR THE
IBM 704 EDPM

In the early 1950s computer programming was mainly done in low-level assembly languages. This changed in 1957 when a compiler for IBM's high-level Fortran (Formula Translation) language became available. It had been developed for the IBM 704 mainframe computer (left), but soon proliferated into other computers. Fortran still lives, although countless programming languages have been developed over the bygone decades. The latest version is Fortran 2008, which was approved as ISO/IEC standard in 2010.

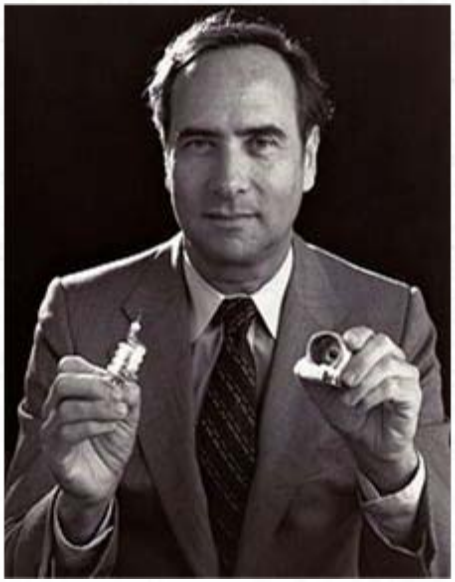
Image source: Wikipedia & Computer History Museum

Phreaking

A blind boy aged 7, Joe "The Whistler" Engressia (later Joybubbles), noticed in 1957 that whistling a certain tone influenced phone switches. This 2600 Hz signal could be used to place free phone calls, a fraud that became known as phreaking (from phone + freak) and paved the way for subsequent hacking of digital phone systems. The "Blue Box" was a popular tool for generating phreaking signals. Among phreakers of the 1960s-70s were Apple cofounders Steve Wozniak and Steve Jobs. The photo shows a blue box built by Wozniak in 1972.

Image source: Wikipedia

Lasers



Soviet scientists F.A. Butayeva and V.A. Fabrikant amplified light in 1957 using mercury as the lasing medium but their findings were not published in any scientific paper. American physicist Theodore H. Maiman (pictured), who built an operational ruby laser in 1960, is therefore usually credited as the inventor of the laser. Today, computing technology requires lasers e.g. for optical communication, optical information storage, and laser printers.

Image source: Wikipedia

The Beginning of CNC

Numerical control of automated machine tools was conceived in the late 1940s by John T. Parsons of Parsons Corp. machining company. A program for computerized numerical control (CNC) called PRONTO was developed in 1957 by Patrick J. Hanratty (pictured) while he was employed by General Electric. As a result, Hanratty is often referred to as "the father of CAD/CAM.“

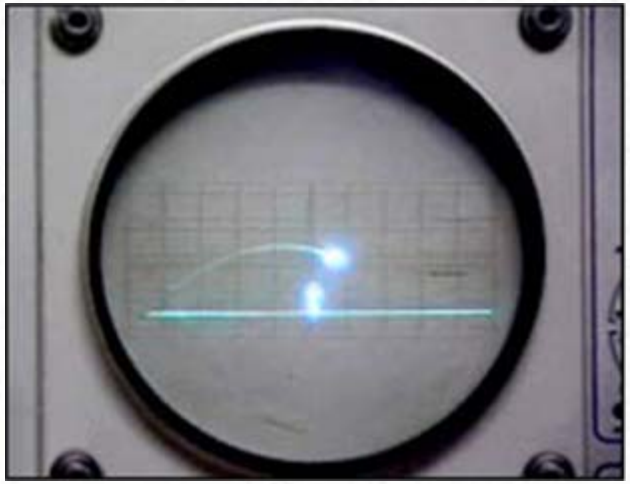
Image source: Unknown

A Not-so-Accurate Prediction

"I have traveled the length and breadth of this country and talked with the best people, and I can assure you that data processing is a fad that won't last out the year."

Business book editor, Prentice Hall, 1957

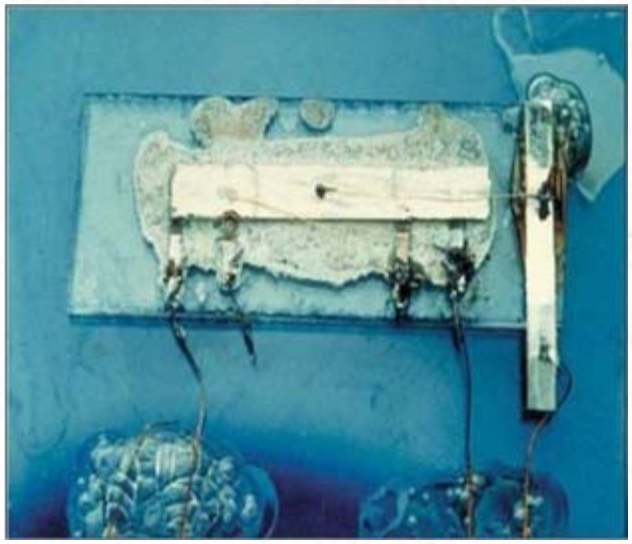
Tennis for Two



A strong contender for the title "Mother of all Computer Games" is Tennis for Two, a video game played on an analog computer with an oscilloscope CRT as its display. It was developed in 1958 by Brookhaven National Laboratory physicist William Higinbotham, mainly to cure the boredom of visitors to the laboratory. It became an immediate success and hundreds of visitors lined up to play the game during its initial showing.

Image source: Wikipedia

Emerges the Integrated Circuits



The first working integrated circuit on germanium was demonstrated by Jack Kilby at Texas Instruments in 1958. This prototype had a transistor (small left dot) attached to two gold wires and a capacitor (middle black dot). The germanium itself, secured on a glass slide, is divided into three resistors by the tabs at the bottom. By showing that all three types of components could work in the same slice of germanium, Kilby offered a way to improve the performance and lower the cost of electronic devices.

Image source: Wikipedia

Ternary Computer

A ternary computer (base-3 system) was built in 1958 at Moscow State University by Nikolai P. Brusenzov and associates. It was named SETUN after a nearby river. Ternary logic has a $(3/2)^n$ advantage over binary logic, but has not seen widespread use due to the complexity of tri-state switches and memory cells. In a way, however, it will be realized in qubit quantum computers where each qubit can be either 0, 1, or their superposition (a true ternary quantum computer has been proposed but not built to date).

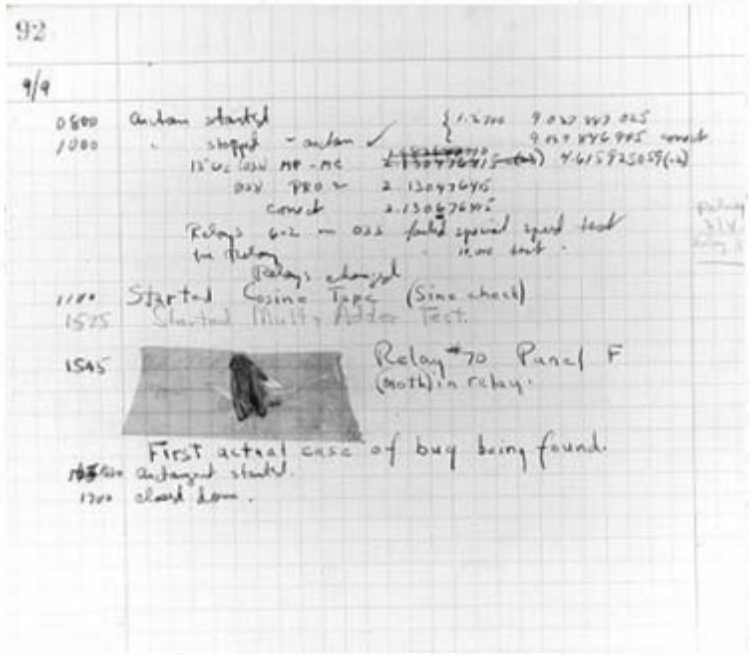
Image source: Wikipedia

The Planar Transistor

Jean Hoerni, a cofounder of Fairchild Semiconductor, invented the first planar, or flat, transistor in 1959. His novel manufacturing approach was to directly imprint semiconducting and insulating channels onto a silicon wafer. The process left intact a protective layer of silicon dioxide that formed naturally on top of the wafer and prevented contamination. The result was the best-performing transistor of its time.

Image source: Fairchild Semiconductor

COBOL



*) Programmers objected; e.g. E.W. Dijkstra reportedly said: “The use of COBOL cripples the mind; its teaching should, therefore, be regarded as a criminal offense.”

*Fortran became the main application program for scientific and engineering computing. COBOL (Common Business-Oriented Language), first specified by Grace Hopper (see earlier slide, her famous “bug” is shown to the left) during the second half of 1959, would become a similar workhorse in business applications. COBOL statements are in almost plain English, as opposed to the mathematical expressions used in Fortran. The approach reflects the idea of “programming without programmers.” **

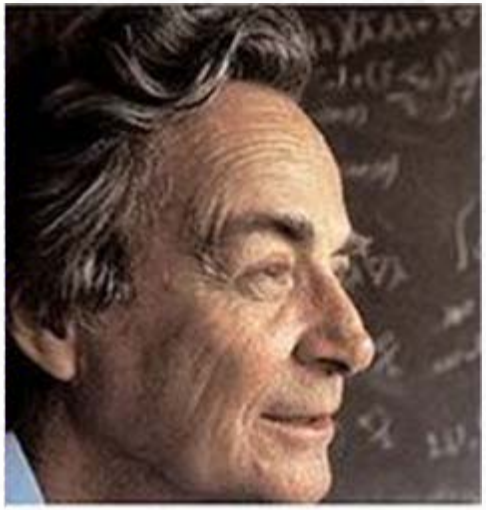
Photo source: Wikipedia

Computer Control

There is some debate about the first application of digital computers to process control, but the introduction of computer control at the Texaco Port Arthur (Texas) refinery in 1959 and the Monsanto ammonia plant at Luling (Louisiana) the following year are two of the earliest. Also in 1959, computer-assisted manufacturing was demonstrated at MIT's Servomechanisms Laboratory.

Image source: Wikipedia & Unknown

Prelude to MEMS and Nanotechnology



The Feynman Lectures on Physics

Richard P. Feynman

At an American Physical Society meeting at Caltech on December 29, 1959, physicist Richard Feynman gave a speech which began with the words "There's plenty of room at the bottom." Some authors see this as the birth of nanotechnology. It is an overstatement, but by highlighting microscopic-scale technology it undoubtedly gave a hint of things to come.

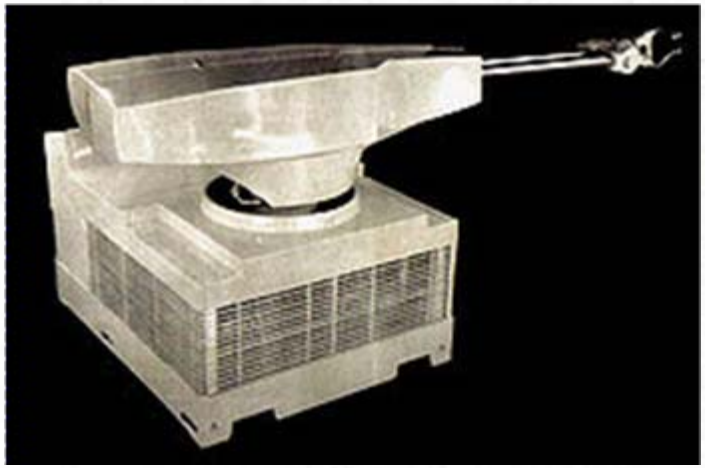
Image source: Wikipedia

Data Modems

Modems on dedicated lines were first introduced in the 1950s as part of the SAGE air-defense system. In 1960 AT&T designed its Dataphone (or Data-Phone), the first commercial modem intended specifically for converting digital computer data to analog signals for transmission across long distance networks (there was a predecessor called "digital subset," a 200 baud modem that was introduced in 1958). The picture shows a modern ADSL broadband modem.

Image source: Wikipedia

Industrial Robots



Unimate, the first industrial robot, began work at General Motors in 1961. Obeying step-by-step commands stored on a magnetic drum, the 4,000-pound arm sequenced and stacked hot pieces of die-cast metal. It was the brainchild of Joe Engelberger and George Devol, Unimate originally automated the manufacture of TV picture tubes.

Image source: Wikipedia

Time-Sharing

Ideas on need for time-sharing constrained resources, such as the processor, lingered in the early computer community. In November 1961 an operating system called CTSS (Compatible Time Sharing System) was demonstrated at MIT on an IBM 709 mainframe computer (later on an IBM 7094, shown). CTSS had been developed under Dr Fernando Corbatò but was never used outside MIT. The demonstrations by Corbatò's group did however convince others of the value of time-sharing.

Image source: IEEE

Integrating Multiple Components

Robert Noyce—cofounder of Fairchild Semiconductor and later cofounder of Intel—saw a way to use Hoerni's process to combine multiple electronic components, including transistors, on a single piece of silicon. Announced in 1961, this resistor-transistor logic (RTL) chip was one of the first commercial integrated circuits. The one shown has four transistors (quadrants in the middle). The white lines are metal traces, which connect the transistors to the two resistors below (horizontal blue bar). The Apollo Guidance Computer used the chip.

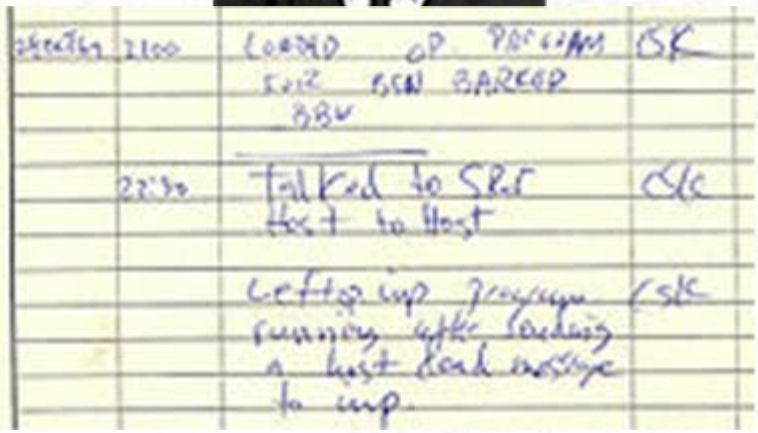
Image source: Fairchild Semiconductor

Communications Satellites

Satellite communication was proposed by science fiction writer Arthur C. Clarke in 1945. Telstar was the first active communications satellite, and the first satellite designed to transmit telephone and high-speed data communications. It was launched in July 1962 and operational until February 1963. Today communication satellites and fiber-optic cables are the backbone of the global communications network that carries the Internet traffic.

Image source: Wikipedia

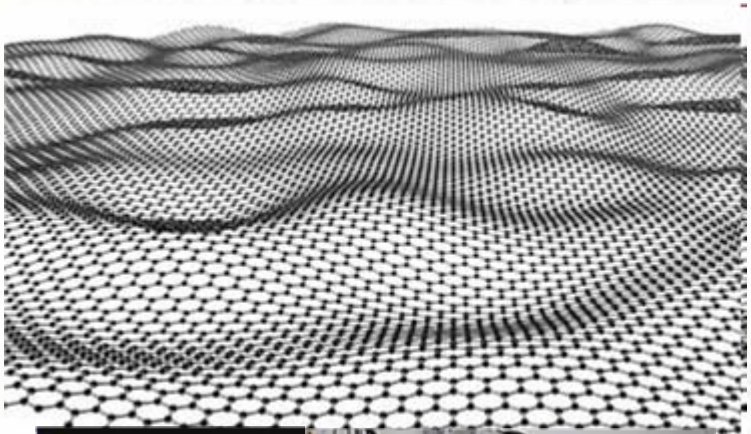
ARPANET



The earliest ideas of a computer network intended to allow general communication between users of various computers were formulated by J.C.R. Licklider in August 1962. DoD's Advanced Research Projects Agency, ARPA (now DARPA), launched a development project based on Licklider's ideas in 1968. The first permanent ARPANET link was established 1969 between interface message processors at UCLA and SRI. The bottom picture shows the log of the first message.

Image source: Wikipedia

The Birth of Graphene



The term "graphene" was coined in 1962 by German chemist Hans-Peter Boehm to describe single-layer carbon foils (top). In 2010 physicists Andre Geim (lower left) and Konstantin Novoselov (lower right) at the University of Manchester were awarded the Nobel Prize for groundbreaking experiments into graphene, and were knighted on New Year's Day 2012. Their work immediately raised hopes for electronics components only one atom thick.

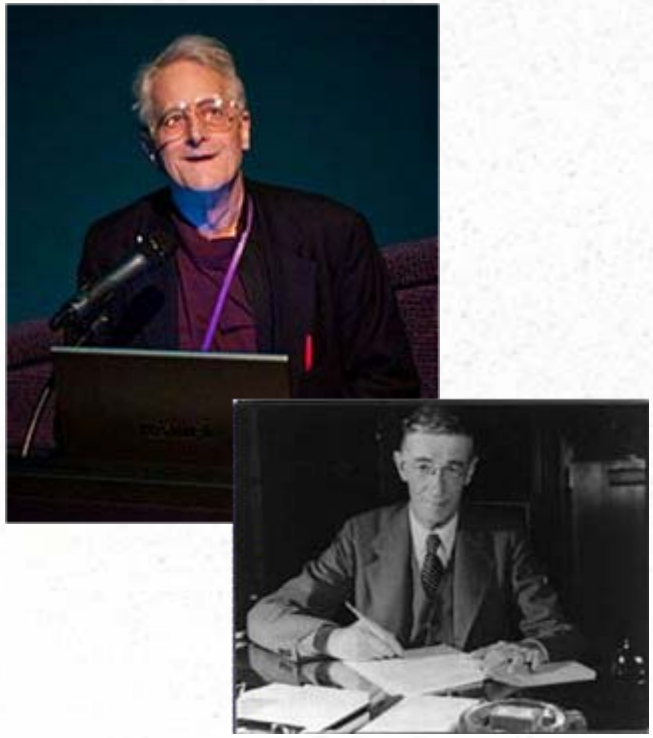
Image source: Wikipedia & Science Friday

The Mouse

The computer mouse is a two-dimensional pointing device that shows its real value with graphical user interfaces (GUIs). The first prototype was invented by Douglas Engelbart at the Stanford Research Institute in 1963. The first known publication of the term "mouse" as a pointing device is in an article by Bill English in 1965; English later invented the ball mouse. Today most mouses (pl. alt. “mices”) have an optical sensor.

Image source: Wikipedia

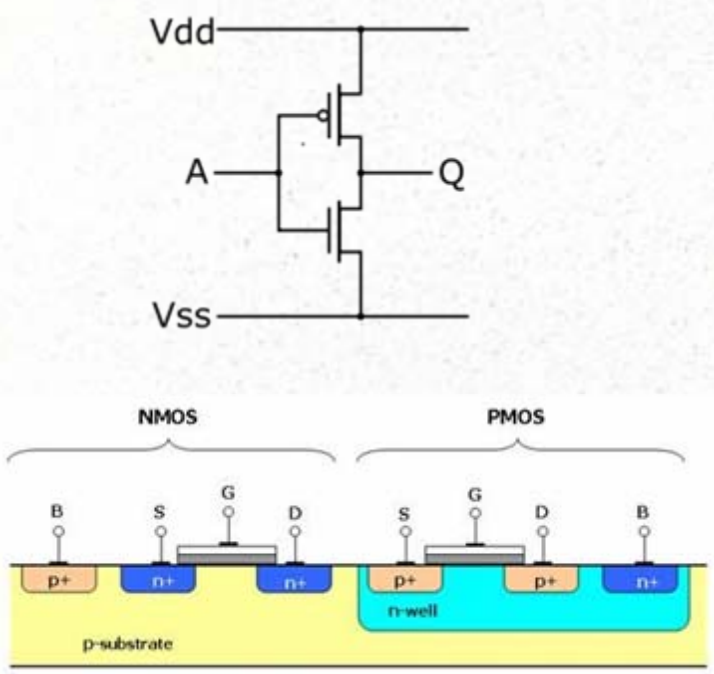
Hypertext



The term “hypertext” was coined in 1963 and published in 1965 by American sociologist, philosopher, and IT pioneer Ted Nelson (top). However, ideas of what we now call hypertext emerged already in 1945 in an article called "As We May Think” by Vannevar Bush (bottom). Bush’s article was about the technology of the day—microfilms—but it later became an inspiration for Nelson.

