

Computer History

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1833

- Michael Faraday, making experiments on AgS, finds that electrical conductivity get increased with increasing temperature. This effect, typical of semiconductors, is the opposite of that measured in metals

1874

- German physicist Ferdinand Braun, age 24, at Würzburg University, probing a galena crystal (PbS) with the point of a thin metal wire, notes that current flows freely in one direction only. This is the rectification effect at the point of contact between metals and certain crystal materials

1901

- Jagadis Chandra Bose, professor of physics at Presidency College in Calcutta, India, demonstrates the use of PbS (galena) crystals contacted by a metal point to detect millimeter electromagnetic waves. He files a US patent for a point-contact semiconductor rectifier for detecting radio signals

1904

- John Ambrose Fleming invents the electronic valve

1906

- Lee de Forest invents the triode by adding a metal gate to the diode

1941

- Konrad Zuse builds Z3, the first programmable electromechanical calculator
- The ABC electronic calculator is completed

1946

- Eckert and Mauchly complete the ENIAC (Electronic Numerical Integrator and Computer) at the University of Pennsylvania. 18000 electronic valves can execute 5000 op/s and store 200 numbers over 167 m². Total cost is \$500K

1947

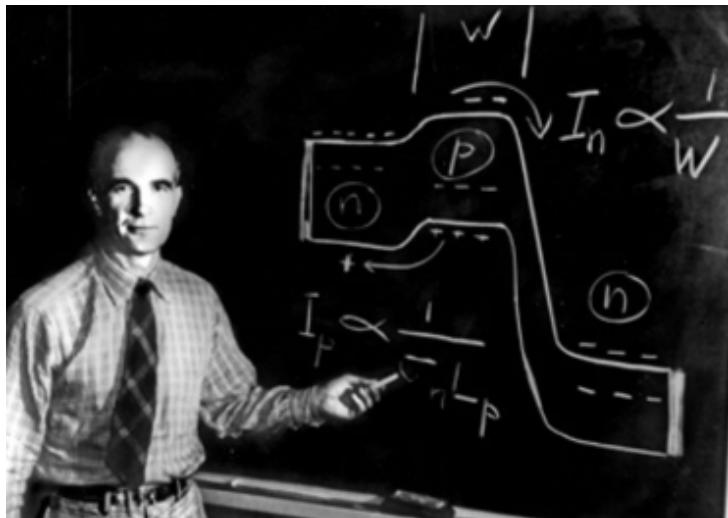
- From November 17, at Bell Laboratories, a division of the telephone corporation AT&T, physicists Walter Brattain and John Bardeen push experiments to figure out what was preventing the device imagined by William Shockley from amplifying. On December 23, all three present the point-contact transistor (they called it the "crystal triode"), the first working solid state amplifier. Actually Shockley missed the crucial discovery, therefore he was excluded by the patent
- A government agency is created in Britain, the NRDC (National Research Development Corporation), to promote the development of a computer industry
- While consulting at the University of Pennsylvania on the EDVAC project, John von Neumann writes a report on the EDVAC. The paper describes a computer architecture in which the data and the program are both stored in the computer's memory in the same address space, today known as von Neumann architecture

1948

- Raytheon introduces CK703, the first commercialized point-contact transistor
- January 23. Partly spurred by professional jealousy, after days of an intense intellectual work self isolated in a hotel room in Chicago, William Shockley comes up proposing the

junction transistor, a three-layer sandwich of n-type and p-type semiconductors separated by p-n junctions. Shockley files a patent in June (2569347). His solution, distinctly different from the mechanically fragile point-contact device, will succeed in the industry.

Shockley also disagreed with Bardeen's explanation of how the point-contact transistor worked. He claimed that positively charged holes could also penetrate through the bulk Ge - not only trickle along a surface layer. Called "minority carrier injection" this phenomenon is confirmed on February 16 by John Shive who achieves transistor action in a sliver of Ge with point contacts on opposite sides, not next to each other.



1949

- During a visit in Olivetti, Enrico Fermi encourages to Adriano Olivetti to invest in computer science



1950

- William Shockley publishes what would become the seminal work of his field, *Electrons and Holes in Semiconductors with Applications to Transistor Electronics*

1951

- GE and RCA introduce the first commercialized Ge alloy-junction (bipolar) transistor
- Eckert and Mauchly build UNIVAC (Universal Automatic Computer). 5200 electronic valves, 125kW, 13 tons, 35m^2, 2.25MHz clock, >\$1M. The design started at the Eckert-Mauchly Computer Corp. (EMCC), and was completed when the company had been acquired by Remington Rand. UNIVAC 1 was a commercial product accepted by the US Census Bureau on March 31
- Magnetic core memories are developed and patented by MIT and by RCA
- Ferranti and the Manchester University release Ferranti Mark I, the first general purpose computer
- July 4. Bell Labs announce that chemist Morgan Sparks fabricated n-p-n junction transistor using the crystal-growing equipment built by his colleague Gordon Teal, based on techniques developed in 1917 by the Polish chemist Jan Czochralski. A small seed of Ge was suspended in a crucible of molten material and slowly withdrawn, forming a long, narrow, single crystal. Sparks dropped two successive tiny pellets of impurities into the molten Ge during the crystal-growing process, the first with a p-type impurity and the second n-type, forming n-p-n structures with a thin base layer
- At Bell Labs "zone refining" technique is developed by William Pfann, that leads to ultra-pure samples of Ge. By repeatedly passing a long tube filled with Ge horizontally through a series of electrical heating coils, melted portions of the Ge are allowed to recrystallize with high purity. This technique did not work for Si, because it melts at higher T (1415°C versus 937°C for Ge) and reacts with almost all other materials. This issue will be solved in 1952 by Henry Theurer

1952

- Olivetti Corporation of America is established with office in NY
- April. 8-day Transistor Technology Symposium is held at Bell Labs, Palo Alto. The first meeting with 300 visitors was held in 1951. Now over 100 representatives from 40 companies, including IBM, GE, RCA and then-small firms Texas Instruments and Sony, attend to learn the solid-state technology news first hand. To get access to that knowledge, 26 companies had to pay a licensing fee of \$25K
- May 7. At Electronic Components Symposium, Geoffrey Dummer conceives the monolithic IC, or the idea to get many electronic components interconnected inside a solid body, with no connecting wires. Despite trying for many years, he was never able to turn his idea into a working device
- Raytheon introduces CK718, the first Ge alloy transistor to be produced in large quantities for commercial applications. Aggressive pursuit of hearing aid market under vice-president Norman Krim made the company the largest manufacturer of transistors between 1952 and 1955. In 1953 Maico Company releases the first all-transistor hearing aid (three CK718 inside)
- November 4. CBS television broadcasts UNIVAC 1 successfully predicting the outcome of US presidential election



1953

- 1M bipolar transistors are produced in US. They are Ge based devices
- Olivetti, the Italian company worldwide known for his mechanical typewriters and calculators, establishes a small laboratory in New Canaan, Connecticut, where Dino Olivetti, Adriano's brother, moved with his family. The lab, directed by Michele Canepa, is aimed to drain knowledge on the emerging market and technology of electronic calculators and to build a transistorized computer. Apart from Adriano Olivetti and his son Roberto, few others in Ivrea see electronics as a potential business (mechanical calculators allow profit margin as high as 10:1, as for the Divisumma 24). The lab will employ about 40 people in 1960, and will be operative until 1962
- November 16. Richard Grimsdale and Douglas Webb at Manchester University demonstrate a prototype transistorized computer. 48-bit, 92 point-contact transistors, 550 diodes

1954

- Following the advice of Enrico Fermi to Enrico Avanzi, the University of Pisa uses Lire 150M, initially allocated to build a synchrotron in Frascati, to develop an electronic calculator dubbed CEP (Calcolatore Elettronico Pisano). Mauro Picone, chairman of INAC, asks Olivetti to get involved in the project
- Jean H. Felker leads a Bell Labs team including engineer James R. Harris to design and build TRADIC (TRAnsistor DIGital Computer), a fully transistorized computer for the US Air Force. 700 point-contact transistors, >10000 diodes 1MHz clock, <100W.