Image source: Wikipedia

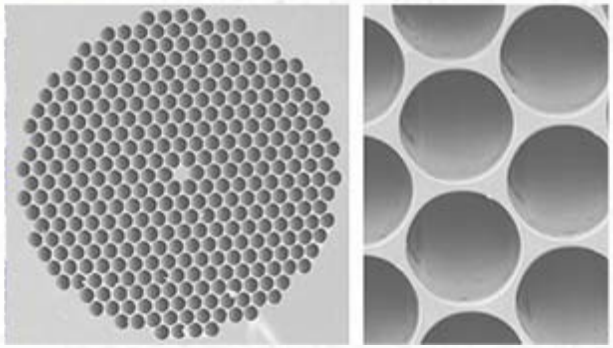
CMOS



Frank Wanlass at Fairchild Semiconductor invented the complementary metal-oxide semiconductor (CMOS) circuit in 1963. (The patent was in Walnass's name, but a conference paper from 1963 also has the name of C.T. Sah.) The CMOS lowers standby power by six orders of magnitude compared with bipolar and PMOS circuits. The vast majority of all high-density integrated circuits manufactured today are in CMOS technology.

Image source: Wikipedia

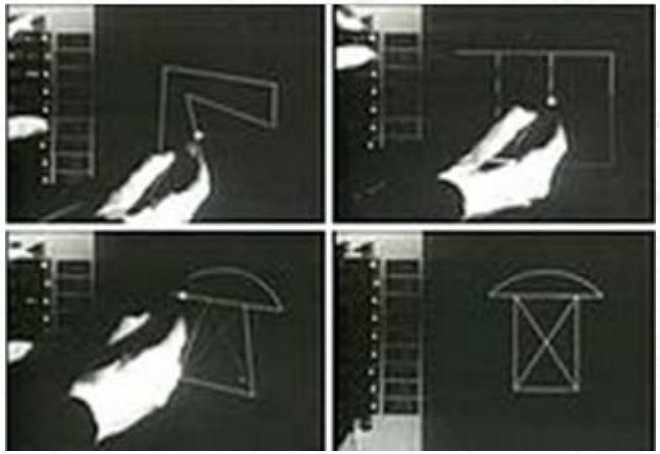
Optical Fibers



Jun-ichi Nishizawa at Tohoku University first proposed the use of optical fibers for communications in 1963. High attenuation was a major obstacle to practical applications. The problem was gradually solved and in 1981 General Electric produced fused quartz ingots that could be drawn into fiber optic strands 40 km long. In 2000 the first high-power photonic crystal fibers became commercially available. PCFs—e.g. the holey fibers shown in the top picture—can carry higher powers than conventional optical fibers.

Image source: Wikipedia

The Ancestor of CAD



Ivan Sutherland, PhD student at MIT, presented in 1963 a program that he called Sketchpad (aka Robot Draftsman) and which is generally seen as the ancestor of today's CAD programs. Sketchpad had a great influence on the way people interact with computers. Graphical user interfaces (GUIs), for instance, were derived from Sketchpad, as was object oriented programming. Sutherland, in turn, had been inspired by Vannevar Bush's "As we may think" (see earlier slide on hypertext).*

**) See also earlier slide The Beginning of CNC (1957)*

Image source: Wikipedia

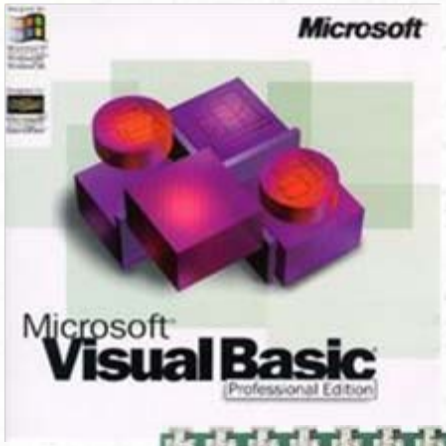
ASCII

A	1	0	0	0	0	0	1
B	1	0	0	0	0	1	0
C	1	0	0	0	0	1	1
D	1	0	0	0	1	0	0
E	1	0	0	0	1	0	1
F	1	0	0	0	1	1	0
G	1	0	0	0	1	1	1
H	1	0	0	1	0	0	0
I	1	0	0	1	0	0	1
J	1	0	0	1	0	1	0
K	1	0	0	1	0	1	1
L	1	0	0	1	1	0	0
M	1	0	0	1	1	0	1
N	1	0	0	1	1	1	0
O	1	0	0	1	1	1	1
P	1	0	1	0	0	0	0
Q	1	0	1	0	0	0	1
R	1	0	1	0	0	1	0
S	1	0	1	0	0	1	1
T	1	0	1	0	1	0	0
U	1	0	1	0	1	0	1
V	1	0	1	0	1	1	0
W	1	0	1	0	1	1	1
X	1	0	1	1	0	0	0
Y	1	0	1	1	0	0	1
Z	1	0	1	1	0	1	0

ASCII, American Standard Code for Information Interchange, was introduced in 1963 to permit machines from different manufacturers to exchange data. ASCII includes definitions for 128 characters: 33 are non-printing control characters (now mostly obsolete) that affect how text and space is processed. Historically, ASCII developed from telegraphic codes. It was used on the World Wide Web as US-ASCII until 2008, when it was surpassed by UTF-8.

Image source: Computer History Museum

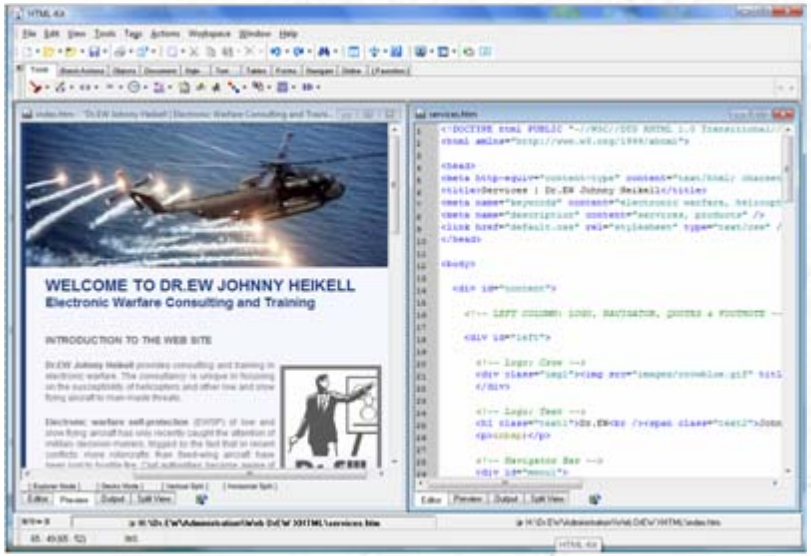
BASIC



The need to train programming skills to new generations of students put demands on suitable training tools. In 1964 John Kemeny at Dartmouth College introduced the BASIC programming language, with the aim of making it easy for students to use computers ("Fortran without tears"). Later the Pascal language would be launched with similar pedagogic goals. Variations of BASIC are in use to this date, e.g. in the form of Visual BASIC (top) and PBASIC in the BASIC Stamp microcontroller (bottom).

Image source: Wikipedia

Integrated Development Environment



Dartmouth BASIC, one of the first programming languages intended to be used interactively, appeared in 1964 (see previous slide). It was the first language to be created with an IDE. The IDE is a programming environment packaged as an application program, typically consisting of a code editor, a compiler, a debugger, and a graphical user interface (GUI) builder. Today IDEs for developing HTML applications are among the most commonly used. The picture shows a screenshot of the HTML-Kit IDE.

Screenshot: Dr.EW

The First Supercomputer

The Control Data CDC 6600, developed by Saymore Cray in 1964, is generally recognized as the first supercomputer. It run at a clock speed of 10 MHz, the central processor had 60-bit word length, and—although being transistorized—used enough power to have to be cooled by a liquid Freon cooling system. The picture shows a part of the system console (front), cooling system (right), and two of its main racks with covers opened.

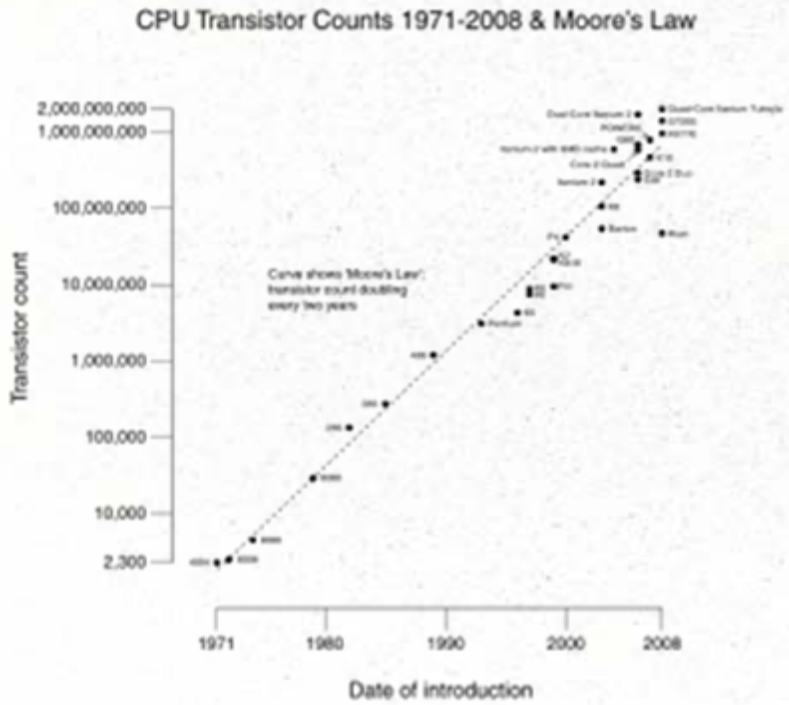
Image source: Wikipedia

IBM System/360

During the 1950s IBM, the "Big Blue," had become the leading computer supplier. Its model 1401 had been a commercial success with over 10,000 units sold. In 1964 IBM System/360 was introduced. It used IBM's "solid logic technology," an intermediate step toward integrated circuits that reduced costs compared with hard-wired components. Several operating systems were used: Operating System/360 (OS/360), BOS/360, TOS/360, etc. The price range was from $133,000 to $5,500,000 depending on the configuration.

Image source: Wikipedia

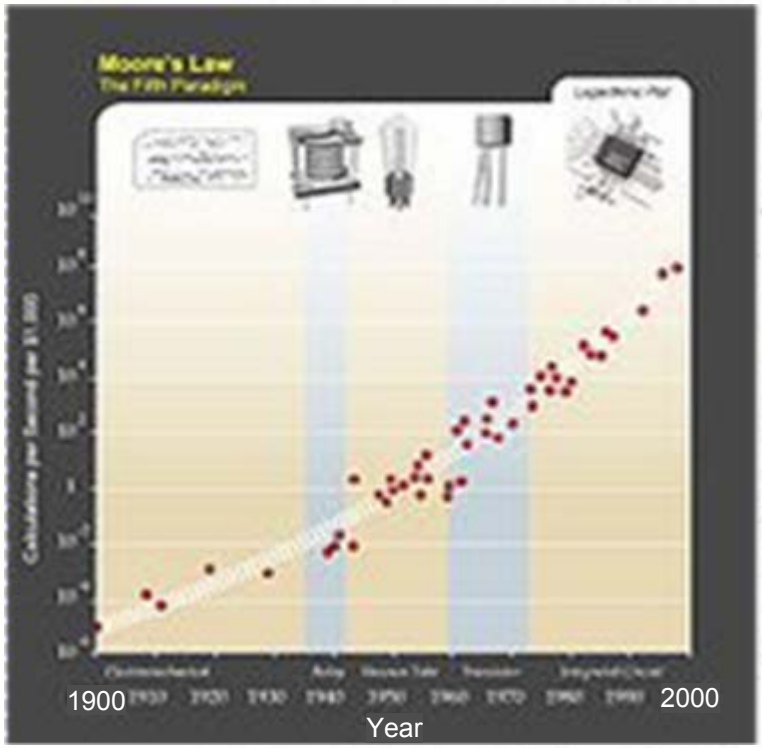
Moore's Law



In 1965, when Fairchild Semiconductor's Gordon Moore predicted that the number of transistors on a computer chip would double every year, the most advanced chips had around 60 components. In 1975, Moore—who cofounded Intel in 1968—reconsidered his prediction and revised the rate of doubling to roughly every two years. So far Moore's Law is valid, but the end is at hand—or is it?

Image source: Wikipedia

Expanded Moore's Law



*In 1999, inventor and futurist Raymond Kurzweil expanded Moore's law from integrated circuits to earlier transistors, vacuum tubes, relays and electromechanical computers. He and other futurists believe that the exponential improvement described by Moore's law will ultimately lead to a technological singularity: a period where progress in technology occurs almost instantly.**

Image source: Wikipedia

*) Some claim that Kurzweil's singularity theory is pure science fiction

The PDP Minicomputer

In 1960 Digital Equipment Corporation introduced the PDP minicomputer concept that would dominated the low-end field for three decades, while IBM retained dominance in the high-end with mainframe computers. The deathblow to DEC came when the market shifted to microcomputers and DEC could not, or would not, adjust. In 1998 the company was bought by microcomputer startup Compaq, which some years later was acquired by Hewlett Packard. The picture shows a a desktop version of the popular PDP-8 that was introduced in 1965.

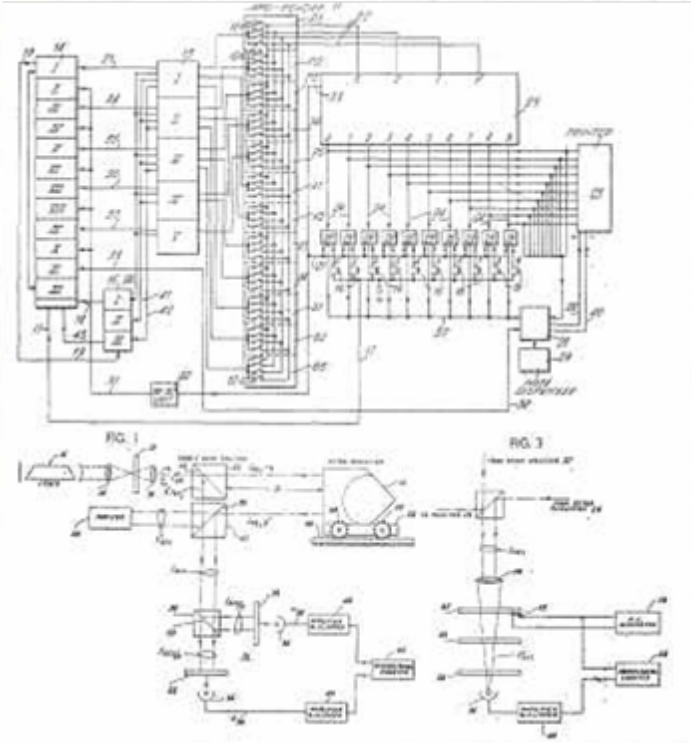
Image source: Unknown

Beginnings of the CD-ROM

James T. Russell, scientist at the Battelle Memorial Institute in Richland, Washington, got the idea for an optical data storage technique in 1965. A patent application for the invention was filed in 1966 (issued in 1970), but it took close to 20 years and over a billion dollars before Sony and Philips could put a usable CD-ROM on the market. Finally, in 1983 Philips produced almost 100,000 optical disks. Russell never received royalties for his part in the invention.

Image source: Unknown

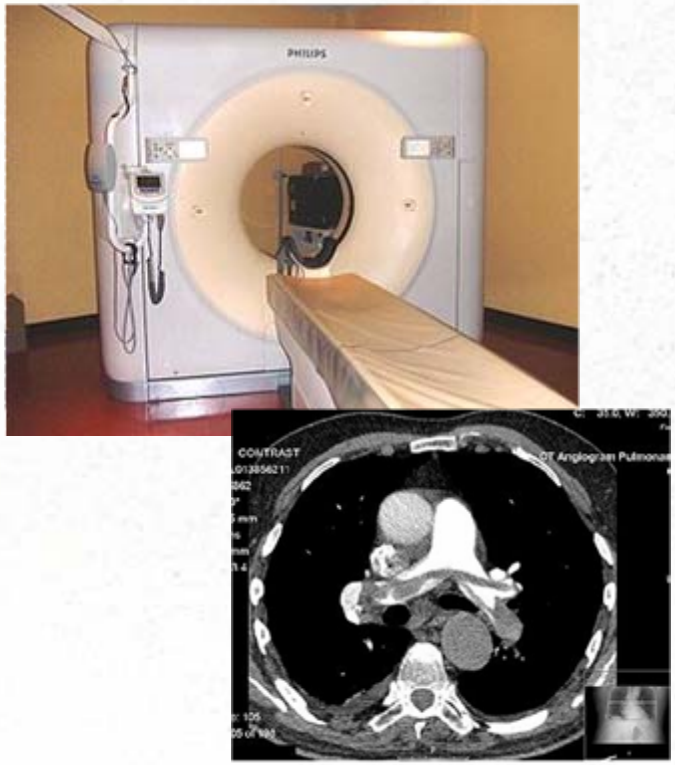
The PIN Controversy



England and Scotland both claim to have invented the four-digit PIN (Personal Identification Number) code. To England the inventor was John Shepherd-Barron, to Scotland it was James Goodfellow. Scotland can support its claim by a British patent issued to Goodfellow in 1966 (image). Both inventions were in connection with ATM projects. This race England won by having Shepherd-Barron's ATM up an running in 1967, one month before their Scottish competitors.

Image source: UK Patent No.1,197,183

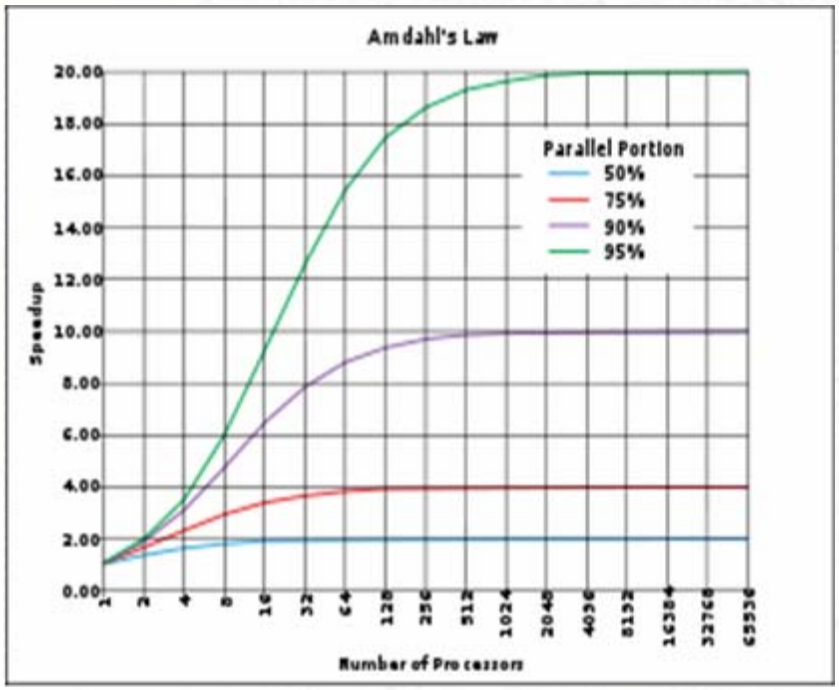
Computer Tomography



During an outing in 1967, British electrical engineer Godfrey Hounsfield conceived the idea of combining X-ray and computer technologies, to create what would become known as the CT scanner. The development was funded by music company EMI and became known as the "EMI scanner" when it was introduced in 1972. Hounsfield was knighted and received the Nobel Prize for his invention, but EMI did not invest in further development and other manufacturers soon flooded the market with improved solutions.