1955

- Physicist William Shockley leaves Bell Labs in New Jersey and moves in Mountain View (CA) where his ailing mother lives. There he establishes the Shockley Transistor Laboratory at 391 San Antonio Road, supported by Arnold Beckman, of Beckman Instruments Inc., to start working on diffused base Ge transistors but with the goal to

develop Si-based devices.



- Remington Rand merges with Sperry Corp. to become Sperry Rand. Their business model is built around the UNIVAC computer division
- Olivetti establishes in Barbaricina, in a historical villa in Via delle Capannine (near Pisa) the Laboratorio di Ricerche Elettroniche (LRE). Soon the original intent (giving support to the CEP project) is displaced in the development of a commercial mainframe. To lead LRE, Adriano Olivetti chooses Mario Tchou, son of Yin Ychou, a Chinese diplomat in Vatican. Mario, born and educated in Rome, enrolls the faculty of Electrical Engineering at the University of Rome La Sapienza in 1942, gets the Bachelor degree from the Catholic University of Washington in 1947. In 1949 he achieves the M.S. in Physics at the Polytechnic Institute of Brooklyn. In 1952 becomes associate professor of Electrical Engineering at the Columbia University. In 1954 Olivetti calls him to join the Italian company. Tchou has strong technical skills as well as managerial attitude. Olivetti's job announcements for LRE appearing on main Italian newspapers

3 terne di Ingegneri e 1 terna di fisici

elettronici

con specifica competenza nelle tecniche impulsive cercansi allo scopo di potenziare e sviluppare gli uffici studi e progetti e i laboratori di ricerca. Si richiedono: seria preparazione scientifica e tecnica, vivi interessi ai problemi relativi alle calcolatrici elettroniche, predisposizione ad eventuale temporaneo trasferimento all'estero per approfondimento preparazione. Saranno valutati adeguatamente il livello di formazione e la posizione attuali. Pregasi non inviare documenti originali, essendo sufficiente un dettagliato curriculum manoscritto, i cui elementi rimarranno strettamente riservati. Indirizzare le domande, che saranno esaminate fino al 30 agosto, alla

Ing. C. Olivetti & C., S.p.A. - Ivrea

1956

- William Shockley recruits 3 engineers and 5 scientists at his Shockley Transistor Laboratory. One of them is PhD Robert Noyce, who quits Philco to join the Lab. Shockley's recruiting methodology is inspired to his belief in the "mental temperature", an objective measure of intelligence and creativity, which could be determined using psychological tests, and found high in "hot minds". Shockley turned out to be a micromanager down to the level of specifying the kind of screw it had to be used. He became increasingly dictatorial and paranoid. In one well-known incident, he demanded lie detector tests to find the "culprit" after a company secretary suffered a minor cut to her thumb on a thumbtack that had been stuck in the door. As a former Lab's employee said, "Shockley ran the company for the benefit of his personality and his image, not for pure economic pay". In short, Shockley feared that by focusing on mere commercial production instead of basic research, he'd lose his status as one of the world's premiere solid-state physicists
- November 1. William Shockley, John Bardeen and Walter Brattain win the Nobel prize in Physics for the invention of the transistor. After he received the Nobel Prize, Shockley decided not to continue research into Si-based semiconductors. He follows instead the Ahab-like obsession of the Four Layers Diode, a kind of hard-to-obtain bistable solid state relais that requires two simultaneous and identical diffusions (the breakdown voltages had to be equal). Shockley felt Western Electric would buy such a device in huge quantities to replace mechanical relays in telephone switching systems.



1957

- 29M bipolar transistors are produced in US
- The semiconductor industry exceeds \$100M
- IBM releases FORTRAN (FORmula TRANslation), a programming language for treatment of scientific and engineering problems. The principal contributor is John Backus
- September 19. Fairchild Semiconductors is founded by Julius Blank, Victor Grinich, Jean Hoerny, Eugene Kleiner, Jay Last, Gordon Moore, Robert Noyce, Sheldon Roberts. They had resigned en masse by Shockley Transistor Laboratory, a loss from which the Lab never recovered and for which they were called "Traitorous Eight", to produce diffused base Si transistors called MESA (their shape recalling the characteristic flat mountains of Arizona). Bankers Bud Coyle and Arthur Rock assist the group for the financial part. Millionaire Sherman Fairchild's Camera and Instrument loans the new startup \$1.38M over 18 months. The new company starts operations in a building at 844 Charleston Road, Palo Alto.



- Olivetti LRE completes ELEA 9001 (or "Macchina Zero"), the first commercial electronic calculator almost entirely built with vacuum tubes. In autumn, when the first prototype of the ELEA 9002 (or "1V") is nearly in completion, Mario Tchou decides to build a fully transistorized model, the ELEA 9003 (or "1T"), a decision not so obvious at a time where transistors are still unreliable and expensive (at the time a sharp tap of a pencil against the transistor's body makes it stop working). The principal hardware design engineer is Giorgio Sacerdoti
- Pier Giorgio Perotto (1930-2003) leaves Fiat for Olivetti LRE, where Mario Tchou assigns him the development of CBS (Convertitore Banda-Schede). By 1958 CBS is widely used on many Olivetti products (e.g. the Audit family) to convert punched tapes into punched cards. Perotto will leave Olivetti in 1993
- Virgilio Floriani of Telettra (a TLC company) and Olivetti set up SGS (Società Generale Semiconduttori), now STMicroelectronics, to produce diodes and transistors, pursuing the vertical integration approach to the emerging mainframe industry in Italy. In 1960 Fairchild will join the partnership
- DEC (Digital Equipment Corporation) is founded by Kenneth H. Olsen

1958

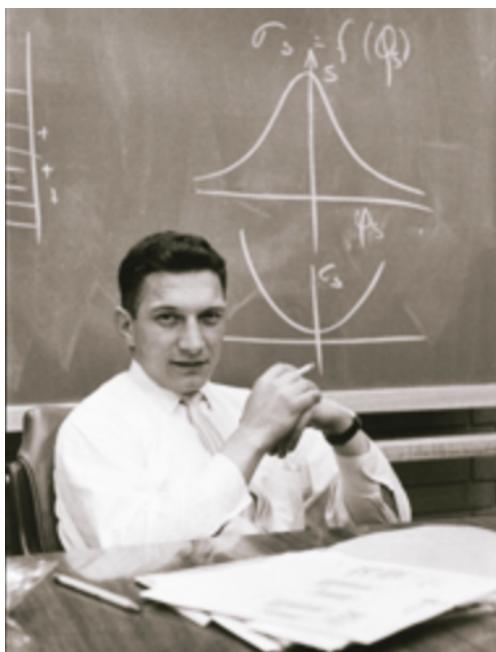
- October. NASA operations begin
- August. Olivetti moves LRE from Barbaricina to Borgolombardo (a fraction of San Donato milanese, near Milano) were the group of engineers from New Canan Lab joined. Employees of LRE will increase up to a thousand



- Sperry Rand starts to develop a full solid state mainframe
- IBM works to the 7070, fully transistorized computer series, launched in 1960
- Fairchild Semic gets an order from IBM for 100 state-of-the-art Si transistors
- Jack Tramiel and Manfred Kapp set up CBM (Commodore Business Machines) in Toronto. They import, repair and resell Czechoslovakian typewriters
- ALGOL (ALGOrithmic Language)

1959

- COBOL (COmmon Business Oriented Language)
- The MOSFET (Metal Oxide Semiconductor Field Effect Transistor) is invented by Dawon Kahng and John Atalla at Bell Labs. It is much smaller, and slower, than the bipolar transistor
- Robert Noyce sketches on his notebook how to connect more transistors on a single Si substrate. His solution exploits the planar process developed by Jean Hoerni in 1958 or the idea to cover the junction area with a thin layer of SiO₂, which made possible batch production of clean, reliable and high performance transistors (patent 3025589)



- Two months later Jack Kilby announces TI has created the first IC with 8 components (patent 3138743). However it is not a truly monolithic device. The hand made assembly, using thin gold wires, is impractical for mass production. Kilby had publicly demonstrated his first working prototypes on September 12, 1958
- July 30. Robert Noyce patents his invention of the IC (patent 2981877). At that time it was not at all obvious ICs would be a good business (if 50% of the transistors on a given

wafer are good, putting together any two of them yields 25% of working ICs. Even a 90% of working transistors would result in 12% overall yield for a 20-transistor IC). Noyce's IC used Si instead of Ge, used by Kilby. Si is better of Ge for many reasons. The originality of Noyce's solution lays on a method to get the transistors electrically isolated, not only interconnected. The method consists in surrounding the components with reverse biased p-n junctions. This idea, combined with the Hoerni's planar process, will provide the first practical method to fabricate monolithic ICs

- Robert Noyce is nominated general manager of Fairchild Semic., Gordon Moore takes over him as R&D director
 - September. Olivetti acquires 34% of shares of Underwood, the big American manufacturer of typewriters, for \$8.7M
 - April. At Fiera di Milano, Olivetti presents ELEA 9003 (1T), one of the first commercial mainframes fully transistorized. The ELEA project started in Barbaricina in 1957 with a team of young researchers (the "Barbaricina group") headed by Mario Tchou. The 9003 1T is completed in Brugherio. In 1959 Elserino Piol sells the first system to textile industry Marzotto in Valdagno. Until 1968, 43 would be sold to Monte dei Paschi, ENI, FIAT, Credito Italiano among others. Ge diodes and transistors assembled on cards made the control logic. The ELEA features many different kind of memories like punched tapes popped out from the teletypewriter, magnetic tape drives as a secondary memory (13MB each), matrices of wired ferritic cores as the primary memory (2 to 8 modules 20kB each, up to 160kB). The ferritic core memories were introduced by Jay Forrester at MIT. Cycle period was 10us, that lasts one single I/O operation, or a memory access. ELEA 9003 could perform 5000 additions/s, exactly how the giant ENIAC did.
- Multiprogramming capacity allowed to run 3 programs concurrently. The ELEA was fueled with 4.5kW. Characters are 6-bits, one instruction takes 8 characters. Up to 20 magnetic tape units can be attached to the central unit. According to the original design of Ettore Sottsass cables run over suspended rails called *blindosbarre* (not buried under the floor as used then) and the rack's height get reduced allowing human operators to be in sight. No OS's inside. Programs are written in machine language. Mauro Pacelli asks Gianni Palermo to write the first compiler in COBOL



- November 8. Adriano Olivetti presents ELEA 9003 to President of Italy Giovanni Gronchi, at Olivetti office in via Clerici (MI)



1960

- February 27. At age of 59, Adriano Olivetti dies for a brain haemorrhage during a train trip from Milan to Losanna (Switzerland). The family counts the rise of Roberto Olivetti. Giuseppe Pero is the new CEO
- May. Olivetti gets listed on the Stock Exchange
- Olivetti LRE starts working on ELEA 6001
- November. Federico Faggin, then 19, gets hired at Olivetti LRE in Borgolombardo. The job interview is held with Mario Tchou in person. After a two months training period Federico is asked to work on a experimental computer featuring 4096x12-bit magnetic RAM and 1000 logic gate CPU, entirely made of SGS Ge transistors. Operands are displayed on 11 Nixie valves. Working alongside 4 technicians he completes the project for the end of 1961 under guide of Sergio Sibani. The computer fits about 200 small circuits into a single rack
- DEC commercializes PDP-1, a fully transistorized and compact minicomputer with time-sharing OS. The PDP (Program Data Processor) series targets scientific and engineering domain problems

1961

- Steve Russel at MIT creates Spacewars for PDP-1
- February. Jay Last, Sheldon Roberts and Jean Hoerni resign from Fairchild to start the Amelco division of Teledyne
- March. Fairchild Semiconductors starts Micrologic, his first commercial IC line. The first device is a simple resistor-transistor logic gate (RTL), designed by Jay Last and first sold in 1962
- Robert Noyce invents a process to directly insulate each transistor in the wafer so that the transistors would not interfere with each other
- The Olivetti Lab in New Canaan is shut down
- At Fiera di Milano, Mario Tchou presents Olivetti ELEA 6001, first of a cheaper and smaller series of ELEA targeted to technical and scientific applications. About 64 were sold until 1968. Like IBM mainframes, also the 6001 uses FORTRAN. At that time LRE counts 300 active researchers
- November 9. At age 37 Mario Tchou perishes in a car accident on the Torino-Milano highway. Also the driver Francesco Frinzi, 28, get died. Tchou had figured out the limitations of FORTRAN. New languages like Algol and Simula seemed more flexible. The day of car accident he was moving from Borgolombardo to Ivrea, probably to meet Mauro Pacelli, head of the software team, to push research in these new directions. Pacelli had developed Palgo, a language inspired to Algol.