Image source: Wikipedia

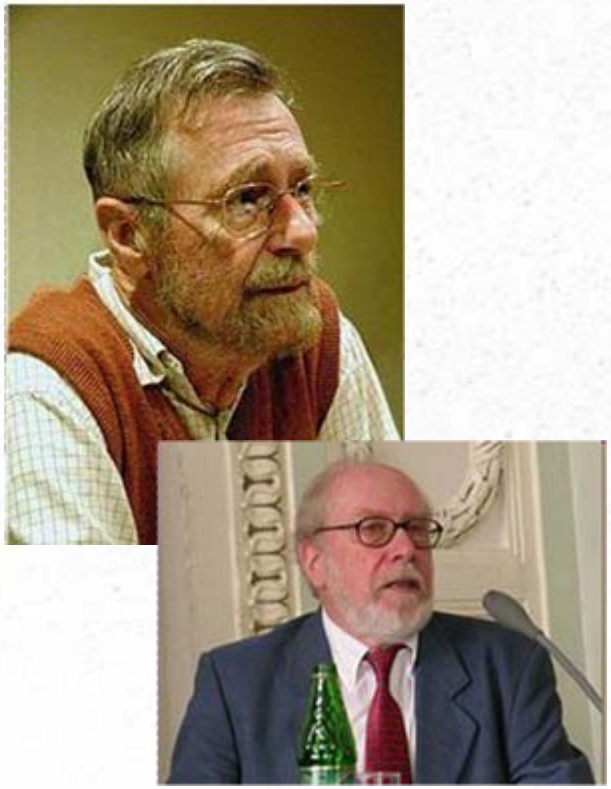
Amdahl's Law



The speedup of a program using multiple processors in parallel computing is limited by the time needed for the sequential fraction of the program. For example, if 95% of the program can be parallelized, the theoretical maximum speedup using parallel computing would be 20x as shown in the diagram, no matter how many processors are used. The basic idea was put forward by Gene Amdahl of IBM in a literal paper published in 1967.

Image source: Wikipedia

The GOTO Statement



Programming techniques, as all major scientific and engineering endeavors, develop incrementally. In 1968 Dutch computer scientist Edsger Dijkstra (top) published a paper entitled ”A Case against the GO TO statement.” Its message became better known through an article entitled “The Go To statement considered harmful,” written by Niklaus Wirth (bottom), then editor of Communications of the ACM. The paper contributed to the development of better structured computer programs.

Image source: Wikipedia

Public-key Cryptography

The idea of public-key cryptography was invented by James H. Ellis (top) at the British communication intelligence agency GCHQ at Cheltenham in the late 1960s. The mathematical solution was found in 1973 by Clifford Cocks (bottom). They were, however, employed by a top-secret institution and could not publish their work. Consequently the honor has largely gone to two American teams that, respectively, invented the Diffie-Hellman-Merkle key exchange concept (in 1976) and the Rivest-Shamir-Adleman (RSA) algorithm (in 1977).

Image source: Unknown

IC Goes to Moon

The Apollo Guidance Computer used in the lunar landing program was designed in the early 1960s and was the first computer to include integrated circuits (top: display & input unit). There were 2048 ICs, each with two 3-input NOR gates. The clock frequency for internal operations was 1.024 MHz. It had 2048 words of erasable magnetic core memory with 16-bit word length. AGC reached the moon with the lunar module of Apollo 11 in July 1969.

Image source: Wikipedia

Nova 1200

The Data General Nova 1200 minicomputer was released in 1969. Quite a number of science and engineering students in the 1970s became familiar it, since it was an advanced low-cost solution. The 16-bit processor was built on only two 15x15" PCBs and mounted in a single rack unit, which contributed to its low cost. It had typically a 32 kB core memory. The input/output unit was a teleprinter, and a paper tape punched in ASCII code was the external memory medium. The earliest Novas came with a BASIC interpreter on paper tape.

Image source: Wikipedia

Liquid Crystal Displays

The Swiss company Hoffman-LaRoche filed a Swiss patent application for twisted nematic (TN) field effect liquid crystals in 1970. A similar application was filed in 1971 in the US by James Fergason et al. The first TN-LCDs were produced the same year by Ferguson's company ILIXCO. By the 1990s, TN-LCD's were largely universal in portable electronics. In 2007 worldwide sale of LCD displays surpassed that of CRT displays.*

Image source: Wikipedia

*) RCA worked on both dynamic and TN LCDs in the 1960s, but the research effort was killed by skeptical company managers

Pocket Calculators

The first hand-held calculator, built using LSI circuits, was Canon's Pocketronic (shown). It was introduced on the Japanese market in fall 1970. It lacked an electronic display, the output was instead on a thermal paper tape. The first truly pocket-sized calculator was the four-function Busicom LE-120A, "Handy LE," introduced in January 1971 and priced at $395. It was built using Mostek's MK6010 "calculator on a chip" and had a 12-digit LED display.

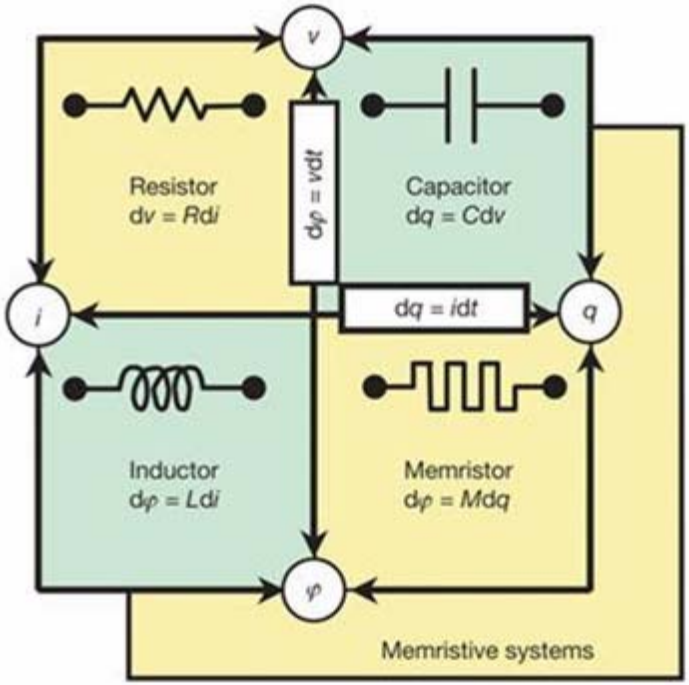
Image source: Unknown

The “at” Symbol

In 1971, Raymond Tomlinson, programmer at Bolt, Beranek & Newman (now part of Raytheon), decided to insert the @ symbol in computer network addresses to separate the user from the terminal. The symbol is much older though. According to some sources it may have been used by monks already in the sixth century to avoid confusion between the Latin word ad (“at,” “toward”) and the abbreviation AD (“Anno Domini”).*

**) Tomlinson is credited with having sent the first ever e-mail in 1971 (over ARPANET, to another computer beside him)*

The Memristor



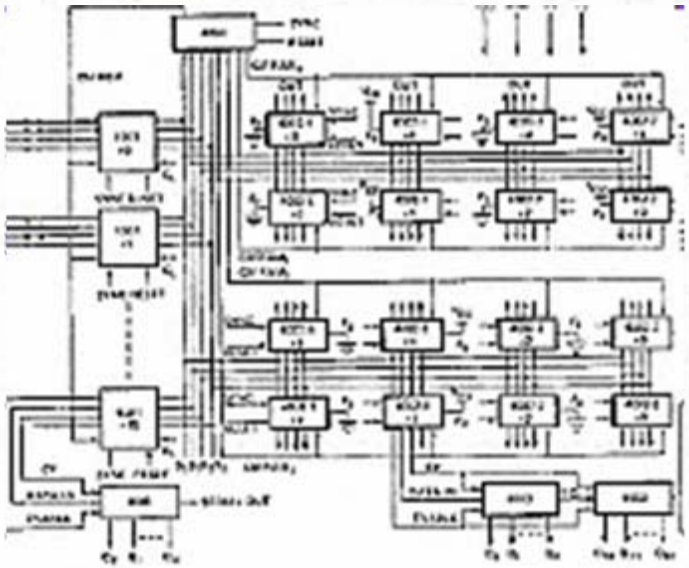
Symmetry considerations led in 1971 Leon Chou at Berkeley to suggest that in addition to the three fundamental passive electrical elements (resistor, capacitor, inductor) there should be a fourth, which should have the ability to remember the charge that has passed through it. He called it memristor (memory resistor). In 2008 researchers at Hewlett-Packard Labs found the missing element on the nanoscale. It raised hopes that memristors can, among other things, become important in computer technology.

Image source: HP Labs

Creeper, the First Computer Virus

The history of computer malware begin in 1971 when Bob Thomas at BBN Technologies wrote a self-replicating program that infected DEC PDP-10 computers running the Tenex operating system. Creeper gained access over ARPANET, the forerunner of Internet. It copied itself to the remote system where the message, "I'm the creeper, catch me if you can!" was displayed. As a countermeasure, the Reaper program was created to delete Creeper. By today's convention Creeper was a worm, not a virus.

Intel 4004



The first advertisement for a microprocessor, the Intel 4004, appeared in Electronic News in 1971 (November 15, 1971 is generally regarded as the birth date even if the circuit was used some months earlier). Developed for Busicom, a Japanese calculator maker, the 4004 had 2250 transistors and could perform up to 90,000 operations per second in four-bit chunks (i.e., the instruction cycle was 11 μs and the word length half a byte).

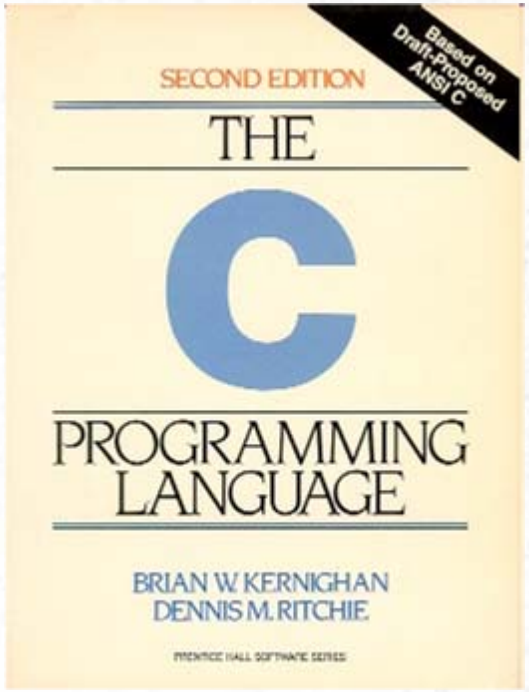
Image source: Computer History Museum

Floppy Disks

The earliest floppy disk data storage media, invented at IBM, were 8 inches in diameter. They became commercially available in 1971. In 1976 Shugart Associates introduced the first 5¼-inch FDD and associated media. By the mid-1990s the 5¼-inch drives had given way to the 3½-inch disk. The most popular version of the 3½ -inch floppy disk had a capacity of 1.44 MB. High-capacity floppies were developed but did not succeed due to competition from CD-ROMs and USB flash drives.

Image source: Wikipedia

C



The C programming language was released in 1972. It was developed by Dennis Ritchie at Bell Telephone Laboratories (Bell Labs) for use with the newly developed UNIX operating system. It remains one of the most popular programming languages, although more recent programs (C++, Java, etc.) aim at overcoming inherent weaknesses of C.

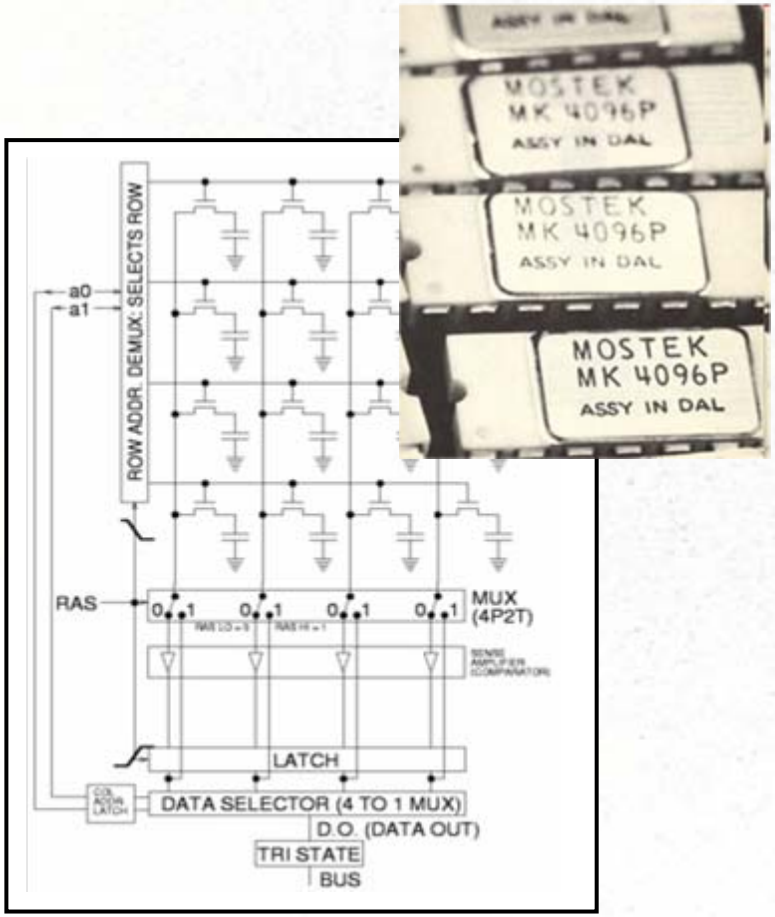
Image source: Wikipedia

Fly-by-Wire

The first digital fly-by-wire aircraft was a modified NASA F-8C Crusader that flew in 1972, mirrored in the USSR by the Sukhoi T-4. The experimental system on the Crusader testbed was based on the Apollo Guidance System form the 1960s. Problems with pilot induced oscillations in FBW systems became apparent to the general public in 1993, when a Swedish JAS Gripen crashed after the pilot ejected during a show over central Stockholm.

Image source: Wikipedia

Mostek MK4096



Intel was the first company to offer DRAM memories in 1970. In 1973 Mostek put out a 4-kilobit DRAM that would lead the way for years to come. The fight was between the 16-pin configuration of the MK4096 and the 22-pin memory configuration used by Texas Instruments, Intel, and Motorola. Mostek went off as the winner after an aggressive public-relations campaign.

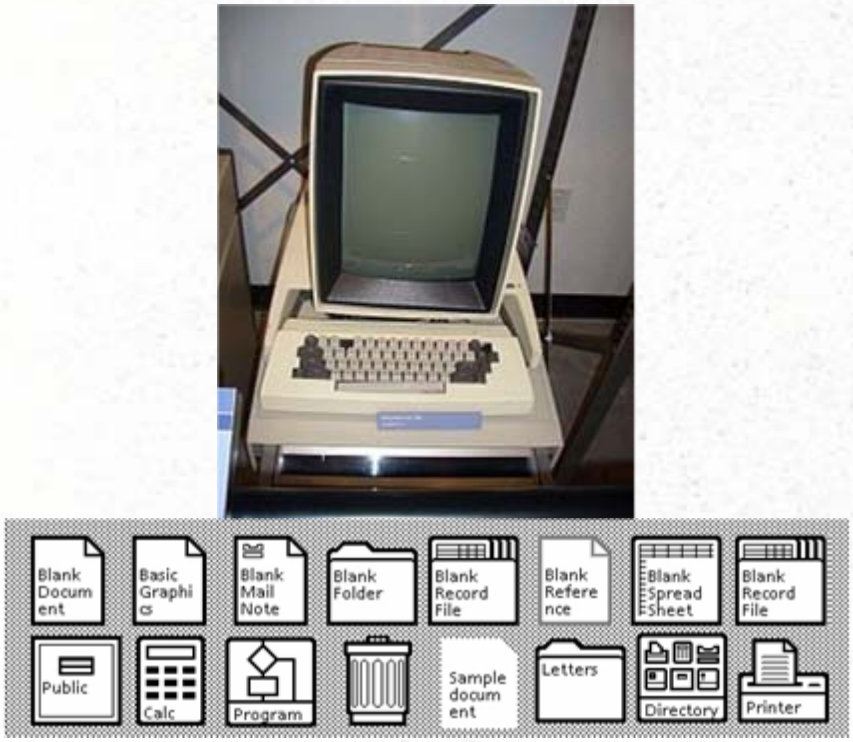
Image source: Wikipedia & Mostek

Ethernet

Xerox PARC (Palo Alto Research Center) began work on Ethernet technology in 1973. In 1975 Xerox filed for a patent for the invention, it was issued in 1977 as US Patent 4,063,220. The work would form a framework for the computer network technology for future local area networks (LANs). The photo shows an RJ45 connector that is used in the most common cat5 cable.

Image source: Wikipedia

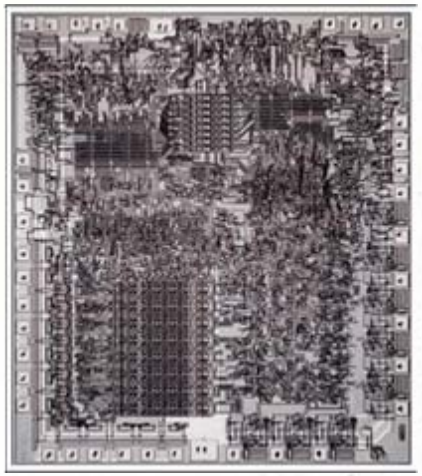
Icons and GUIs

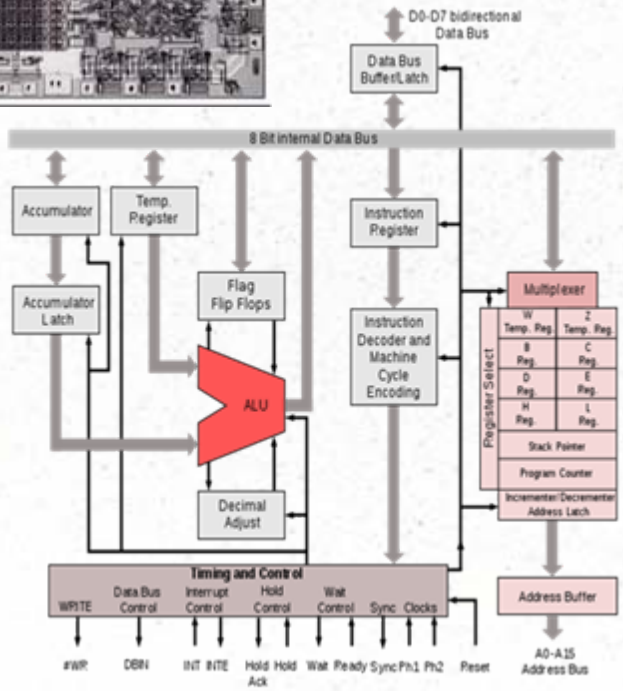


The Xerox Alto personal computer (top), released in 1973, introduced the public to graphical user interfaces (GUIs) and icons (bottom). Steve Jobs visited Xerox PARC and was given a presentation on GUIs. The result was Apple Lisa (introduced in 1983), which popularized GUIs in personal computers and made Apple a success story. Question: 40 years after Xerox Alto, Linux still retains a command line interface in its terminal. Is this a reason to the limited popularity of Linux in desktops?