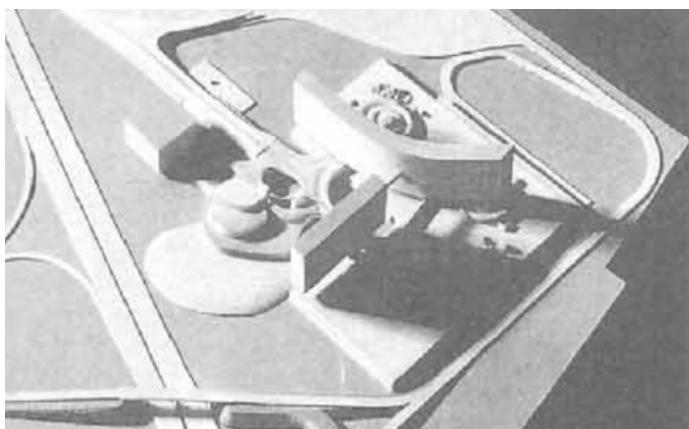
- Federico Faggin leaves Olivetti to get a M.S. in Physics at the University of Padova
- November 13. CEP is officially presented at the University of Pisa
- David Allison, David James, Lionel Kattner, Mark Weissenstem and two others quit Fairchild to set up Signetics, an all-IC company

1962

- Giorgio Sacerdoti takes over Tchou in the direction of LRE
- Eugene Kleiner quits Fairchild Semic.
- October. Sperry Univac releases UNIVAC 1107, the first solid-state member of the 1100 series. Unlike previous two-address machines, UNIVAC 1107 is a single-address machine, with up to 65536 words of 36-bit core memory
- October. Olivetti LRE merges with Olivetti-Bull, a division created in 1949 with support of Bull and Ottorino Beltrami as chief executive. The new holding is called Divisione Elettronica Olivetti (DEO)

1963

- November. Giuseppe Pero, Olivetti's CEO, passes away
- Olivetti DEO moves from Borgolombardo to Pregnana Milanese. Architet Le Corbusier is called to design the new operating center, which would occupy an area of about 300000 mq next to the Milano-Torino highway. It will never see the light



- Olivetti gets into financial problems. Bruno Visentini is asked to search Italian investors. New share holders came in DEO, the so called gruppo di intervento, including Mediobanca, Fiat, Pirelli, La Centrale, IMI, IRI, leaded by Enrico Cuccia. Visentini is the new president
- ELEA 4001 gets completed. 100 units will be sold until 1968

1964

- First commercial graphics computer - IBM 2250 console, \$125k
- IBM 360 is announced. The IBM System 360 (S/360) family of mainframe computers

would be delivered until 1978. They cover the complete range of applications, from small to large, both commercial and scientific. To research, develop, build and market this product, IBM spent \$5B. IBM 360 makes more clear the distinction between OS and application programs

- April. The Fiat manager Vittorio Valletta says that "Olivetti è strutturalmente solida e potrà superare senza grosse difficoltà il momento critico. Sul suo futuro pende però una minaccia, un neo da estirpare: l'essersi inserita nel settore elettronico, per il quale occorrono investimenti che nessuna azienda italiana può affrontare".
- July. GE acquires Compagnies des Machines Bull, becoming Bull General Electric
- August. 75% of Olivetti Electronic Division (LRE) is sold to GE for \$12M and is called Olivetti General Electric (OGE). Ottorino Beltrami is general director until 1970. Olivetti management learns product and project planning principles from GE.
- Spring. To stimulate IC demand Robert Noyce decides to sell its low-end FF IC for less than its cost of production. This strategy pays off. Within a year, IC sales will raise 150%

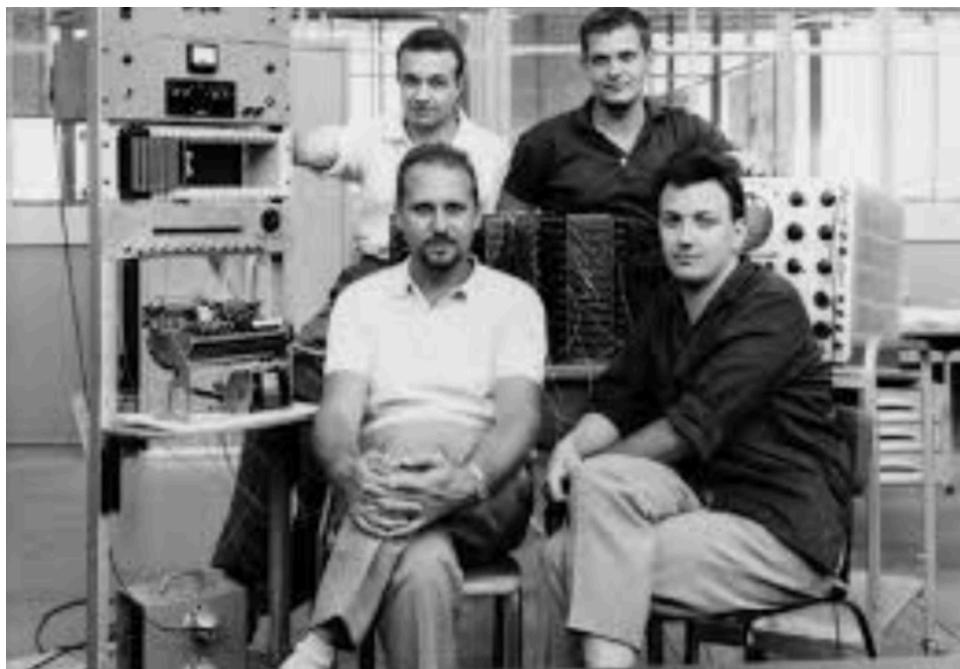


- Kurtz and Kemeny introduce the Dartmouth Time Sharing System (DTSS), a novel technique to distribute computer processing in time slices. At that time computers were gigantic and expensive so that only big companies or universities could afford one. Until then people were assigned a batch of time during which they were the sole user of the computer. However this led to inefficiencies due to the frequent thinking, reading or printing activities of the user, which meant downtime for the central processing unit. With the Time Sharing methodology many users were able to interact at the same time with the central unit. Actually the computer, after a small portion of program execution on one problem, quickly switched its focus to another one, and so forth in a cyclic timely way. Kurtz and Kemeny developed also a programming language called BASIC (Beginner's All-purpose System Instruction Code).
- December. RCA announces Spectra series of minicomputers, compatible with IBM 360

1965

- July 1. OGE (Olivetti General Electric) is officially established. Marisa Bellisario is product manager. Until 1968 OGE continues to play an important R&D activity under the direction of Visentini
- DEC presents PDP-8, the first minicomputer, created by a team leaded by Edson de Castro. It was the first real commercial success of the PDP series.
- CBM is involved in the financial scandal of Atlantic Acceptance Corp.
- AT&T dismisses the Shockley Transistor Laboratory
- At Bema Show (NY) Olivetti presents the Programma 101 (P101), the first desktop programmable computer, with program and data stored in memory. The "Perottina", by the name of his inventor Pier Giorgio Perotto, has 16 programming instructions. 40000 units will be sold for \$3200. La Perottina anticipò di 2 anni l'uscita sul mercato dell'analogico progetto della Hewlett Packard (HP 9100), la quale fu poi costretta a pagare

\$900K per aver violato alcuni brevetti della P101, in particolare la cartolina magnetica. La memoria era realizzata con 4 fili magnetostrettivi (dove l'applicazione di un campo magnetico produce una variazione di densità che si propaga lungo il filo con la velocità del suono). Era dotata di tastiera e stampante.



- Gordon Moore establishes the Moore's Law, which states that the number of transistors per IC doubles each year. This rate, observed since 1962, is predicted to stay valid for a decade. In reality the doubling interval will increase up to 3 years in 2013, with an average of 2 years in the period 1970-2013
- Analog Devices is founded by Ray Stata in Cambridge, Massachusetts
- GE-115 is introduced by OGE. It is an evolution of ELEA 4001. Its variants GE-105 and GE-130 have different memory sizes and CPU speed. The ELEA systems use COBOL and FORTRAN. IBM is the main direct competitor on the Italian market. About 5000 units will be sold. In US it is dubbed "The Dolly" (it. la bambola)



1966

- IBM introduces magnetic disk drive for mass storage. The random access to a disk drive exceeds immensely the sequential access to a tape drive. DOS (Disk Oriented System) starts to replace TOS (Tape Oriented System)
- Eliza, a AI chatbot ante-litteram, runs on PDP-10 simulating a psychiatrist during a analytical session
- Achieved M.S. in Physics with Laude, Federico Faggin gets hired in CERES, leaded by Sergio Sibani. CERES is also the Italian representative of GMe (General Microelectronics) a MOS IC company based in Silicon Valley CA, where Faggin is sent to learn the product lines

1967

- First Consumer Electronic Show (CES)
- Commodore gets in troubles in Canada and goes into bankrupt. Irving Gould, a Canadian financier, acquires Commodore and becomes the president. He instructs Jack Tramiel to take the company into the fast growing calculator business
- Charles Sporck and two others leave Fairchild to set up National Semiconductors
- Federico Faggin joins SGS-Fairchild in Agrate Brianza where he works on two MOS IC at R&D under Fabio Capocaccia
- Minicomputer market gets expanded. By 1967, some 95% of all banks in the US would use computers to handle checking accounts
- John Sarace and coll. at Bell Labs propose the idea of a self-aligned gate MOSFET in which the G is made out of highly doped p-type vacuum-evaporated amorphous Si instead of Al. This is the process: 1. grow thin-oxide layer 2. vacuum deposition of amorphous Si 3. annular shaped G defined in Si 4. remove thin-oxide outside G region 5. B deposition to form D junction (inside the annular ring) and S junction (outside) 6. contact mask 7. Al deposition (evaporated) 8. metal mask. All transistors being isolated, with S in common, it was a proof-of-concept structure, not a real IC. Boyd Watkins described a similar self-aligned, silicon-gate structure at General Microelectronics in 1965 but patent filing was delayed until 1969. The Silicon Gate Technology (SGT) will be a milestone in the fabrication of MOS IC

1968

- July 1. Noyce and Moore resign from Fairchild Semic. On July 18, they found Intel (Integrated Electronics) in Middlefield Road, Santa Clara, Mountain View. Their objective is to develop semiconductor memories to counter magnetic core memories. Few weeks later also Andy Grove and Leslie Vadàsz join Intel. Tom Klein takes over Vadàsz in Fairchild. Klein, Vadàsz and Grove were Hungarian hebrews escaped during the rebellion of 1956
- Data General is founded by Edson de Castro and Herb Richman
- February. Federico Faggin, then an SGS employee, is guest engineer for 6 months in Fairchild (PA), where head of MOS division Leslie Vadàsz proposes him to work on Silicon Gate Technology (SGT). In the mid-1960s MOS were enhanced-mode, p-ch, with metal gate (Al). V_t was -5 to -8V, mainly due to Si crystal orientation [111] and to the high work function difference W(Al)-W(Si). The fabrication process was 1. grow thin-oxide layer 2. mask define S and D regions 3. form junctions by B deposition 4. mask define thermal thin-oxide in the G region 5. Al deposition 6. S,D contact etching 7. G contact on top of the thin-oxide. However, the gate mask would inevitably misalign in relation to the S and D masks. The workaround was to make the thin-oxide region large enough to ensure that it overlapped both the S and D, to avoid gaps in the inversion channel. But this led to C_{gs} and C_{gd} parasitics, contributing to an overall input capacitance according to the Miller effect C_g+C_{gs}+A*C_{gd} (A>>1), which was both large and variable, a strong limiting factor to the MOS switching rate. Part of the solution was to define the metal gate electrode first and then use that as a mask to define S and D regions. This was called the self-aligned gate method, from the original idea of Robert W. Bower in 1966 (patent US3472712, published in 1969). Unfortunately Bower's idea won't work in practice because Al could not withstand the high T required for subsequent process steps. As shown by Thomas Klein in 1967, W(Si,p+)-W(Si,n) was 1.1V less than W(Al)-W(Si,n), suggesting that switching from Al to amorphous p+ Si as the gate electrode material would reduce V_t of intentional MOS by 1.1V, while keeping high V_t for parasitic MOS, which was typical for Si [111]. All this stuff had been worked on single transistors but not to the point where commercial IC could be done. This is the scenario where Faggin starts his work, nailing in few months a number of original improvements that would make SGT the standard MOS process in the 40 years to come, yielding 3 to 5x faster, 2x denser IC than metal gate (given same power consumption), and preparing the way for DRAM, microprocessors, EEPROM, CCD devices.
The first original solution proposed by Faggin is the "buried contact", where the amorphous Si of the G contact is routed over the D area of the - or different- MOSFET and let it doing an ohmic contact with the D well below through a squared window. This meant a significant space saving (metal traces could run over the buried contacts) at the cost of an additional mask. Faggin then works on a precision etching method for the amorphous Si contacts. To cut Si leaving SiO₂ intact he found an optimal mixture of HNO₃ (nitric acid) and HF (fluoridric acid) dubbed "Freddy's etch" (Freddy was Faggin's nick name)
Faggin notes that the vacuum-evaporated amorphous Si as G material, like Al, tends to break when routed across the SiO₂ step at the tub well boundaries. To address the problem Faggin, supported by Tom Klein, decides to use poly-Si by vapor-phase deposition from decomposition of SiH₄ at high T, where Si atoms came from all directions like snow, not like rain from a single direction. Another Faggin's invention to mitigate the same effect was to grow a thin SiO₂ layer, then apply a layer of silicon nitride and remove it outside the tub area, where the SiO₂ is let continuing to grow. During thermal oxidation Si is consumed from the wafer and incorporated in the growing oxide. Since SiO₂ contains 2.2x10²² molecules cm⁻³ while Si contains 5x10²² molecules cm⁻³, the thickness of consumed Si is 0.44x the thickness of formed SiO₂. The final result is a half-height step at the tub's contour.
Faggin further gets improved the process by using *phosphorus gettering* (a technique used in bipolar process) to soak up impurities that caused leakage currents. The P dopants applied on the wafer's back diffuse into the bulk trapping the impurities. This

treatment was impossible with the metal gate because it happened at 800-900 °C, where Al would get diffused in Si. SGT reliability gets enhanced immensely

- Faggin proposes to use thermal doping instead of ionic implantation described by Bower
- Bootstrap load is another important achievement exploited by Faggin. It is a dynamic capacitor added to a logic port to achieve an output voltage swing equal to the supply voltage Vdd, rather than Vdd-Vt. This is especially important with static random logic circuit (e.g. a push-pull driver). With metal gate it's easy to fabricate isolated capacitors: diffusion, thin oxide, Al deposition. With SGT one additional mask would be required for the diffusion. Faggin notices that the metal side of the capacitor is always biased in such a way, even with no diffusion underneath, an inversion layer or "virtual" diffusion exists. The first commercial application of this solution is the MCS-4 set of IC
- Faggin develops 3708, the first commercial IC using SGT. 3708 is a 8 to 1 analog multiplexer with 3-bits decoding logic for input selection. The 3708 is 5x faster than previous metal-gate model 3705, RdsOn 3x smaller, leakage current 100x to 1000x smaller.
- July 1. Faggin gets hired in Fairchild Semiconductors