Image source: Wikipedia

Intel 8080

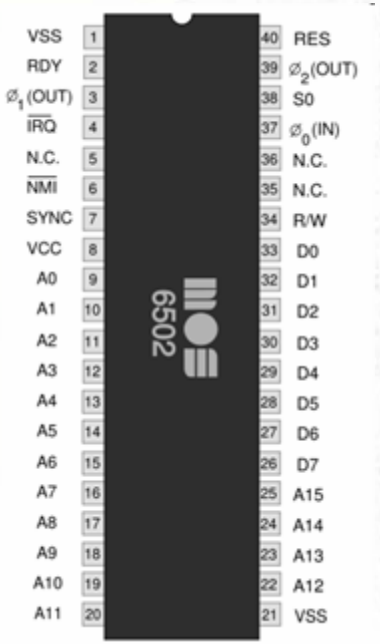




In 1974 Intel introduced the 8080. With roughly 5,000 transistors and 2 MHz clock speed it was the heart of the Altair personal computer. Its predecessors were Intel 4004, the 4-bit CPU released in 1971, and Intel 8008, a byte-oriented microprocessor released in 1972.

Image source: Intel

MOS Technology 6502



MOS Technology introduced an elegant 8-bit processor, the 6502, in 1975. It sold for only $25 at a time when the similar but slower Intel 8080 and Motorola 6800 cost $179. The secret behind the low cost was a fabrication process that "yielded 10 times as many good chips as the competition." The 6502 almost single-handed forced processor prices to drop, helping launch the personal computer revolution. It was used e.g. in the Apple II tabletop computer.

Image source: Unknown

RISC

In 1975, a team at IBM decided to build a new minicomputer architecture from the ground up. They would use only simple instructions that could be executed one per cycle. However, their work does not seem to have made a real impact. More important was the 1981-84 RISC project at the University of California, Berkeley, lead by David Patterson. He also coined the term RISC (Reduced Instruction Set Computer). An early application was the SPARC processor of the Sun-4 workstation from 1987. Today RISC computers are used in smartphones and supercomputers alike.*

*) *See the slide on ARM architecture later in the presentation.*

Image source: Wikipedia

The First Digital Camera

The first digital camera was built in 1975 by Steven Sasson, an engineer at Eastman Kodak (shown with his invention and a modern digital camera). The camera weighed 3,6 kilos and needed 23 seconds to produce a 10,000 pixel black-and-white picture. The memory device was a cassette recording tape. Sasson's employer, however, was slow in adapting to the digital age and as a result Kodak is today only a shadow of its glorious past. Kodak filed for Chapter 11 bankruptcy protection in early 2012.

Image source: Unknown

Altair 8800

The MITS Altair 8800 was a microcomputer design from 1975, based on the Intel 8080 CPU and sold as a mail-order kit. Today the Altair is widely recognized as the spark that led to the personal computer revolution of the next few years: The computer bus designed for the Altair was to become a de facto standard in the form of the S-100, and the first programming language for the machine was Microsoft's founding product, Altair BASIC.

Image source: Wikipedia

H. Edward Roberts, The Man Behind Altair

There are reasonable claims that H. Edward Roberts, founder of MITS, deserves credit as the inventor of the personal computer. He was a classic hobbyist entrepreneur who built a little business, sold it in 1977 to become a millionaire, and went on to study medicine and become a country doctor. According to him, Bill Gates was "a very bright kid, but he was a constant headache at MITS. You couldn't reason with him, he did things his way or not at all."

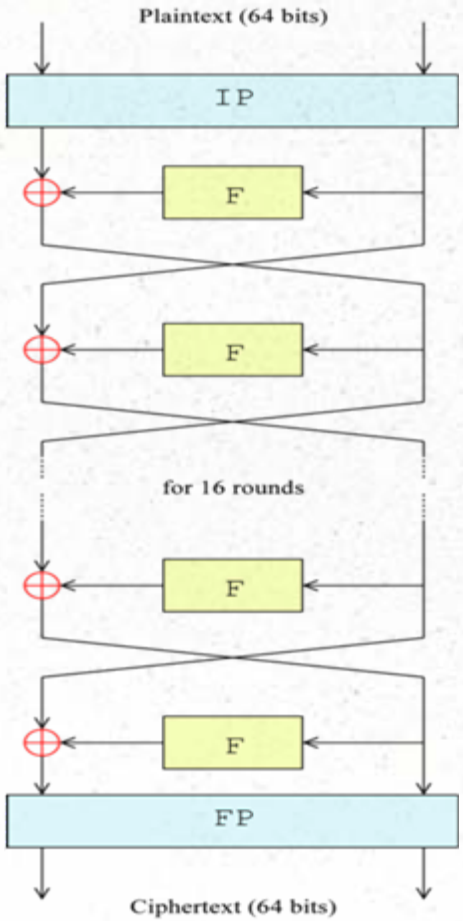
Image source: Unknown

Birth of "Big Brother"

The Orwellian "Big Brother" society was born around 1975, when Inslaw, Inc. delivered the Prosecutor's Management Information System (PROMIS) to the US Department of Justice. PROMIS is able to utilize databases written in different software languages and running on different operating systems. It is a controversial system that has been acquired by foreign intelligence services – sold with backdoors for the NSA. Al-Qaeda is said to have bought a copy on the Russian black market. Fear and murders are part of its myths.

Image source: Wikipedia/US DoJ

Data Encryption Standard



The symmetric-key DES algorithm was selected by the US National Bureau of Standards as a federal encryption standard in 1976. It was based on Lucifer, an algorithm invented by IBM scientist Horst Feistel, and used only 56-bits in its key, which was seen as a backdoor required by the NSA. The weakness was finally proven beyond doubt in 1997, when a team of computer scientists, and thousands of volunteers who run software in the background on their computers, broke a DES message.

Image source: Wikipedia

Apple/Macintosh Computers

The Apple II computer, introduced in 1977, was among the first successful personal computers. The original Apple II operating system was only a built-in BASIC interpreter contained in a ROM. Macintosh (shown together with the original Apple logo) was introduced in 1984 (a year after Lisa, see earlier slide). It was the first commercially successful personal computer to use images (GUIs with icons), rather than text (command lines), to interface with the user. It eclipsed the Apple II series in 1993.

Image source: Wikipedia

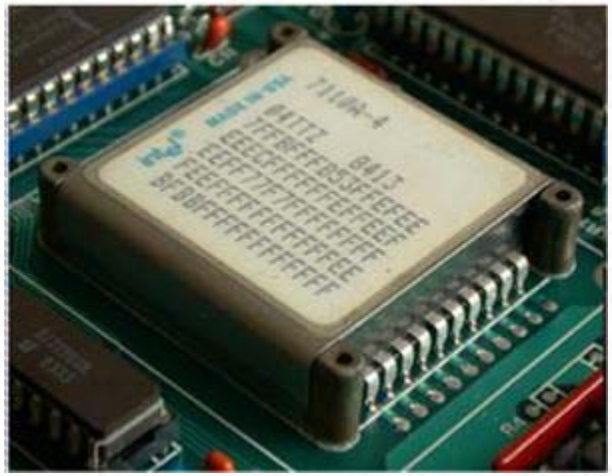
The Once-Bitten Apple

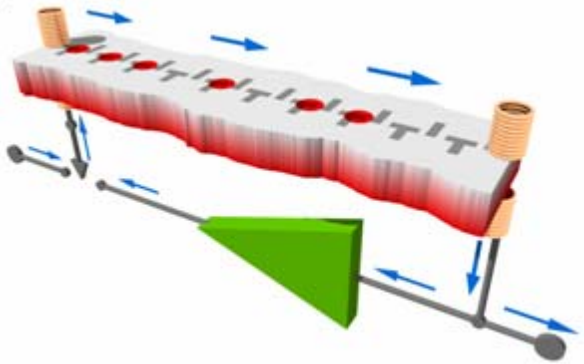
The once-bitten apple, Apples modern logo, is a traditional symbol of sin. But it also reminds of the death of Alan Turing: In 1952, Turing was arrested for a homosexual relation, a criminal offence at the time in Britain. The official persecution became too much for Turing. In 1954 he prepared a cyanide potion, injected it into an apple and took a bite. He was dead within minutes. The funeral of one of greatest in computer history was attended by only four people, one of them being his mother.*

Image source: Wikipedia

**) Simon Singh, in "The Code Book," claims that Turing dipped the apple into cyanide, like the Wicked Witch in Snow White did. However, the suicide theory has been contested by professor Jack Copeland.*

The Magnetic Bubble Memory





Bubble memory is a type of non-volatile computer memory that uses a thin film of a magnetic material to hold small magnetized areas, known as bubbles or domains, each of which stores one bit of data. It started out as a promising technology in the 1970s, but encountered reliability and scaling problems and also failed commercially as hard disk prices fell rapidly in the 1980s. A further nail in the coffin was the development of faster and less expensive EEPROM semiconductor memories.

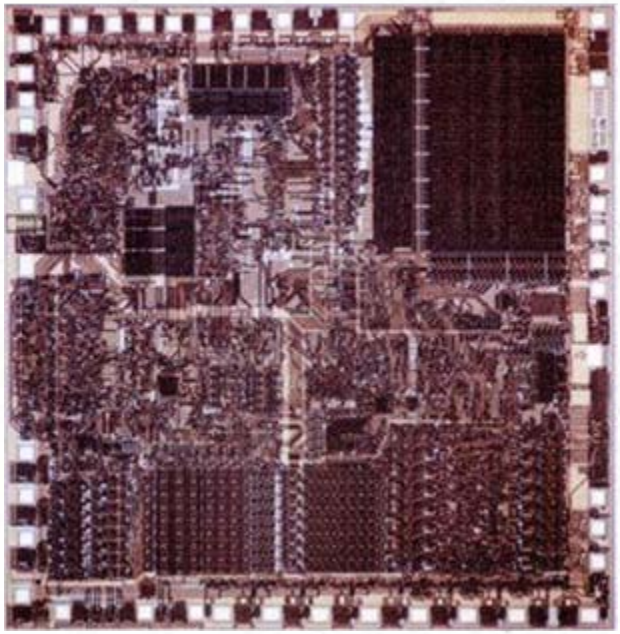
Image source: Wikipedia/Wikimedia

A Not-so-Accurate Prediction

”There is no reason why anyone would want a computer in their home.”

Ken Olsson, president, chairman, and founder of Digital Equipment Corp., 1977

Intel 8086 & x86 Architecture



In 1978 Intel introduced the 8086 chip, a 16-bit microprocessor containing 29,000 transistors and built as an extension of the 8-bit 8008 and 8080 processors. It established what later became known as the x86 instruction set architecture that still predominates among today's chips – though not in embedded systems – but is hard pressed by ARM's RISC architecture (see below). Major competitors were the 16/32-bit Motorola 68000 and 16-bit Zilog Z8000.

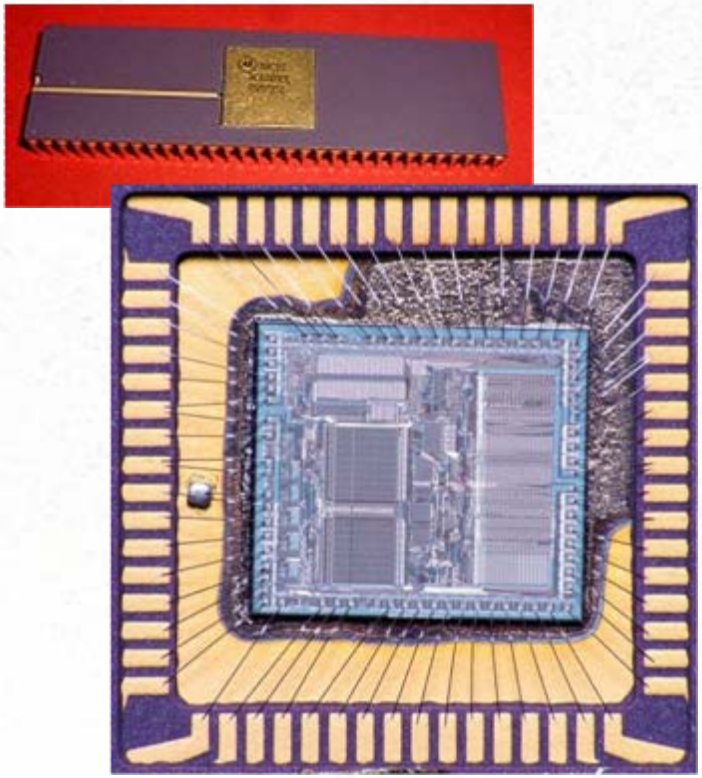
Image sources: Intel & Wikipedia

The Computer "Worm"

In 1979 John Shoch and Jon Hupp at the Xerox PARC discovered the computer "worm," a short program that searches a network for idle processors. Initially designed to provide more efficient use of computers and for testing, the worm had the unintended effect of invading networked computers, creating a security threat. Shoch took the term worm from the book "The Shockwave Rider," by John Brunner, in which an omnipotent "tapeworm" program runs loose through a network of computers.

Image source: Computer History Museum

Motorola 68000



Motorola's 68000 microprocessor, introduced in 1979, had 68,000 transistors and powered the Macintosh 128K computer. Chips have several layers; shown here is the layer of wires that link transistors (central blue square). Larger wires around the chip connect it to the surrounding integrated-circuit package. The 68000 is famous as the loser in IBM's selection of a processor for what was to become its PC (see below). Intel's 8088 was the winner and as a result we still have the Microsoft-Intel PC duopoly.

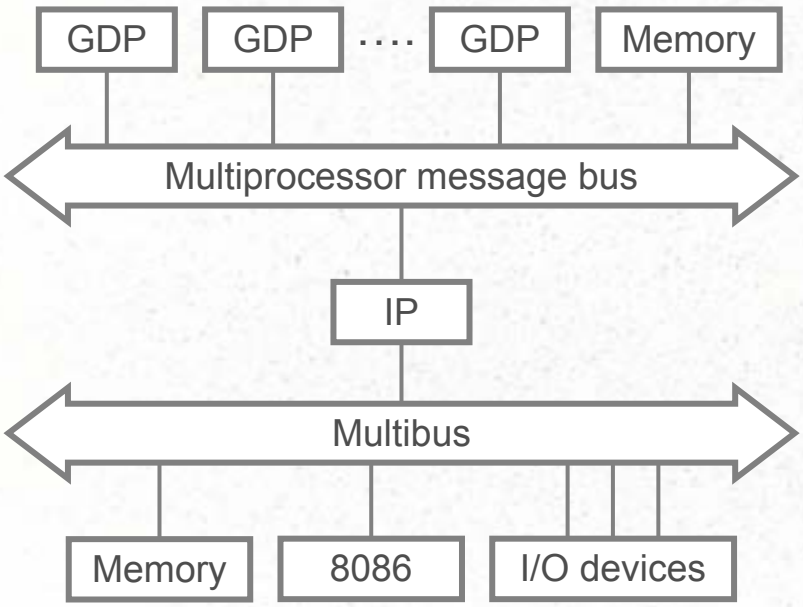
Image source: Wikipedia/William Blair

Birth of ASIC and FPLA

Around 1980, the British company Ferranti introduces a gate array integrated circuit, the Uncommitted Logic Array. It was used in Sinclair's 8-bit ZX81 (pictured) and ZX Spectrum low-end home computers, released in 1981 and 1983 respectively. Ferranti did not push on development in the field, but the ULA is generally regarded as the forerunner of today's ASIC and FPLA technologies. Ferranti went bankrupt in 1993 after losses from a failed acquisition.

Image source: Wikipedia

Intel iAPX 432



Legend: GDP = General Data Processor, IP = Interface Processor

Intel wanted to make a leap in processor design with an ambitious 32-bit, multi-chip architecture called iAPX 432 (Intel Advanced Processor architecture, a.k.a. Intel 8800), which it introduced in 1981. The concept led however to an unacceptably slow processor and iAPX became a major failure that nearly broke the back of Intel. As a result Intel refocused its efforts on the x86 architecture (see above). Today Intel prefers to forget the failure and its corporate website does not mention iAPX 432.

Image source: Dr.EW based on unknown lecture script

The IBM PC

*1981 became a watershed year in personal computing, because it brought computer giant IBM into the PC arena. The IBM PC was release in August 1981. It was built around an Intel 8088 processor clocked at 4.77 MHz. The operating system was primarily PC-DOS, a co-development between IBM and Microsoft. It also had one or two 5¼" floppy disk drives. It was released as an open architecture, which made it possible for other manufacturers to reverse-engineer clones. This led to rapidly lowering prices and immense popularity.**

*) IBM sold its PC business to the Chinese Lenovo Group Ltd. in 2005.

Image source: Wikipedia

Osborne 1

Osborne 1 was the first commercially successful portable microcomputer, introduced in April 1981 by Osborne Computer Corporation. It weighed 23.5 pounds (10.7 kg), cost US$1795, and ran the then-popular CP/M 2.2 operating system. Its principal deficiencies were a tiny 5 inch display screen and single sided, single density floppy disk drives whose disks could not contain sufficient data for practical business applications.

Image source: Wikipedia

The First Laptop

The Epson HX-20 was announced in November 1981, although it first sold widely in 1983. With a weight of only 1.6 kg, it is generally considered both the first notebook and handheld computer. It had 16 kB of RAM but could be connected to an external floppy drive. The operating system consisted of the EPSON BASIC interpreter and a system monitor program. Its 120x32 pixel LCD display (small even for cell phones today) allowed four lines of 20 characters to be displayed.

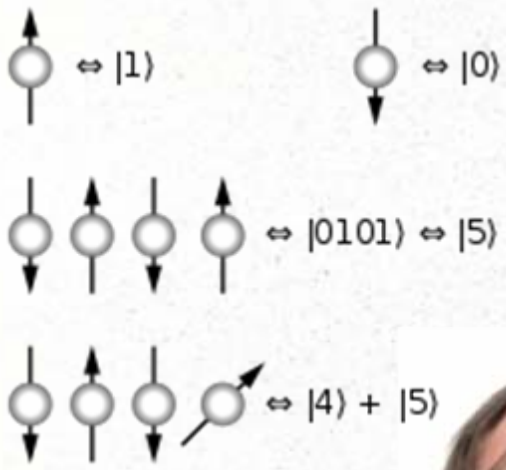
Image source: Wikipedia

MS-DOS

In 1981 Microsoft bought a CP/M clone called 86-DOS from Seattle Computer Products and continued its development under a contract from IBM. The first version of MS-DOS (which IBM called PC-DOS) was released in 1982. It became popular in IBM PC clones in part due to being offered at a lower price than its principal competitor, CP/M from Digital Research. MS-DOS was displaced by Windows; the latest stable release of MS-DOS was in 2000.

Image source: Wikipedia

Quantum Computing



Physicist Richard Feynman suggested in 1981 (some say 1982) that if quantum properties could be "read" and set, a computer could use an electron, photon, or other particle to store not just a single 1 or 0, but a number of values at once. In 1985, David Deutsch at Oxford University (picture) created the design for such a quantum computer, including an algorithm to be run on it. But despite massive research an undisputed quantum computer still remains at large.

Image source: Wikipedia

The Transputer & Occam

The Transputer was a short-lived and commercially failed program by British semiconductor manufacturer INMOS. It aimed at revolutionizing concurrent processing. The first prototype was completed in 1982, the company was finished in 1989. The program was a dual effort, with the Transputer being the hardware part, built to execute the Occam software. Although it failed, the effort contributed to improving parallelism in ordinary CPUs.

Image source: Wikipedia

The First Public Network

The French Minitel project was an ambitious program aimed at providing all French access to information on a computer network. It opened as a national telephone book in 1982, but gradually evolved into provide banking services, travel reservations, weather reports, etc. At its peak, some nine million French households had been issued a Minitel set for free. However, it was not an open platform and politics limited the offered information. As a result, the utility of Minitel diminished with the growth of the worldwide web and it was was terminated in 2012.

Image source: Musee de l'Informatique

The FGCS Project

The Fifth Generation Computer System program started in 1982 and aimed at giving Japan the lead in computer technology by developing a massively parallel computer. Ten years and $400 million later it was declared a failure. It failed for numerous reasons, most notably due to the difficulty of predicting technology development: concurrent processing became less important as CPUs developed, the growing importance of GUIs, the emergence of Internet, etc.

Image source: Unknown

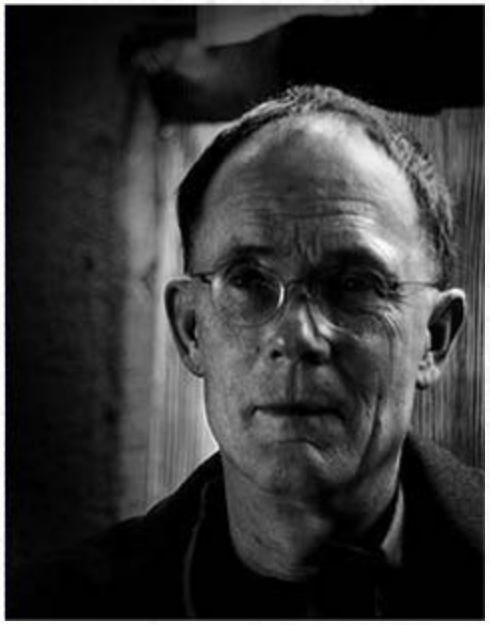
“GNU’s Not UNIX”

FREE SOFTWARE FOUNDATION

MIT programming wiz kid Richard Stallman grew mad at the high license fees that Bell Laboratories asked for the UNIX operating system. In 1984 he set up the Free Software Foundation. Its main undertaking would be the GNU project, a UNIX clone with no ties to Bell, and which would be distributed for free. By 1990 most components were ready. An exception was the kernel of the OS. The missing part would be provided the next year by a Finnish student.

Image source: Wikipedia

“Cyberspace”



Science fiction author William Gibson used the term “cyberspace” in 1982 and it became popular through his 1984 novel Neuromancer. In current usage "cyberspace" stands for the global network of interdependent information technology infrastructures, telecommunications networks and computer processing systems. The term has become a conventional way of describing anything associated with the Internet and the diverse Internet culture.

Image source: Wikipedia

Scientific Computing

Scientific computing is said to have started with a paper published by John von Neumann (born János Neumann) and Herman Goldstine in 1947. In the 1980s, commercial software packages became available, most notably Matlab, Mathcad, and Mathematica. Open-source solutions are increasingly popular due to the high license fees asked for commercial programs. Examples are GNU Octave, SciLab, FreeMat, Python(x,y), and Sage. The two first mentioned are similar to Matlab, Octave more so.

Image source: Wikipedia

Quantum Cryptography

Quantum cryptography (QC) was invented in 1984 – the same year as quantum computing – by Gilles Brassard (left) and Charles Bennett (right). A year later they proudly announced that no technology will allow their encryption method to be cracked as long as laws of physics prevail. In 2008, a Swedish professor and his graduate student pointed to a potential weakness in QC; later various research teams have been able to hack the key in practice. "Sic transit gloria mundi."

Image source: Unknown

Handheld Computers

Two names are often mentioned as ancestors of today's handheld computers, including smartphones: Psion Organizer and Palm Pilot. Organizer I was launched in 1984, but it is Organizer II from 1986 (top left) that is mostly mentioned. A decade later the next step was taken: Palm Pilot with a clean GUI (right bottom, early model). However, neither included mobile communication. This allowed Nokia to spearhead the next evolution with its Communicator, also introduced in 1996 (see slide below).

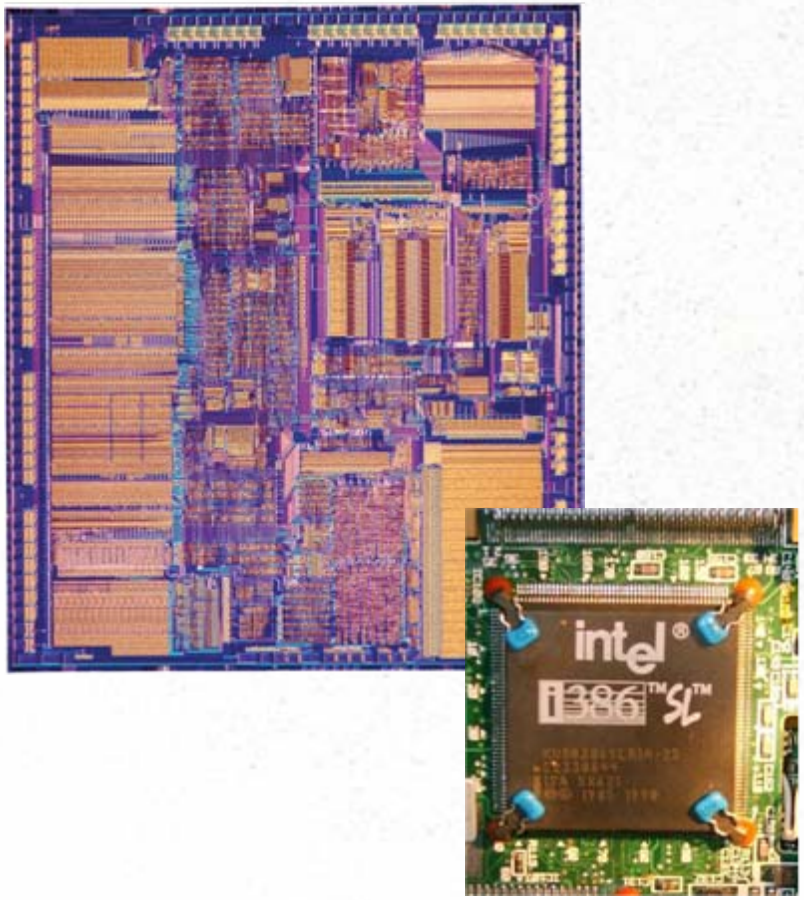
Image source: Unknown

Windows

Microsoft introduced the Windows operating environment as an add-on to MS-DOS in November 1985. It was in response to growing interest in graphical user interfaces (GUIs), an area into which competitor Apple had entered first. Today Windows dominates the market for microcomputer operating systems. The picture shows a screenshot of Windows Vista, a less successful version that was released worldwide in January 2007.

Screenshot: Dr.EW

Intel 386



Intel's 386, released in 1985, had 275,000 transistors and allowed a computer to work on multiple applications at the same time. Technical problems forced Intel to reduce the clock frequency from 16 to 12 MHz, and also to limit its use to 16 instead of 32-bit software. The 386 was popular in embedded systems long after it vanished from desktops and was produced until 2007. Its successor, the 486, was Intel's first chip with a data cache, which stored a subset of memory onboard for faster processing.

Image source: Intel

van Eck Phreaking

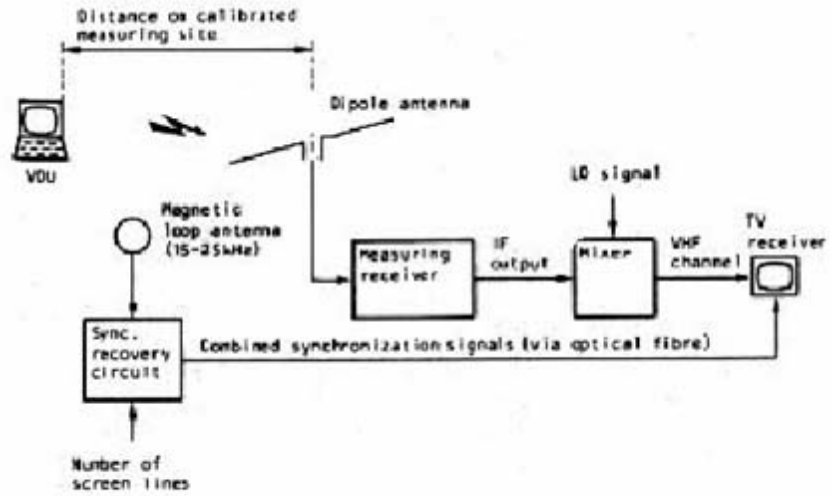
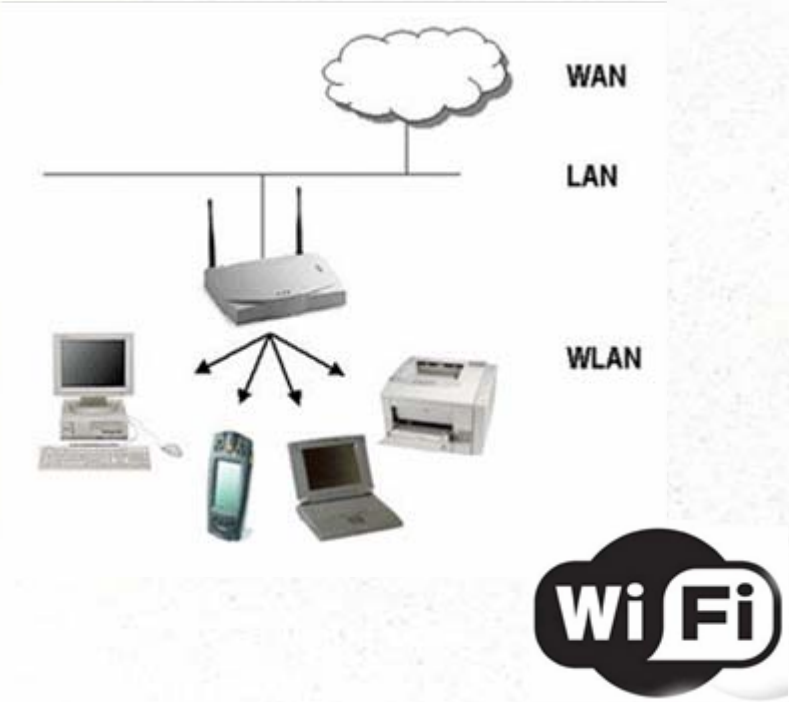


Fig. 2. Measurement set-up

Dutch engineer Wim van Eck published in 1985 a paper on security risks of emission from computer displays. Using a television set, antenna and equipment worth $15, he was able to eavesdrop on real systems at distances of hundreds of meters – later known as van Eck phreaking. van Eck's work was the first unclassified account of what had been a closely guarded government domain: TEMPEST (see earlier slide). The figure shows van Eck's equipment setup.

Image source: Unknown

IEEE 802.11 & WLAN / WiFi

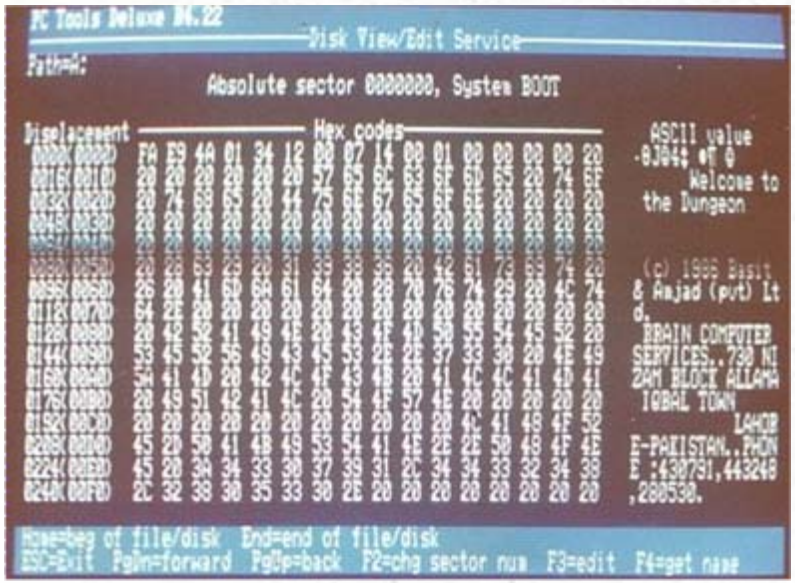


*) Australian claims that they invented Wi-Fi are not entirely unsubstantiated

The US Federal Communications Commission released in 1985 the ISM band for unlicensed use. This paved way for the development that led to the IEEE 802.11 standard and wireless local area networks (WLAN). The related and trademarked Wi-Fi (wideband fidelity) technology is controversial with numerous legal battles over patent infringements. The fact however remains that WLAN / Wi-Fi have become an important part of mobile computing.*

Image source: The Wi-Fi Consortium & Unknown

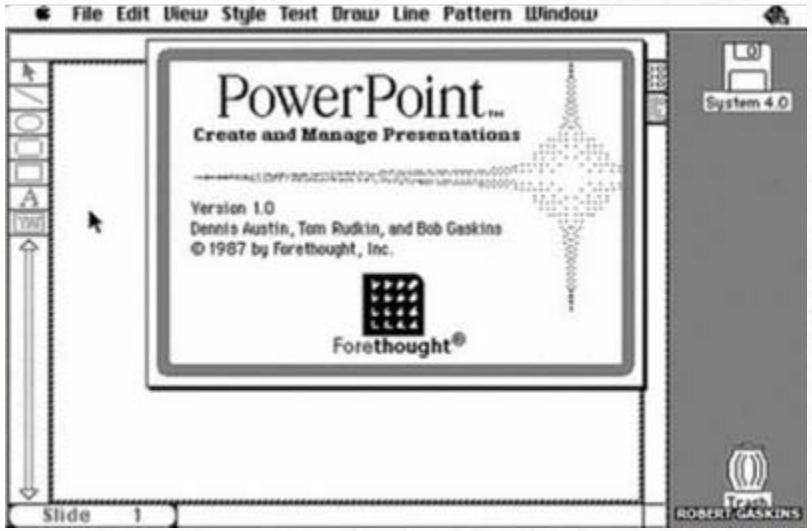
Brain, the First PC Virus



Microsoft encountered the malware curse in earnest on January 19, 1986, when Pakistani brothers B.F. and A.F. Alvi released the Brain virus. It exploited MS-DOS boot sector weaknesses on the IBM PC. It relied on people exchanging infected floppy disks and therefore took months to spread. Although it had some advanced features (stealth, rootkit attack, etc.), it's major effect was to change the disk label (the "name" of the disk) to read "©Brain."

Image source: Unknown

PowerPoint



The word "powerpoint" has become a household name and synonymous with slide presentations. The PowerPoint software was originally developed by Silicon Valley start-up Forethought. It was first released in early 1987 (screenshot of Version 1.0 shown) and run only on Macintosh computers. Six months later Microsoft bought Forethought for $14 million. PowerPoint was officially launched as a Microsoft product in 1990. (See later slide for critical comment on powerpoints.)

Image source: BBC

ARM Architecture

Just about every mobile phone today utilizes the ARM (formerly Advanced RISC Machine and Acorn RISC Machine) architecture. Its roots go back to 1987, when Acorn Computers launched a personal computer called Acorn Archimedes (development commenced in 1983). Archimedes did not however see commercial success and the company's ARM department became an independent business unit in 1990. In January 2011 ARM claimed that over 15 billion ARM processors had been shipped.

Image source: Unknown

64,000 Processors in Parallel

In 1987, Thinking Machines released its CM-2 supercomputer, in which 64,000 simple processors run simultaneously, and could form connections dynamically, somewhat like the process in the human brain. These "massively parallel" machines are thus attractive for artificial intelligence research. The company declared bankruptcy in 1994, but its impact on computing was significant.

Credit: ©Thinking Machines Corporation, 1987.
Photo: Steve Grohe

A Not-so-Accurate Prediction

"I believe OS/2 is destined to be the most important operating system, and possibly program, of all time."

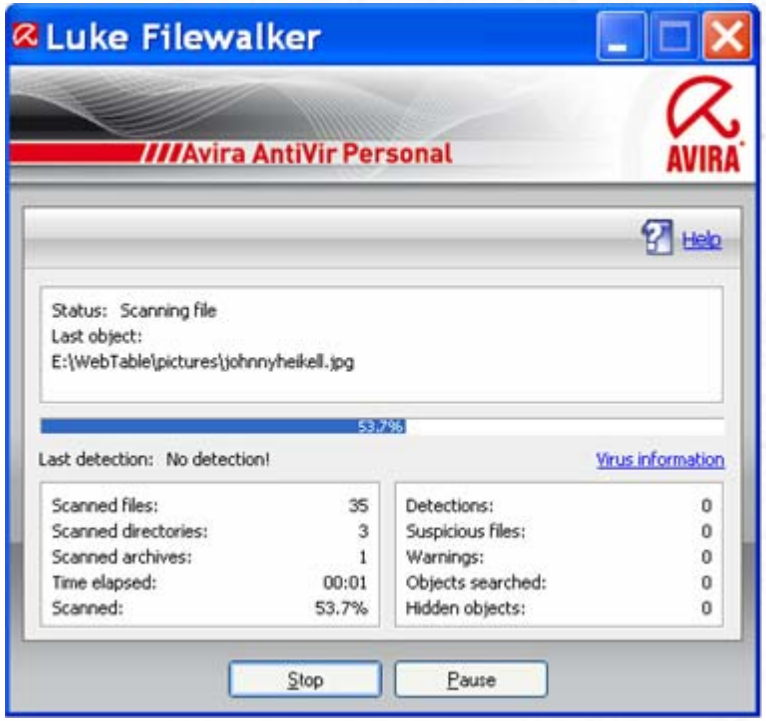
Bill Gates, 1987

The First Worm

Computer worms are self-contained programs that spread without human interference (see earlier slide). The Morris Worm is generally seen as the first of its kind. It was released on November 2, 1988 by Cornell University graduate student Robert Tappan Morris (pictured) and caused damages estimated between $10 and $100 million. Morris was the first person indicted under the U.S. Computer Fraud and Abuse Act, He later became a professor at MIT.

Image source:

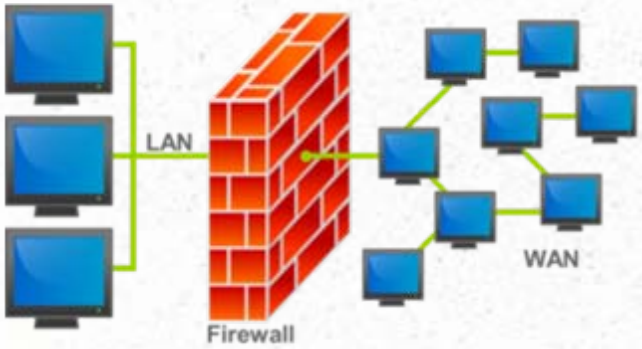
Security Programs: Antivirus



Reaper was the first program developed to clean a computer virus (the Creeper worm in 1971, see earlier slide). The exact development of general-purpose antivirus/anti-malware programs is unknown, but by 1988 several commercial antivirus programs were offered, among them the German Avira AntiVir. Today AntiVir is one of the most popular freeware (adware) antivirus solutions.

Screenshot: Dr.EW

Security Programs: Firewalls



Firewalls developed in parallel with anti-malware programs. The firewall inspects network traffic passing through it, and denies or permits passage based on a set of rules. The first paper published on firewall technology was in 1988 by engineers at DEC. Today the Windows operating system is delivered with a firewall, but more advanced solutions can be obtained from third-party sources.