- SGS is acquired by IRI. Few years later it will join Thomson Semiconducteurs, becoming SGS Thomson, and later STMicroelectronics.
- Olivetti sells to GE the remaining 25% of OGE, which becomes General Electric Information Systems Italia (GEISI), an Italian subsidiary of an American company. Beltrami is confirmed CEO.
- Sharp asks Rockwell to design a set of IC for its calculators with display
- John Schroeder and Jack Schmidt resign from Fairchild to set up Computer Microtechnology
- HP presents HP9100A, the desktop programmable calculator inspired to Olivetti Programma 101. To make use of the magnetic card, HP was ordered to pay \$900k in royalties to Olivetti. The internal memory is a ferritic cores implementation
- Douglas Engelbart gives a demonstration (known as "The Mother of All Demos") of three of his fundamental achievements in the field of human-computer interaction, the mouse, the hypertext and the bitmapped screens, long before the personal computer revolution. The DARPA-funded project, started at his Augmentation Research Center Lab (ARC) at the Stanford Research Institute, in Menlo Park (CA). His intention was to focus on making the world a better place.

1969

- With its 5 to 10x reduction in space and 5 to 10x reduction in power dissipation, MOS IC technology promises to replace the bipolar technology. However, in 1969 MOS IC are still slow and unreliable, counting for less than 5% of all IC produced worldwide
- May, Intel introduces the 3101, 64-bit Schottky bipolar SRAM
- Intel 1101 256-bit SRAM uses the MOS p-ch process and relies on SGT rather than metal gates. Access time is 1.5 us, 3x faster than ferritic cores memories

- Busicom (formerly Nippon Calculating Machine Corp) asks Intel to produce 7 custom ICs to be used in a family of desktop calculators. 3 of them had similar functions. Ted Hoff, head of the Application Research group, comes up with the idea to replace hard-wired logic with a single programmable IC working as a general purpose minicomputer, like those he saw at Stanford Univ. Moreover, instead of the serial shift registers and the SRAM asked by Busicom, he proposes to adopt DRAM devices, with a simpler cell structure (3 transistors instead of 6). Bob Noyce encourages Hoff to go forward in that direction. Hoff's assistant Stanley Mazor defines the 45 instructions set. The project is then passed to Leslie Vadasz, head of MOS division, but gets stuck for months (custom logic design was not the Intel core business)
- Data General presents NOVA minicomputer
- MITS is founded in Albuquerque
- Xerox Parc starts operations in Palo Alto
- Lee Boysel and Jack Faith leave Fairchild to set up Four Phase
- W.J.Sanders III leaves Fairchild to set up Advanced Micro Devices
- UNIX is released by Ken Thompson and Dennis Ritchie of Bell Laboratories. It will be the OS most used on mainframes in the 70s. The first assembly version run on a PDP-7. Few principles drove the design: each program shall do one single job well, the output of a program can be the input of another one. Between 1969 and 1979, UNIX went through 6 releases, or editions.



- May. GE cede a Honeywell la GE Information System, nata per sviluppare la serie NPL per fronteggiare IBM. La nuova società viene chiamata Honeywell Information Systems. GEISI becomes Honeywell Information System Italia (HISI)
- Telnet is developed beginning with RFC 15. The name stands for "teletype network". It is based upon the notion of a virtual teletype
- CCD image sensors are invented at Bell Labs. Basically they are arrays of MOS capacitors

1970

- Intel 1103 1024-bit DRAM MOS (p-ch) IC. It exploits the bootstrap loads. It shows a real competitive advantage over ferritic memories
- Intel's dynamic shift registers can work over a wider range of frequencies, due to the SGT. National Semiconductor well established market of metal gate IC is progressively eroded
- CMOS, Bi-CMOS
- April. Federico Faggin is asked to move from Fairchild to Intel, MOS design dept., where Leslie Vadasz assigns to him the Busicom project. Vadasz decides to reduce the 4004's pin count from 40 to 16. This choice will slow down performances by a factor of 3, because address, instructions and data must be multiplexed over a single 4-bit bus (16 pin packages were a kind of dogma in Intel)
- MOS Technologies is founded in Valley Forge
- Garret AiResearch Corp releases MP944, the first MOS/LSI integrated Microprocessor chip set, for the US Navy F14A "Tomcat" fighter jet. The project started in 1968
- Xerox PARC is founded in Palo Alto by Jack Goldman, Xerox Corporation's chief scientist. They wanted to dominate the "paperless office" of the future. Much of PARC's early success in the computer field was under the leadership of Bob Taylor, who guided

the lab from 1970 to 1983. "The atmosphere was electric – there was total intellectual freedom. There was no conventional wisdom; almost every idea was up for challenge and got challenged regularly" (John Warnock). Unfortunately Xerox management, just focused on photocopiers, never understood the revolutionary value of PARC's vision and creations

- May. GE sells its computer business to Honeywell. GEISI is acquired by Honeywell, and becomes Honeywell Information Systems Italia (HISI). Marisa Bellisario continues her work at product planning. When Beltrami leaves GEISI, Marisa Bellisario competes and loses with marketing manager Carlo Peretti for the CEO position
- Dov Froham joins Intel. Previous experiments with floating silicon gate devices carried out in Fairchild culminate with the invention of EEPROM
- CCD image sensor, originally invented at Bell Labs, are successfully manufactured in Intel with SGT

1971

- Busicom engineer Masatoshi Shima gets sick for the 5-months delay of the project. Faggin understands the SGT and the bootstrap loads are the key technologies to attack the problem. In February, after 11 months of 80-hours-per-week hardworking, Federico Faggin, with the help of Shima, completes the 4000 family: Intel 4004, the first 4-bit microcontroller, 2300 transistor, 750kHz, 60\$, 15V, 750mW, 8 clock per instruction; 4001: 2048-bit ROM; 4002: 320-bit DRAM; 4003: 10-bit shift register for IO. The 4004 had required 5 masks. The 4004 will be protected by two patents (3821715, 3753011). Patent 3753011 is a bistable FF with preset, used to float external bus at power on (there were no pins available for RESET). The same design methodology will be reused by Faggin for all the first 4 Intel microprocessors and the first 3 Zilog microprocessors, except for the p-ch to n-ch and the n-ch bootstrap load to depletion load major changes. The rights of use of 4004, initially an exclusive ownership of Busicom, are transferred to Intel in exchange of the development costs (\$65k). At this time Busicom suffers the competition with custom IC based products
- April. The first Busicom calculator with printer (141-PF) is ready. 100000 will be sold. The first prototype is now exposed at the Computer History Museum if Mountain View
- June, 27. The SGT is patented by Faggin and Thomas Klein ([3673471](#)). This invention will make the MOS technology to supersede the bipolar technology in mass production of complex IC, in all but the highest speed applications
- Alan Shugart at IBM invents the floppy disk drive
- Intel releases 1702, the first 2038-bit PROM. Dov Frohman discovered that a floating Si gate can accumulate electrons for years. UV rays can reach the gates through a Quartz window, getting bits erased.
- November. Intel announces publicly the 4004 chipset to the general market with the name MCS-4 (Micro Computer System 4-bit), advertising it on Electronics News magazine n.15
- Intel moves headquarters in Bowers Avenue, Santa Clara
- June. TI announces TMS1802 NC on Electronics magazine
- RCA sells its computer business to Sperry
- In the 1960's IBM had 7 major competitors in US: Burroughs, Sperry Rand, NCR, CDC, Honeywell, GE, RCA. They were called "IBM and the Seven Dwarfs". In the 70's IBM has only 5 major competitors: Burroughs, UNIVAC, NCR, CDC, Honeywell. They are called "BUNCH"
- April 16. The original specification for the File Transfer Protocol (FTP) is written by Abhay Bhushan and published as RFC 114
- Visentini calls back Beltrami in Olivetti as CEO to initiate a profound transformation of the company toward ICT, a process which will completed by Carlo De Benedetti in early 1980s. Revenues due to electronic products rise from 23% in 1971 to 60% in 1977.

1972

- Federico Faggin designs Intel 1201, subsequently renamed 8008, the world's first 8-bit uP. It has 3500 transistor, 800kHz, \$120, 18-pin package. Intel is still reluctant to use

40-pin packaging, imposing a significant limiting factor. The 1201 project was initially assigned to Hal Feeney in 1971, based on the specifications of CTC, a startup recently established in San Antonio (Texas) with focus on intelligent computer terminals. Also Seiko, printers manufacturer that wants to develop a desktop calculator, is interested in the 1201. Feeney and Faggin complete the project in April. The 8008 could address 16 KB of memory and had an instruction cycle of 12 us

- Mostek releases Micro8, a 8-bit uP developed with Olivetti. Micro8 will be used for the TC800
- Atari Corporation is founded by Nolan Bushnell and Ted Badney
- Pong is created by Allan Alcorn in Atari
- C language is created by Dennis Ritchie at Bell Laboratories. It pushes the concept of pointer, a direct incarnation of CPU's indirect addressing
- IBM pioneered a fast n-ch DRAM MOS process for its System 370 Model 158
- Gary Kildall creates PL/M, a programming language based on COBOL, FORTRAN, ALGOL60
- Cray Research Inc. (CRI) is founded by computer designer Seymour Cray

1973

- Atari PONG, by Al Alcorn, is released
- R2E, a Bull company, presents Micral-N, a programmable microcomputer built around Intel 8008
- Intel 2102 1024-bit the first 5V Silicon gate n-ch fast SRAM MOS (n-ch) IC. The 5V working voltage allows TTL compatibility
- Mostek releases the first 5V Silicon gate n-ch MOS SRAM IC with depletion mode FET loads, which allows the gate output to reach the full supply voltage, then providing a constant current
- Intel will reply to Mostek releasing the 2102A, four times faster than 2102.
- Xerox PARC releases Alto, considered the first friendly PC. Alto was not freely available on the market. Alto features mouse, ethernet and a bit-oriented graphics on a portrait oriented screen. What you see onto the screen is what you get printed onto the paper
- The UNIX kernel, 4th edition, is moved to the PDP-11 and is almost entirely rewritten in C

1974

- Intel releases the 4040, an extended version of the 4004. It can interface more easily with PROMs and other standard memories
- Federico Faggin, supported by Shima, designs Intel 8080A, 4500 transistor, 2MHz, 350\$, 150\$, 8-bit. The package is 40-pin, so that address, instructions and data bus are not multiplexed. 8080 is code compatible with 8008. The Intel 8080 is the world's first second-generation 8-bit microprocessor. The 8080 employed N-channel MOS with SGT with two power supplies: +12 and +5 volt, making TTL compatibility much easier than possible with P-channel MOS. The 8080 registers used static, rather than dynamic memory, and the instruction cycle became 2 rather than 12 μ sec!
- Tomoshiro Nishikado (?) creates Wester Gun Arcade game using TTL ICs
- Stewart Brand, in his book Two Cybernetic Frontiers, firstly uses the term Personal Computer
- Andy Grove assumes the role of Intel executive vice-president and marketing manager
- Gwary Kildall creates CP/M (Control Program Monitor) for the 8080, the first OS for microcomputer. It will inspire MS-DOS
- July, the share price of Intel stock fell 30% overnight. The contraction of memory market brought the termination of roughly 30% of Intel's 2500 employees
- October. Federico Faggin and Ralph Ungermaann leave Intel to set up Zilog Inc. in Campbell to focus on making microprocessors. The reasons that prompted Faggin to leave Intel were many. The most compelling was discovering that Intel had patented his "buried contact" idea, without his knowledge, under the name of Leslie Vadasz, his former boss at Fairchild and now at Intel. The new startup headquarters are in State Street, Los Altos, where they rent an office. Faggin is President and CEO of Zilog from

inception until December 1980. In few weeks a business plan is written and presented to VC Exxon Enterprises, a subsidiary of Exxon Corporation, the oil company.

- December. Faggin comes up with the idea of the Z80 (or what in those days he called Super-80). Basically a chipset with a CPU and a number of peripheral components designed around a 5V bus. The initial idea is to rely on Synertek for the wafer fabrication

1975

- January. Altair 8800, 8080-based, by MITS (Micro Instrumentation & Telemetry Systems, Inc.) of Ed Roberts. It is presented over Popular Electronics of January. Sold for 375\$. Altair 8800 was built around S-100, the 100 lines bus that allowed expansion of the system with user's boards
- Motorola 6800, 8-bit uP, \$175, 72 instructions, 64K addr space. Chuck Peddle and Charlie Melear are the designers
- MOS Technology 6502, 3510 transistor, \$25, by Chuck Paddle, RRIOT 6530 (64B Ram, 1KB Rom, IO port, Timer 8-bit), Very easy to use, internal clock, 64K addr space, 56 instructions
- February. Bill Gates and Paul Allen write for 8080 a BASIC interpreter. It is considered the first programming language written for a personal computer. They sold the BASIC interpreter to MITS until 1977. Ed Roberts had scheduled a meeting with Allen and Gates in March 1975
- Steve Bourne developed the Bourne Shell
- Fortune magazine article on Intel microprocessor. Federico Faggin is not even mentioned. Intel gets start a campaign against Faggin diminishing his fundamental contribution to the invention of SGT and microprocessor
- June. Zilog obtains \$500k initial fund from Exxon Enterprises, the VC arm of Exxon.
- Kodak creates the first experimental digital camera based on Fairchild's commercial CCD sensors
- ICT industry gets into recession. Because of the bubble of the early '70s in the stock market, there was no venture capital money. In the entire 1975 only \$10M of VC were invested in high tech. The industry was hundreds of millions of dollars a year
- April. Masatoshi Shima leaves Intel to join Zilog. His first goal is to do the detailed design of the Z80-CPU. Z80 will keep binary code compatibility with 8080, in order to take the market share of the 8080. Two sets of index registers were added in order to go into the market of Motorola's 6800.