Image source: Wikipedia

World Wide Web

Tim Berners-Lee, a physicist/ programmer at CERN struggled with sharing information among incompatible computers. In 1989 he used existing ideas of hypertext and Internet to create the first World Wide Web pages. The rest, as they say, is history. In 1994 Berners-Lee founded the World Wide Web Consortium (W3C) as a body to standardize and shape the evolution of the Web.

Image source: Wikipedia

Web Search Engines

Alan Emtage, a student at McGill University in Montreal, created the very first tool used for searching on the (pre-web) Internet in 1990. It was called Archie, for "archive" without the "v." Google, the presently dominant search engine, rose to prominence around 2000. The company achieved better results for many searches with an innovation called PageRank, an iterative algorithm that ranks web pages based on specific criteria.

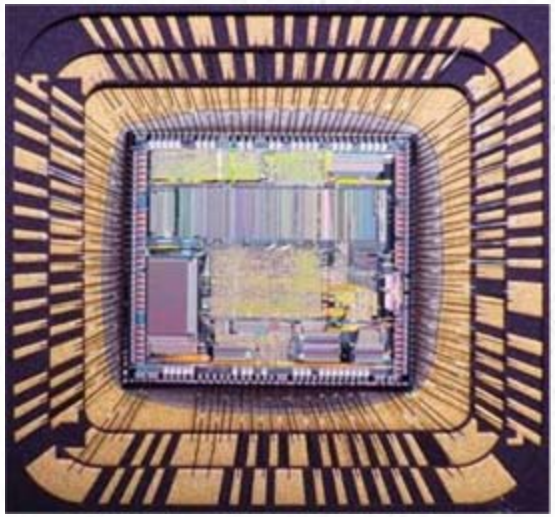
Image source: Wikipedia

Python

Guido van Rossum, Dutch computer scientist, released the first version of Python in 1990. It is a relatively simple but powerful scripting language (scripting languages are typically used for system housekeeping, rather than for data processing). Other well-known scripting programs are Perl and Ruby. Python is developed as an open-source product, managed by the non-profit Python Software Foundation. Python 3.0 was released late in 2008 and caused an upheaval since it is not downward compatible with earlier versions.

Image source: Wikipedia/The Python Software Foundation

AMD 386



In 1991 AMD released a 386 clone, called Am386, with approximately 200,000 transistors. The Am386 was 100%-compatible with the Intel 80386 design and sold in millions of units, thereby positioning AMD as a legitimate competitor to Intel, and helped in bringing competition to the industry. The Am386 could outperform Intel's 386 (and partly even the later 486) despite the lower number of transistors (see later slide on the misconception about the number of transistors).

Photo by: William Blair

PGP

For as long as electronic communication has existed, governments have used this information channel to spy on each other and on citizens. Worried about people's liberty and privacy, Philip Zimmerman wrote in 1991 an e-mail encryption program that he called Pretty Good Privacy (PGP). After some legal controversies it has seen widespread use, but there is – and will remain – suspicion that public encryption methods are not "government safe."

Image source: Wikipedia

Linux

In 1991 a student at Helsinki University, Linus Torvalds, developed the kernel that the GNU UNIX clone lacked. It was named Linux and turned into the single most important component of the open-source movement. Even so, Linux (the word is now associated with the entire GNU/Linux operating system) remains chiefly used in servers, while its market share in home and enterprise desktops is low. One reason is that PC suppliers sell their computers with Windows, but not Linux, installed.

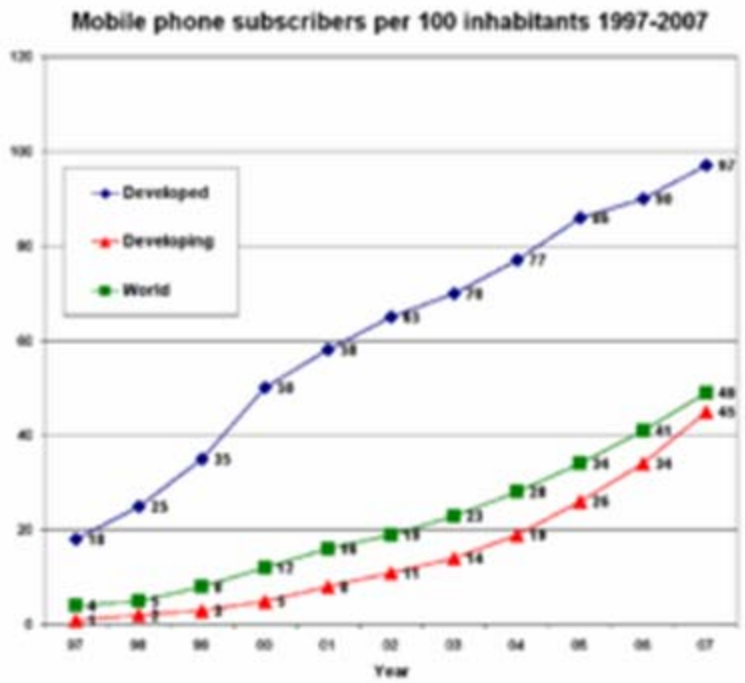
Inage source: Wikipedia

A Not-so-Accurate Prediction

"… and it probably never will support anything other than AT-harddisks, …"

Linus Torvalds in his Linux release note from August 26, 1991

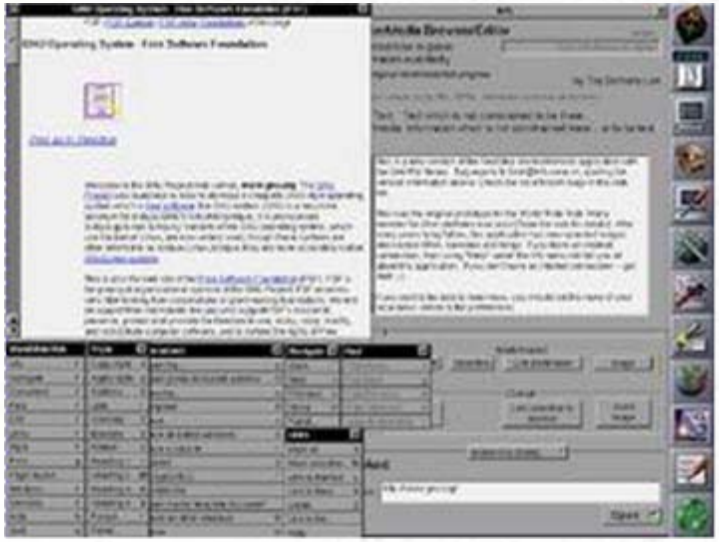
Digital Mobile Phones



Computer technology entered mobile/cellular phones in 1991, when Radiolinja in Finland launched the first "modern" network based on digital 2G (second generation) GSM cellular technology. 2D communication was an immediate success, leading in part to overoptimistic expectations for 3D technology and the “dot-com bubble” a decade later (see slide below).

Inage source: Wikipedia

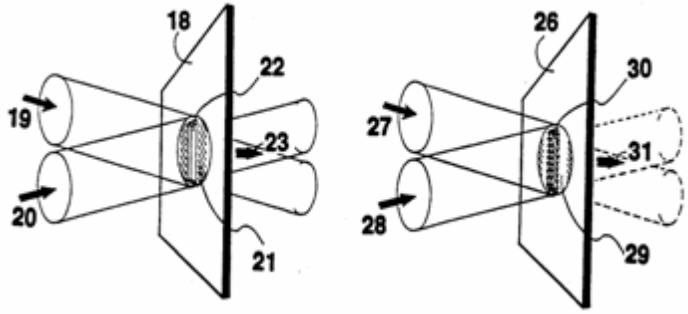
Web Browsing



The World Wide Web for the NeXT computer (screenshot shown), released in 1991, is credited as the first web browser. The introduction of the NCSA Mosaic web browser in 1993 led to an explosion in web use. The Mosaic team leader, *Marc Andreessen, soon left the team and formed Netscape Corporation with Jim Clark. Their Netscape Navigator gained 90% of the browser market at its peak. At this stage Microsoft recognized the growing importance of the Web and began to develop Internet Explorer. the global market share of IE peaked at about 63% in 2009.*

Image source: Wikipedia

Optical Computing



U.S. Patent 5,093,802, entitled "Optical Computing Method Using Interference Fringe Component Regions," was issued to John Hait at Rocky Mountain Research Center (Montana) in 1992 (patent application filed in 1989). The patent outlines a method for building optical logical components. Over two decades has passed and we have seen no optical computer materialize.

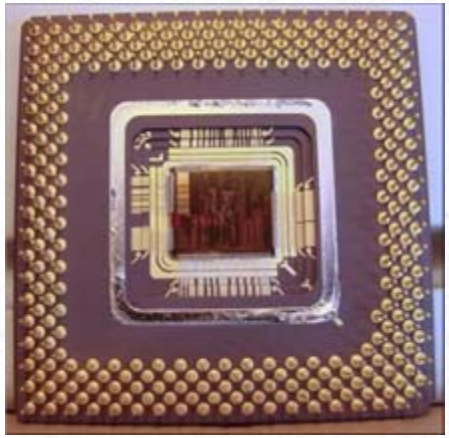
Inage source: U.S. Patent 5,093,802

A Not-so-Accurate Prediction

"Windows NT addresses 2 Gigabytes of RAM, which is more than any application will ever need."

Microsoft on the development of Windows NT, 1992

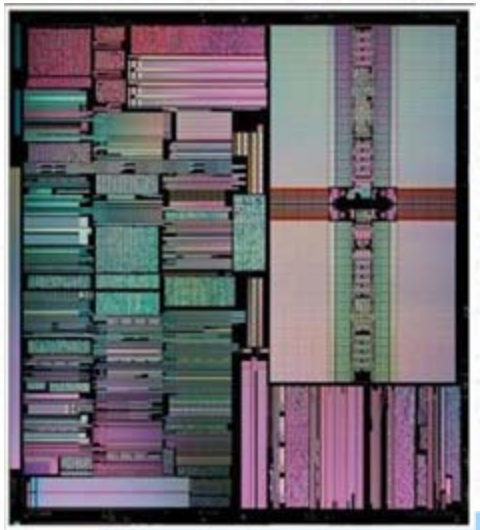
The Intel Pentium Family



The Pentium (sometimes called i586) processor family debuted in 1993 and had 3.1 million transistors. It used a technique called branch prediction to forecast upcoming instructions, so it could execute them more quickly. It was also designed with multimedia processing in mind. During its production life from 1993 to 1999, CPU clock frequency grew from 60 MHz to 300 MHz, process size decreased from 0.80 µm to 0.25 µm, and voltages dropped from 5 V to 1.8 V.

Image source: Intel

IBM Power PC



Also in 1993, IBM introduced the PowerPC 601 with more than 2.8 million transistors and RISC architecture (Reduced Instruction Set Computer). Developed jointly with Apple and Motorola, the chip was used in the Apple Power Macs and was still in 2003 introduced in the vehicle-management computer of the developmental F-35 stealth fighter jet – an aircraft that will become operational around 2015. The military mostly plays with old hardware.

Image source: Tom Way & Wikipedia/USAF

Exits a Hacker

Hackers' Song:

"Put another password in,
Bomb it out and try again
Try to get past logging in,
We're hacking, hacking, hacking

Try his first wife's maiden name,
This is more than just a game,
It's real fun, but just the same,
It's hacking, hacking, hacking"

*) Nonetheless, Mitnick was harmless compared with hacking by criminal gangs and government agencies

*From its inception at MIT in 1969, computer hacking has grown to a criminal activity of serious economic and national security proportions. In 1995 the FBI arrested the most notorious hacker to that date, 31 year old Kevin Mitnick, who spent the next five years in prison. In his 2002 book, "The Art of Deception," Mitnick stated that he compromised computers solely by using passwords and codes that he gained by social engineering. He forgot that he already in 1981 was convicted of stealing computer manuals.**

Song from: The Nutcracker (Hackers UK)

Wiki

The word wiki is of Hawaiian origin and means quick (Hawaiian Wiki-Wiki bus, top). It entered the IT world in 1995, when Ward Cunningham (center) launched a user-editable web site as part of the Portland Pattern Repository (logo, bottom). Today, Wiki refers to a piece of server software that allows users to freely create and edit web page content using any web browser. A Wiki supports hyperlinks and has a simple text syntax for creating new pages and crosslinks between internal pages on the fly.

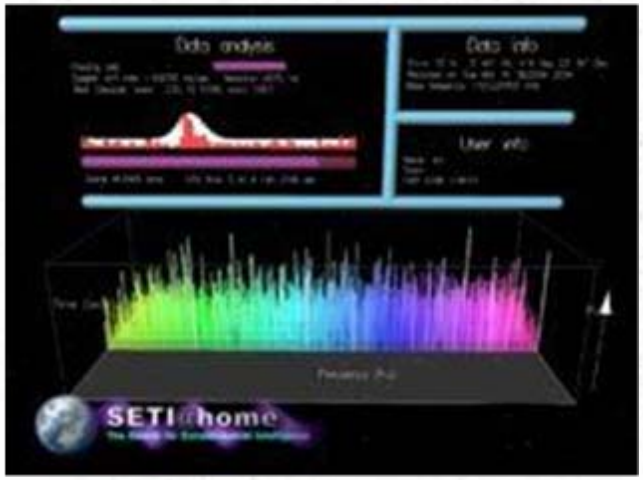
Image source: Wikipedia

“Computer in Your Pocket”

With the release of the Nokia 9000 Communicator in 1996 the world got an “office computer in your pocket.” It was a somewhat bulky mobile phone with a keyboard and a large grayscale LCD display as well as Internet connectivity. It was built around the Intel 386 processor and had 8 MB internal memory. The photo shows a Nokia 9210 from 2002. Neck pain from bending over the Communicator became know as “kommariniska” in Finnish. The word also translates as “communist neck.”

Image source: Wikipedia

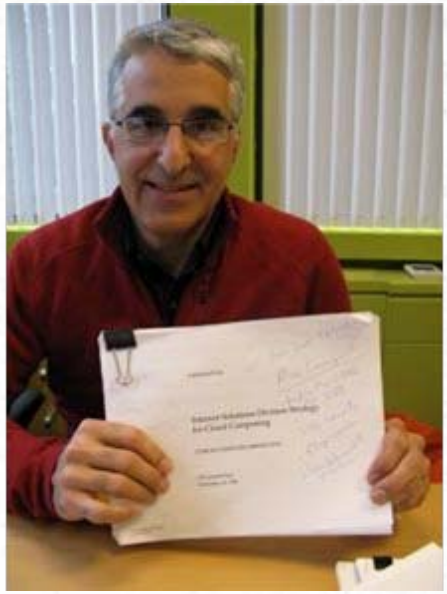
Grid Computing



Grid computing aims at reaching supercomputer-like processing power by using large numbers of distributed computers and clustering them over the Internet or a similar grid. One of the first applications of volunteer grid computing was the Great Internet Mersenne Prime Search, which was started in January 1996. SETI@home has been conducting the Search for Extraterrestrial Intelligence grid computing project since 1999.

Image source: Wikipedia

The Term "Cloud Computing"



In 1996 a group of Compaq Computer executives was plotting the future of the Internet business. Their vision was detailed and prescient. Not only would all business software move to the Web, but what they termed "cloud computing-enabled applications" like consumer file storage would become common. In the picture the then Compaq marketing executive George Favaloro poses with a 1996 Compaq business plan with the term "cloud computing" (see also later slide on cloud computing.)

Image source: MIT Technology Review

Computer Chess

Chess allows about 10^{123} different games to be played. In 1997, however, a specialized IBM computer, Deep Blue (shown), was able to beat Garry Kasparov, the reigning chess world champion. The Japanese form of chess, shogi, is even more difficult as it allows 10^{224} games and it took until 2010 before a computer beat a professional shogi player. The remaining challenge is go, by many seen as the ultimate board game.

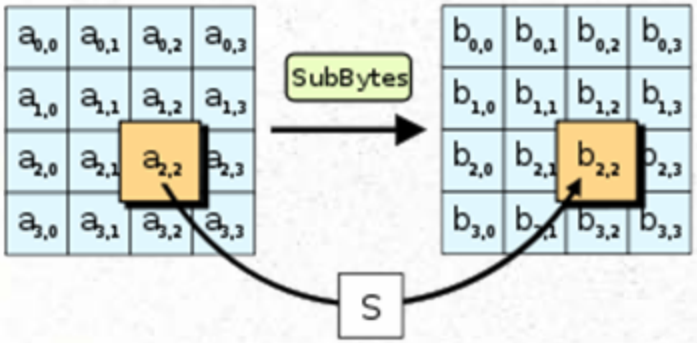
Image source: Wikipedia

USB Flash Drive

The USB flash drive (thumb stick) memory entered the market in 1998 and quickly replaced the 3.5” floppy desk (bottom) as a small, lightweight, removable data storage device. Where the capacity of the floppy disk was only 1.44 MB, USB thumb drives have reached 256 GB and are growing. The thumb stick is essentially a NAND-type semiconductor flash memory integrated with a USB interface.

Image source: Wikipedia

Advanced Encryption Standard



In 1998 two Belgian cryptographers, Joan Daemen and Vincent Rijmen, published an encryption algorithm called Rijndael. It was selected by the US National Bureau of Standards in October 2000 as the basis for a new federal encryption standard and given the name Advanced Encryption Standard. AES can have key sizes of either 128, 192, or 256 bits. So far (by early 2012), the AES is not known to have been broken although a slight weakness has been found.

Image source: Wikipedia

Y2K and Y2K38

Unix timestamp on February 13, 2009 at exactly 23:31:30 (UTC).

We survived the Y2K "Millennium Bug" that was caused by old computer programs having the year represented only by the last two digits. The next similar scare will be the Y2K38 "Unixbug" that is caused by the 32-bit second counter in Unix systems. The clock started ticking on 1 January 1970 and the counter overflows at 03:14:07 hours on 19 January 2038. If nothing is done, the Unix clock jumps back to 13 December 1901. However, the first problems emerged already in 2006.

Image source: Wikipedia

Intel Pentium 4

In 2000, Intel unveiled the Pentium 4 chip, a completely new design; it had 42 million transistors. The original Pentium 4 run at 1.4 and 1.5 GHz, but was outperformed by AMD's lower-clocked Athlon. It posed a new set of code optimization rules and was disliked by developers, but the marketing community liked its high clock frequency. (The two distinct blocks on the right are part of its cache.)

Image source: Intel

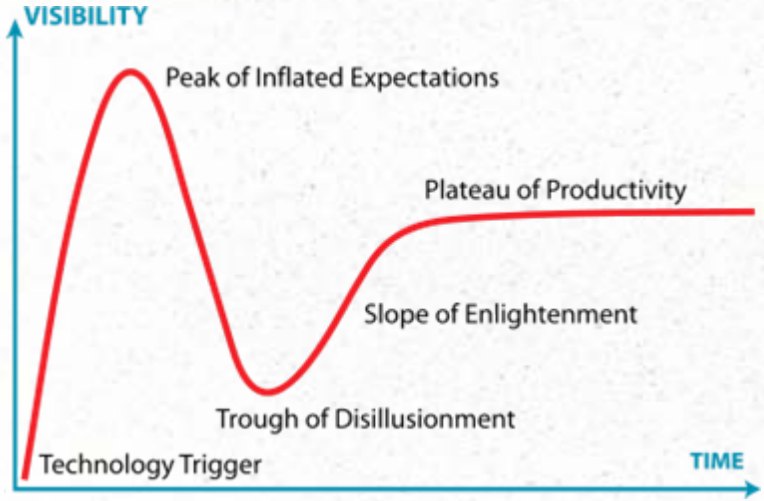
Misconception About the Number of Transistors (Moore's Law)

It is a popular misconception that exponential processor transistor growth translates into a proportional exponential increased processing power or processing speed. In fact, processor performance can increase without increasing the number of transistors in a processor. The AMD64 processors, for instance, had better overall performance compared to the late Pentium 4 series, which had more transistors.

Misconception About Clock Speed

There is a popular misconception that the clock speed of a processor determines its speed, also known as the “Megahertz Myth.” The processor speed actually depends on the number of instructions per tick which can be executed as well as the complexity of each instruction. The clock speed can therefore only be used for comparison between two identical circuits.

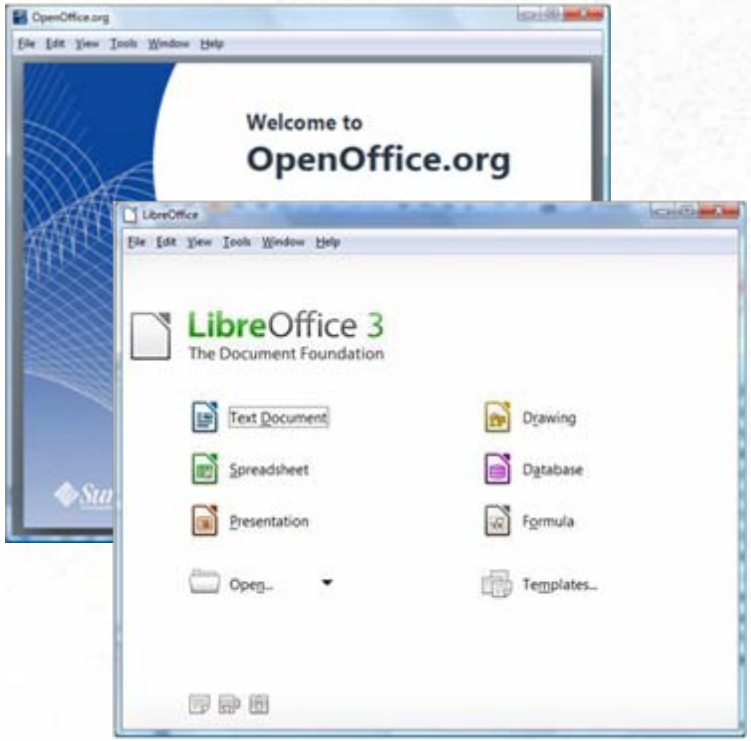
The Dot-Com Bubble



The "dot-com bubble" (sometimes the "IT bubble") was a speculative bubble covering roughly 1998–2001, with a climax in March 2000. It was a typical case of the Hype cycle (pictured), with venture capitalists moving into the rapidly growing IT sector. Their inflated expectations caused stock market prices to rise artificially. Europe also saw similar overblown anticipations on 3G mobile communication, with operators paying excessive prices for UK, German, and Italian 3G licenses.

Image source: Wikipedia

OpenOffice.org & LibreOffice



*) OOo was renamed Apache Open Office in early 2012

In July 2000 Sun Microsystems released the source code of its StarOffice software suite as an open-source package, renamed OpenOffice. It contains all the major tools that MS Office users have become familiar with. Voluntary developers became disillusioned with OOo after Sun had been acquired by Oracle. In 2010 they released it under the name LibreOffice and it is now developed separately from OOo. The market share of open-source office packages remains low despite being given away for free.*

Screenshots: Dr.EW

Echelon

In 2001, the Temporary Committee on the Echelon Interception System recommended to the European Parliament that citizens of member states routinely use cryptography in their communications to protect their privacy. Echelon is a global network of computers and communications intercept stations operated by the Anglo-Saxon countries, spearheaded by the American NSA. Created during the Cold War as a tool for national security, it is suspected of being used also for commercial espionage against the rest of the world.

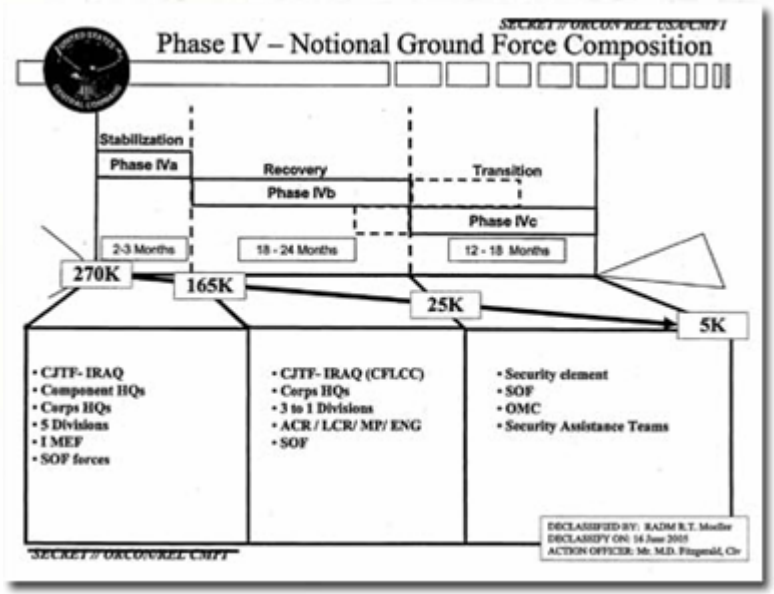
Images: Wikipedia/Landesamt für Verfassungsschutz

Skype

Skype ("skaip"), short for "sky pear-to-pear," materialized the idea of combined voice-text-video communication over the Internet. The basic service offered by Skype is free, the company makes its revenues from more advanced services. The Skype software was written by three Estonians in 2003 and commercialized by two young Swedish entrepreneurs. In 2005 Skype was acquired by eBay for $2.6 billion, and for 8.5 billion by Microsoft in 2011. The end may be at hand, however, with web browsers entering this field (see slide on WebRTC below).

Image source: Wikipedia

General Point, Power Point



Critical voices have been raised over the domination of computer-generated slide presentations, "powerpoints." It is claimed that systematic planning is traded for strongly worded and visually attractive presentations, and that decision-makers fall into the trap of "seeing is believing." These voices became louder after the release of unrealistic US DoD PPTs outlining the 2003 invasion of Iraq and its postwar development (shown). The slides may in part have influenced president Bush to make disastrous decisions (see earlier slide on PowerPoint history).

Image source: National Security Archive

Stealth in Cyber Attacks

Greek authorities discovered in 2005 a sophisticated spyware that had been hidden into four telephone switching computers by someone who had modified the software and inserted 29 secret programs. The spy system came apart only when a software upgrade provided by the manufacturer led to some text messages, sent from the system of another cell phone operator, being undelivered. The level of skill needed to pull off the operation indicated that the culprit was a government.

Image source: Wikipedia

Spying on One's Customers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Sony's long-term rootkit CD woes

Internet professor Michael Geist explains why Sony's rootkit problems have significant long-term implications for the industry.

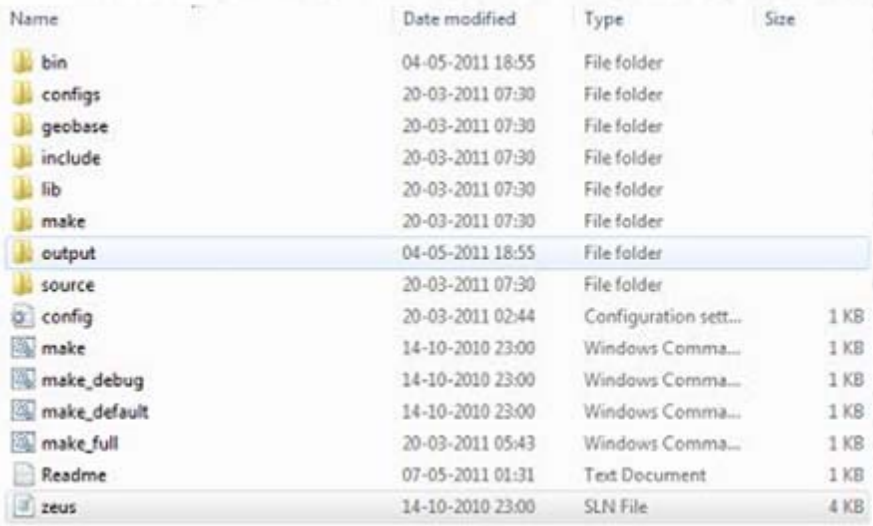
"Sony BMG, the world's second largest record label,

One of the first serious cases in which companies used computer technology to spy on their customers emerged in 2005, when Sony delivered music CDs containing spyware. If the CD was played on a Windows computer, a rootkit was installed and sent information about the computer to Sony. Later cases are Facebook apps that collect user information for marketing purposes, iPhones with GPS receivers that report the location of the phone to Apple, etc. This is the commercial arm of "Big Brother."*

**) Google does the same as soon as you use it*

Image source: BBC

The Zeus Trojan



Name	Date modified	Type	Size
bin	04-05-2011 18:55	File folder	
configs	20-03-2011 07:30	File folder	
geobase	20-03-2011 07:30	File folder	
include	20-03-2011 07:30	File folder	
lib	20-03-2011 07:30	File folder	
make	20-03-2011 07:30	File folder	
output	04-05-2011 18:55	File folder	
source	20-03-2011 07:30	File folder	
config	20-03-2011 02:44	Configuration sett...	1 KB
make	14-10-2010 23:00	Windows Comma...	1 KB
make_debug	14-10-2010 23:00	Windows Comma...	1 KB
make_default	14-10-2010 23:00	Windows Comma...	1 KB
make_full	20-03-2011 05:43	Windows Comma...	1 KB
Readme	07-05-2011 01:31	Text Document	1 KB
zeus	14-10-2010 23:00	SLN File	4 KB

In 2007 a sophisticated malware, the Zeus trojan (a.k.a. ZeuS, Zbot, PRG, WSNpoem, etc.), was identified. It is sold on the black market to cyber criminals who use it to steal passwords and other e-banking data being entered on infected computers. The criminals cashed probably billions of dollars before the source code of Zeus (toolkit pictured) was leaked to the Internet in 2011, when security experts began to study it in earnest.

Image source: Unknown

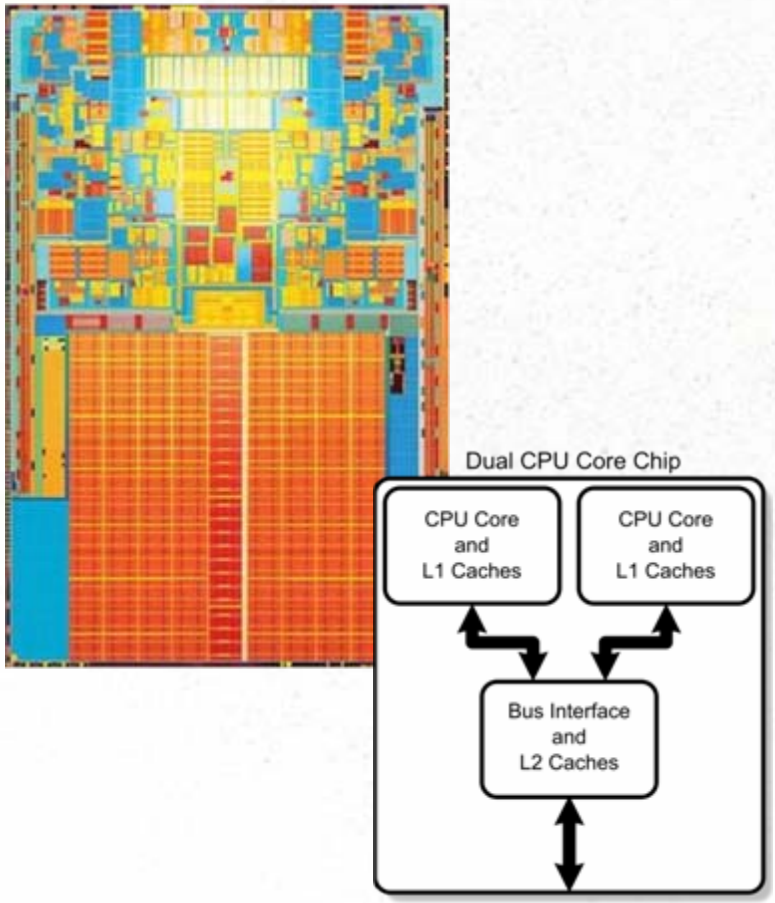
Denial of Service

The world became aware of what a DoS attack means when Estonia in April 2007 was hit by a massive attack originating in Russia. The reason for the cyberattack was that Estonia relocated a Soviet-era statue, the Bronze Soldier, to a less conspicuous location in Tallinn. A move opposed by both Russia and the Russian minority in Estonia. Luckily, Estonia's telecom system was linked to other countries over a few routes only and it could counter the attack by disconnecting itself from the rest of the world.*

*) A similar attack came during Russia's armed invasion of Georgia in 2008

Image source: Wikipedia

Dual Core Processors



Some of the latest chips improve performance by incorporating more than one "core"—the part of the chip that handles instructions—into a single circuit. Putting multiple cores on a chip is one way manufacturers have been able to increase transistor count without also increasing power consumption. Intel's 2007 Core 2 Duo has 410 million transistors and a large data cache (big orange block).

Image source: Intel & Wikipedia

Intellectual Property Gone

In 2008 online thieves based in China broke into the networks of three of the world's biggest energy companies and stole some of their most important proprietary information: details of their oil discoveries. The value of the information amounts to billions. The companies did not realize the extent of the losses before being informed by the FBI the next year. IT security company McAfee estimated that globally, $1 trillion worth of intellectual property was stolen on-line in 2008.

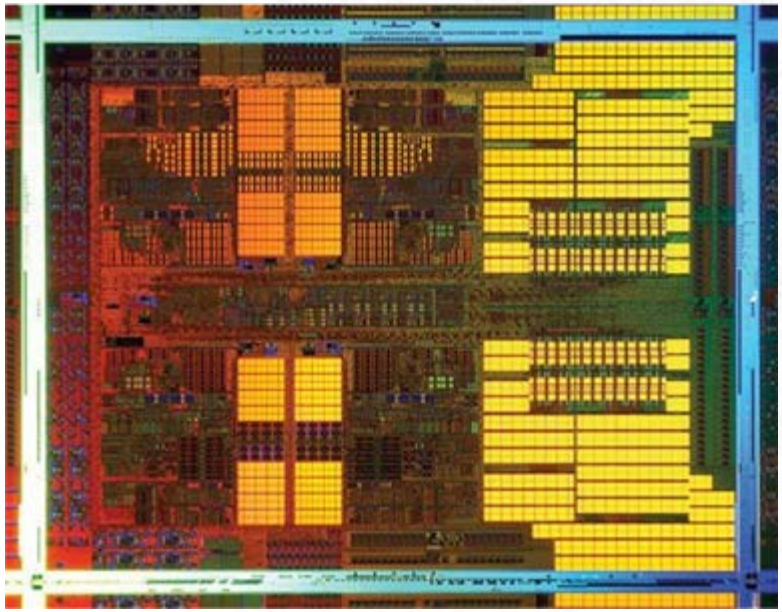
Image source:

Spaceworm

A computer worm was detected on the International Space Station in July 2008 (it was reported the following month). It is said to have been the W32 Gammima.AG, which was first detected in 2007. It is a Windows-based worm that spreads by copying itself onto removable media and is capable of stealing passwords for online games. NASA downplayed the incident by saying that "we have had viruses that have made their way on board before."

Image source: Wikipedia

AMD Phenom II



AMD's Phenom II "Deneb," released in early 2009, has four cores (flanking the rightmost yellow blocks), a large shared cache, is built in 45 nm technology, and has around 758 million transistors. In April 2009 AMD demonstrated that Phenom II could break the 7 GHz barrier.

Image source: AMD

Cloud Computing

Use of the term "cloud" in technology goes back to the Virtual Private Networks (VPN) that telephone companies begun to offer in the 1990s. Later the term has been associated with distributed computing on the Internet (image). More recently it has been adopted by processor manufacturers to describe large multicore processors. As of late 2012, Tilera supplies a 100-core/64-bit processor in a 45x45 mm package.*

Image source: Wikipedia

**) With this interpretation cloud computing can be seen as a child of grid computing*

Can Clouds be Trusted?

The main incentive for cloud computing is to cut IT administration costs, which can eat 70% of the total IT budget. Cloud service providers claim that data is completely safe due to the virtualization technology used. But in late 2012 came reports that researchers at RSA and two American universities had cracked the encryption code (GNUPrivacy guard) of software on a commercial cloud (Amazon) by inserting a spyware in their own files on the same cloud.

And this is just the start of the public hacking effort….

Passwords

MOST POPULAR PASSWORDS

Nearly one million RockYou users chose these passwords to protect their accounts.

1.	**123456**	17.	**michael**
2.	**12345**	18.	**ashley**
3.	**123456789**	19.	**654321**
4.	**password**	20.	**qwerty**
5.	**iloveyou**	21.	**iloveu**
6.	**princess**	22.	**michelle**
7.	**rockyou**	23.	**111111**
8.	**1234567**	24.	**0**
9.	**12345678**	25.	**tigger**
10.	**abc123**	26.	**password1**
11.	**nicole**	27.	**sunshine**
12.	**daniel**	28.	**chocolate**
13.	**babygirl**	29.	**anthony**
14.	**monkey**	30.	**angel**
15.	**jessica**	31.	**FRIENDS**
16.	**lovely**	32.	**soccer**

Source: Imperva

The New York Times

In December 2009, 32 million passwords were stolen by an unknown hacker from the RockYou company. An examination of the list revealed that the most popular password was "123456," used by nearly 1% of RockyYou customers. Why do people choose easy-to-guess passwords, despite warnings about the risks? Security experts suggest that we are simply overwhelmed by the sheer number of things we have to remember in this digital age.

Image source: Imperva/The New York Times

Humans, the Weakest Link

WikiLeaks, the web site for leaked government secrets, began to publish about half a million US government documents in the summer of 2010. The bulk was cables on the war in Iraq and Afghanistan, and messages from embassies around the world, that originated in the classified SIPRNet. Army intelligence analyst Bradley Manning, 22 years at the time, was the confessed source. The blame was put on a grass root level individual, but the case points to extreme naïvety in the government's security thinking.

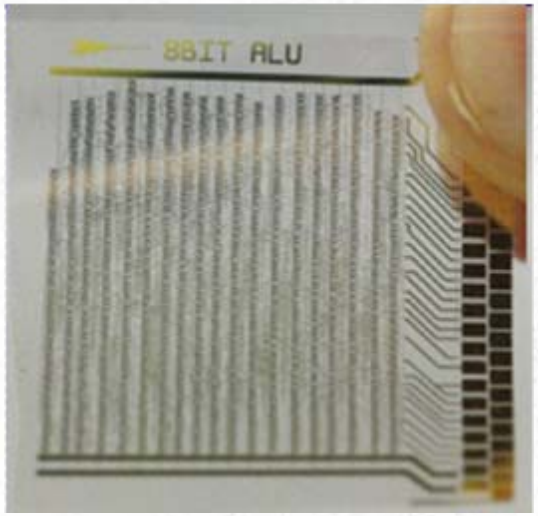
Image source: Wikipedia, WikiLeaks

Malware & Collateral Damages

The Stuxnet worm gave a display of cyber-age collateral damages. Stuxnet is a product of the NSA and Israel's Unit 8200 intelligence organization and was aimed at Iran's nuclear establishment. It was discovered in 2010 and targeted Siemens' Simtec industrial control and data acquisition system that runs on Windows (shown), and which Iran used in its nuclear enrichment plants. However, the developers did not limit its global reach and Stuxnet infiltrated unrelated industrial complexes around the world.

Image source: Wikipedia

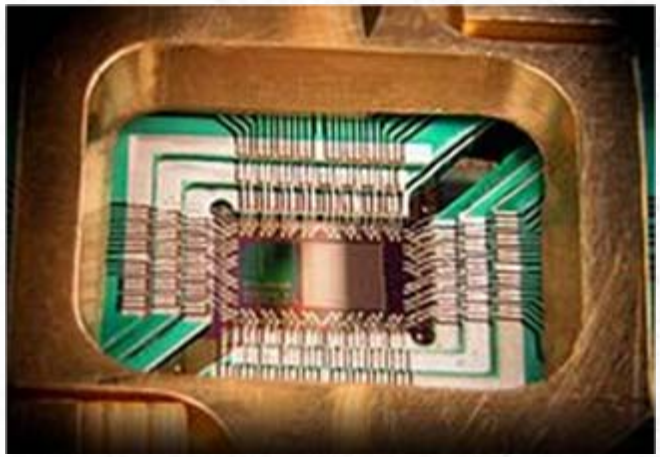
Organic Processor



In early 2011 a team of Belgian and Dutch scientists announced a fully plastic (organic) processor. Its 4000 transistors and 6 Hz clock speed makes it comparable with Zuse's computer from 1941 (see earlier slide). Seven decades of development has decreased the size however. With 2 cm square and built on a 25 um plastic foil (similar to food wrapper films) it is only like a flake of paint on Zuse's Z3.

Image source: IEMC

The "First" Quantum Computer



D-Wave
The Quantum Computing Company™

Canadian company D-Wave Systems announced in May 2011 that it has signed a $10 million contract with Lockheed Martin for the delivery of a quantum computer called D-Wave One™. However, much secrecy has surrounded the development and skepticism lingers in many quarters. The picture shows D-Wave's 128-qubit superconducting adiabatic quantum optimization processor.

Image source: Wikipedia

WebRTC

WebRTC (Web Real Time Communication) is an open standard for real-time communication between web browsers. A draft was issued in April 2011 by the World Wide Web Consortium (W3C), but as of November 2012 the standard still undergoes major changes. Its first victim may become Skype, because WebRTC will allow teleconferencing using browsers only. WebRTC is therefore opposed by Microsoft, which acquired Skype for $8.5 billion in 2011 (see earlier slide on Skype).

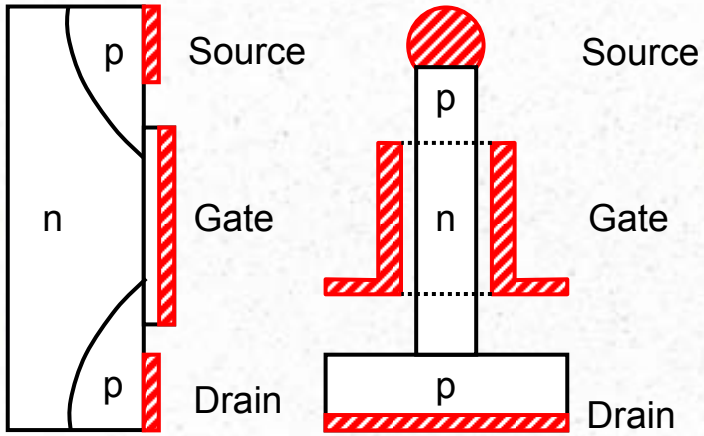
Image source: Wikipedia

Computing Record

As with other human endeavors, people want to define records also in computing. The computing record as of November 2012 was the Cray XK7 "Titan" at Oak Ridge National Laboratory, an updated version of the earlier "Jaguar" computer. It has achieved 17.59 petaflops, but the theoretical maximum is 24.8 petaflops. Its 560,640 processors are housed in 200 cabinets covering 404 m^2 and draw 9 MW power.

Image source: Unknown

TFET and Power Consumption



An exaflop (10^{18} flops) supercomputer built with traditional 2D planar transistors (left) would require its own power station. A solution being looked into by a number of research groups is the 3D tunnel-FET transistor, formed around a nanotube poking out of the substrate (right, compared with a traditional FET transistor left). TFET transistors are expected to allow chip voltages below 0.5 V, have a power consumption just one tenth of that of traditional transistors in the "On" state and almost none in the "Off" state.

Image source: DrEW based on IBM

Software Challenges

There is a problem with multicore processors however: Most computer programs weren't designed with multiple cores in mind. Their instructions are executed in a linear sequence, with nothing happening in parallel.

Fortunately, the fundamentals of parallelism were worked out decades ago for supercomputers (remember Amdahl’s Law?). The challenge is to find ways to make that old work useful.

Nearing the End of Moore's Law

So far, history has proved Gordon Moore more or less right. But transistor growth may soon slow for a number of reasons:

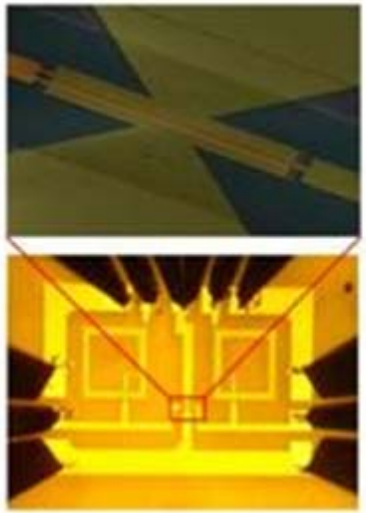
- *Difficulties to contend with the heat produced and power consumed by transistor-crammed chips*
- *Photolithography as we know it is expected to reach its ultimate limits before 2020*
- *Chip voltages cannot be reduced forever*

The Limits of Silicon Technology

Still in 2002 Intel's chief technology officer Pat Gelsinger said, "We're on track, by 2010, for 30-gigahertz devices, 10 nanometers or less, delivering a tera-instruction of performance."

But Gelsinger was wrong. By 2010 Intel and its competitors were making processors that topped out at less than four gigahertz, and 22 nm had only reached the design lab.

Hope for Moore's Law in New Technologies?

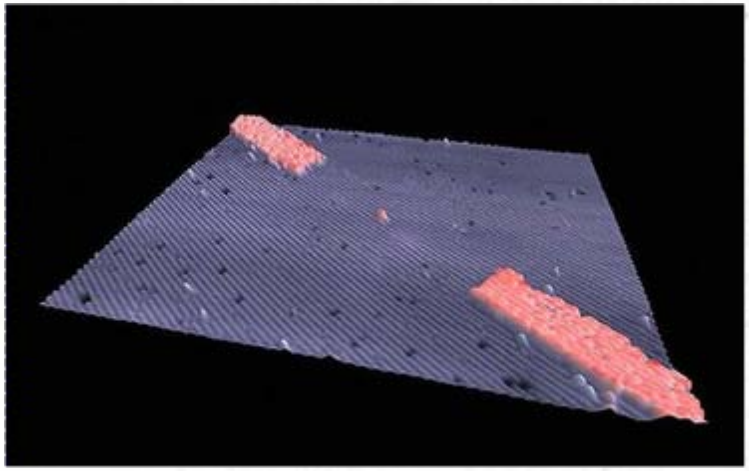


*) As had Jack Kilby's groundbreaking IC of 1958, see earlier slide

Miniaturization of integrated circuits based on photolithography may soon come to an end. However, new technologies have emerged that may push miniaturization to the nanoscale. On the forefront are memristors and graphene. In 2011 the first quantum computer was announced and shortly after researchers at IBM presented the first graphene integrated circuit. The graphene IC has only one transistor (framed in the bottom picture) and two coils, but it operates at 10 GHz.*

Image source: IBM

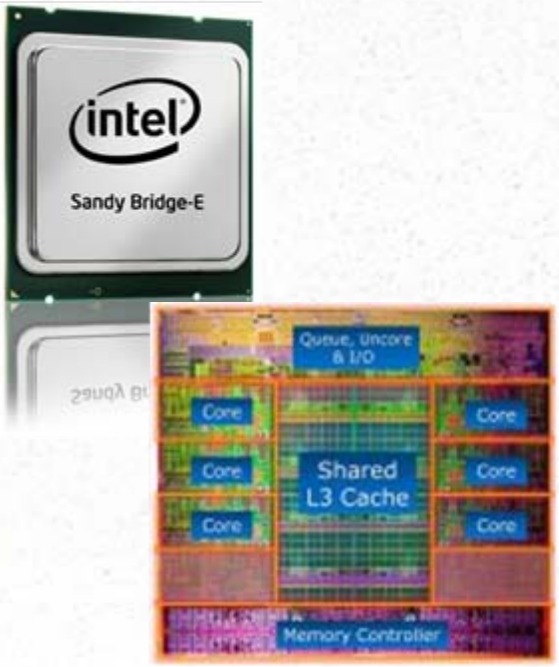
Single-Atom Transistor



Miniaturization reached its ultimate limit in February 2012, when scientists at the University of New South Wales, Australia, reported having created a single-atom transistor – at least under the eye of a scanning tunneling microscope. It is a phosphorous atom that has replaced a silicon atom in a group of six, and which acts as a switch when a voltage is applied. Ok, it might take a while before this device finds its way to computer stores.

Image source: UNSW/Sydney Morning Herald

Monster Chip



A general-purpose monster chips in early 2012 was Intel's Core i7 3960X (Sandy Bridge E) with 6 cores and 2.27 billion transistors in a 2011-pin package, sucking 130 W power. The processing speed is 177,730 MIPS at 3.33 GHz. This can be compared with the Cray 1A supercomputer from the 1970s that weighed 5.5 tons, consumed 115 kW power and had a theoretical speed of 160 MIPS at 80 MHz. The price tags are $990 for the Intel chip, $7.9 million (1977 dollars) for Cray 1A.*

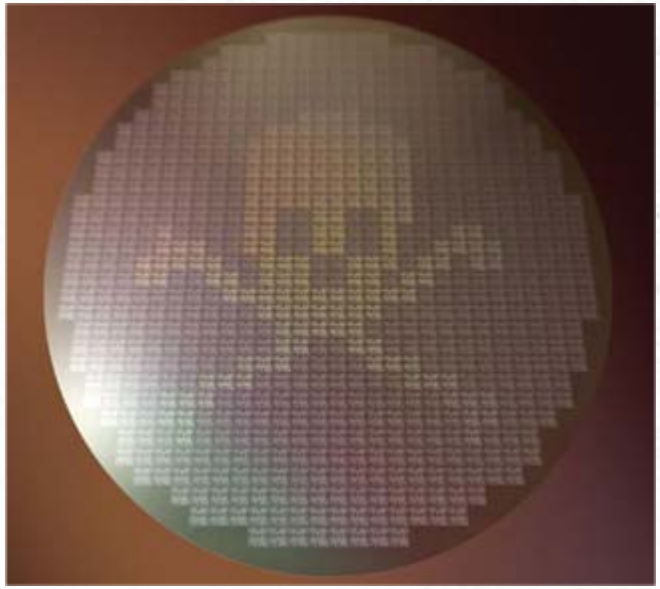
Image source: Wikipedia

*) Care is needed when comparing MIPS values

Death to Moore's Law!

Despite impressive progress in hardware technology, there are alternatives that should be considered. Steve Wozniak, the inventor of the Apple II, once said: "The repeal of Moore's Law would create a renaissance for software development. Only then will we finally be able to create software that will run on a stable and enduring platform."

Malicious Hardware

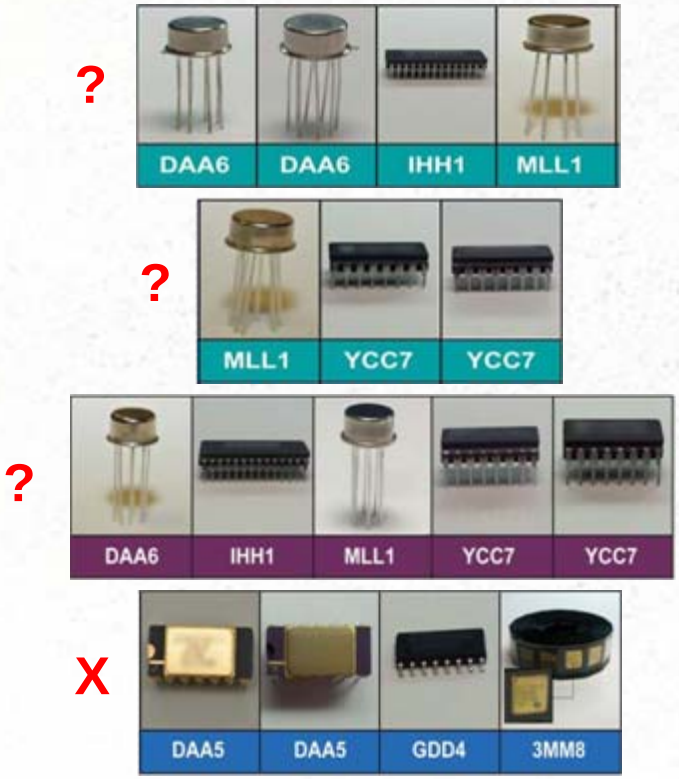


Modern integrated circuits have become so complex that malicious agents could fit circuits with hidden, almost impossible to detect structures ("kill switches," "electronic trapdoors," etc.). The concern was first raised by the military, but the threat has been recognized by civilian authorities as well. The search for tamper-proof techniques is on, but most likely the complexity of ICs has exceeded the point where reliability cannot be guaranteed with certainty.*

*) It has been claimed that French defense contractors have used such circuits

Image source: IEEE

Counterfeit ICs



In February 2012 the US Government Accountability Office – the watchdog of Congress – presented a report on the authenticity of electronic components for military ICs bought on the Internet. An independent laboratory inspected the 16 purchased components (shown, all from Chinese suppliers): 12 were found to be suspected counterfeits and 4 were clearly bogus parts, meaning that the vendors had altered production codes to match those required. Not a single one got the clear mark. Buying cheap has its risks.

Image source: GAO

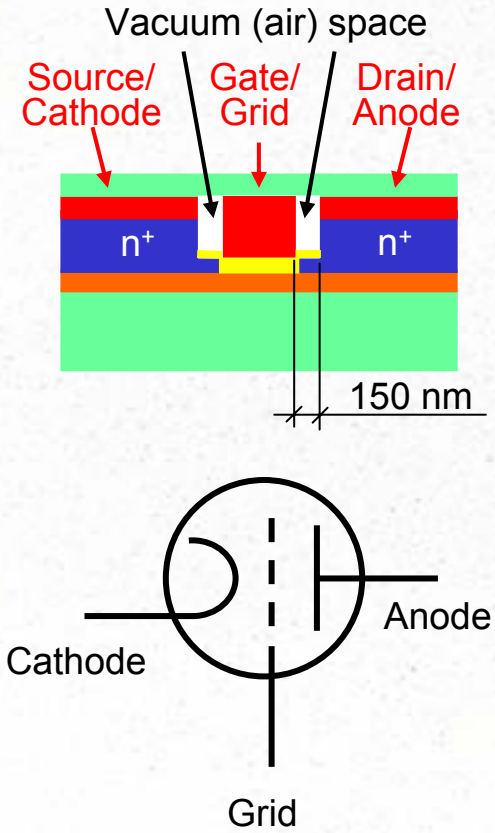
*Smartphone TEMPEST**

A demonstration at the 2012 RSA computer security conference showed how the secret key used by an app on smartphones can be accessed due to RF leakage from the chip doing the encryption – the consequence of poor TEMPEST/EMCON design. A non-optimal antenna three meters away from the device picked up the signal, to reveal a stream of peaks and troughs representing 1s and 0s of the secret key. With optimal equipment the eavesdropping range is far longer. Are mobile banking and commerce secure enough?

Image source: Technology Review

*) History repeats itself: Recall earlier slide on van Eck preaking from 1985

Return of the Vacuum Tube?



Interest in vacuum electronics has not vanished in the age of transistors. Vacuum tubes are intrinsically faster and less susceptible to strong radiation, which is important in space and military applications. In 2012 NASA researchers reported having developed a nano-scale vacuum tube circuit that does not require a vacuum enclosure (top, traditional vacuum tube for comparison at the bottom). It has already operated at 460 GHz, some ten times faster than silicon transistors. However, it is still only a proof-of-concept device.

Image source: Dr.EW based on Unknown

The Situation a Decade into the 21st Century

Computing technology emerged as a tool for solving practical problems for both civil and military purposes. Today the capability of ordinary PCs greatly exceeds the needs of average computer users. Now a major force behind development is entertainment, the need to fill our spare time with video games, films, music, web surfing, gossiping, etc. And if the need does not exist, it is quickly created by marketing people playing on our socio-psychological weaknesses.

Memory Cost Development

The enormous growth of computing power is made possible by equally dramatic cost reductions due to advances in technology and manufacturing processes. When IBM introduced the 8” RAMAC magnetic disk memory in 1956, a megabyte of memory cost the equivalent of $80,000 (2009 money). In 2012 a 1 TB hard drive sells for $150 or less – 0.015 cents per megabyte.

Processor Development

On November 15, 2011, Intel celebrated the 40th anniversary of the Intel 4004 microprocessor and made the following claims about the development since then:

- *Processor performance has increased by a factor of 350,000*
- *Transistor power consumption has decreased by a factor of 5,000*
- *Price has decreased by a factor of 50,000*

Computer-Age Privacy

The 2012 Petraeus sex scandal in the US offered a glimpse of the ease by which authorities can infringe on our privacy. It was no match for the FBI to access e-mail correspondence of General Petraeus – CIA director at the time – and his mistress (pictured), whether it was done legally or not. On the other hand, citizens only too willingly support "Big Brother" by posting intimate details, photos, and opinions on social media and web discussion groups.

Image source: Unknown

This is War!

The New York Times

On June 1, 2012, The New York Times confirmed what had generally been suspected: malware attacks by Duqu, Stuxnet, and Flame over the previous few years were a joint US-Israeli war effort. Mikko Hyyppönen, CRO at F-Secure, commented: "Now there is no return, other countries will follow." Mankind has entered the era of Cyber Warfare in which computers – and the Internet – not only support warfare but are destructive weapons in their own right. And the border between war and peace is more blurred than ever.

Image source: Nat W/Flickr

US-Israeli Malware Smithy

As of December 2012 the identified products of the US-Israeli malware cooperation is as follows:

- ***Stuxnet**, found in June 2010, attacks an industrial control systems by Siemens*
- ***Duqu**, found in September 2011, collects information on control systems (assumed precursor of Stuxnet)*
- ***Flame**, found in May 2012 but released some years earlier, possibly a fallback to the Duqu/Stuxnet duo*
- ***Gauss**, found in August 2012, collects information on bank transactions primarily in the Middle East*
- ***Narilam**, found in November 2012, destroys data bases and information on Iranian computers*

Microsoft's LM & NTLM Obsolete

A hardware solution for cracking passwords was presented at the Passwords^12 conference in Oslo, Norway, in December 2012. 25 AMD Radeon graphics cards on five servers can check 348 billion passwords per second. A 14-char password on a Windows XP computer (LM hash) can be cracked in six minutes, an 8-char password with 95^8 combinations – commonly used in business life – on later models (NTLM hash) yields in 5.5 hours. So how fast can the NSA do it?

Image source: Oslo University

Threats by RF Communication

Our increasing dependence on mobile communication widens the door for criminal activities: Violent demonstrators jamming or spoofing the radio network of riot police, car thieves jamming satellite tracking systems installed in stolen trucks to avoid being tracked (pictured), thieves breaking into private homes jamming the RF link of security systems, etc. Electronic warfare has expanded from the military to the civilian realm.

Image source: The Economist

Finally: An Accurate Statement

”Bill Gates is a very rich man today ... and do you want to know why? The answer is one word: versions.”

Dave Barry

Welcome Windows 1, 2, 3, NT, 95, 98, 2000, ME, Xp, Vista, 7, 8. We’re so happy to pay for all of you!