1976

- Steve Wozniak Apple 1 (6502-based)
- Apple Computer is founded by S.Jobs, S.Wozniak, Ronald Waynej
- Mike Markkulla invests \$250000 in Apple. He brings Regis McKenna into the company
- Commodore takes over MOS Technology Inc, with a IC manufacturing plant in Valley Forge, Pennsylvania privately owned and valued at around \$12 million. In 1976 CBM was, not for the first nor the last time, struggling mightily. Texas Instruments had virtually destroyed their calculator business by introducing machines priced cheaper than Commodore could possibly match. The reason: TI owned its own chip-fabrication plants rather than having to source its chips from other suppliers. It was a matter of vertical integration, as they say in the business world
- May. Zilog Z80 is introduced in the market. Z80-CPU: 8-bit, 8200 transistor (8080's was 4800), depletion-mode, 5V N-ch with silicon gate, 64KB address space, 2.5-4Mhz, 1us instruction cycle, roughly 200 x 200 mils, \$200. Faggin co-designed the Z80 with M. Shima. The layout of the Z80-CPU is hand-drawn by Federico by two thirds. The Z80 is software compatible with the 8080 but is faster and has twice the number of registers and instructions. The development platform is also released. Companion peripheral chips are Z80-PIO, CTC, SIO, DMA. The chip is launched on the Electronic News, a weekly newspaper in the electronics field, with an article titled "The Battle of the 80's"
- Zilog obtains his second \$500k fund from Exxon Enterprises. At this moment board of directors is formed by Federico Faggin, Ralph Ungerma and three from Exxon. Faggin's ambition is to involve new external investors with the final goal of incorporating the

company. Exxon rejects the proposal and Faggin relinquished (Z80 is done, keeping his position might get him ousted from Zilog). The entire Zilog in those days had 11 people, plus a computer architect Bernard Peuto get hired to begin the process of defining the next generation processor.

- March. Zilog starts design of z8000
- Bill Gates wants to sell BASIC to Jack Tramiel 3\$ per copy. Tramiel replies "I've already get married" and got the licence for \$50k
- First 16kbit RAM IC
- Fairchild releases VES (Video Entertainment System), based on F8 microprocessor. It will be replaced by Atari VCS (Via deo Computer System) in 1978
- Warner Communications acquires Atari
- Micro-Soft co-founder Bill Gates, in response to the habit of copying his BASIC for ALTAIR 8800, he discloses an open letter to hobbyists in defence of proprietary software. In his opinion the software must be payed, as it is for the hardware.
- Richard Stallman, a researcher at the AI Lab of MIT, faces the ethical problem of being impeded to modify a proprietary source program unless he accepted to not disclose his work with others. He perceive the limits imposed by intellectual property as limitation of freedom

1977

- January. The first wafer foundry of Zilog Inc. produces its first working Z80 chip. That goes to the credit of Len Perham, get hired in Zilog on may 1976 to create and run the fab. This foundry was the key to give Zilog independence, so that they would not be in a position of underdog to their second source. Mostek è la nuova second source
- Commodore PET 2001 (595\$), by Chuck Peddle and others, (6502-based), 6540 Rom, 4KB 6550 Ram, Micro-Soft BASIC (with floating point arithmetic). Jack Tramiel ebbe l'idea vincente di accettare preordini, cioè incassare i soldi e consegnare il PET a 90 gg
- Apple 2 (6502-based). It has an Integer BASIC version. The 4KB version is sold for \$1300. Apple 2 is presented at the West Coast Computer Faire by Jobs
- Tandy TRS-80 (\$600) (Z80-based), 4KB Ram, 4KB Rom, a monitor and a cassette recorder. Initially it ran the Tiny BASIC. By one year it was replaced with the Micro-Soft BASIC. The Tandy's Radio Shack distribution promotes its diffusion
- Byte magazine later dubbed the three competitors the "1977 Trinity"
- Apple incorporated. At the end of the year it had sales of \$775000
- Albert Charpentier designs VIC (6560/6561) in MOS Technologies, a single-chip graphic controller and sound generator. He hoped Atari would use it, but they didn't
- Atari VCS 2600 (6507, 8KB address space) 128B Ram. Come chip VDP ha il TIA (Television Interface Adapter), creato da Jey Mayner. Il TIA generava grafica sfruttando il raster del TV. The killer app will be the porting of Space Invaders, an Arcade game published in 1978
- RSA (Ron Rivest, Adi Shamir, Leonard Adleman)
- Kazuhiko Nishi is an engineering student in Tokyo who wants build his version of Pong using a microprocessor. He drop university and founds ASCII Corporation and starts the I/O magazine. In August he calls Bill Gates. They are the same age and like each other. Key made a special trip to the US and made the case to Gates and Paul Allen that he should start an Asian arm of Microsoft operated by ASCII Corp.

1978

- DEC VAX 11/780, 32-bit, 5 mhz 16 kb RAM chip (\$500)
- Intel 8086 uP: the first x86, 16-bit, 1MB address space, organized in 16 pages
- Intel 8088, 8-bit, 29000 transistor, 10MHz
- Starts Apple Lisa project under the direction of Jeff Raskin (6809-based)
- June, the Japanese Tayto (?) releases Space Invaders, an Arcade game by Tomoshiro Nishikado (?). It is a program for 8080. La grafica, in raster, non è generata da un VDP ma dalla stessa CPU. Questo faceva sì che al diminuire del numero degli alieni essi avanzano più velocemente. Un limite tecnico che divenne una design feature. Per l'alieno si ispira ai tripodi del film La guerra dei mondi. La dinamica del gioco (gameplay) è un

fixed shooter inspirato a Breakout.

- March, Olivetti's business model evolves towards IT with the Gruppo Informatica Distribuita, headed by Marisa Bellisario
- June. Visentini calls Carlo De Benedetti, major stocks owner of Olivetti, to assume the role of CEO and VP. A new positive season gets started. Elserino Piol counters Marisa Bellisario thinks the TC 800 and the small BCS cannot evolve further, and a new line of products is required, more general purpose, which will be the Linea 1 (L1)
- Kazuhiko Nishi is Vice President of Microsoft subsidiary in Japan. He brings the BASIC language in Japan
- Nolan Bushnell quits Atari. Raymond E. Kassar is the new CEO..
- Exxon creates Exxon Office Systems
- z8 uC (?)

1979

- January. The 7th edition of UNIX is released. It includes the Bourne *shell*, and a FORTRAN 77 compiler
- December. 3BSD, the first full featured BSD (Berkeley Software Distribution), is released by the *Computer Systems Research Group* at University of California, Berkeley. From this point, UNIX diverged into two important variants: BSD and System V. Thompson spent the 1975/1976 academic year as a visiting professor at the University of California at Berkeley, the university from which he had graduated. There, he worked with several graduate students, adding many new features to UNIX (one of these students, Bill Joy, subsequently went on to cofound Sun Microsystems). Over time, many new tools and features were developed at Berkeley, including the C *shell*, the *vi* editor, an improved file system (the *Berkeley Fast File System*), *sendmail*, a Pascal compiler, and virtual memory management on the new Digital VAX architecture
- Motorola 68000: 32-bit, 16MB addr space, 56 instructions
- Zilog Z8000 is released. 16-bit, 110 instructions. The initial idea was to feature 24-bit address space or 32MB. It would require more than 50 pin, non standard package. In order to fit it into a cost effective 48-pin package digital architect Bernard Peuto counts on 128kB-pages memory segmentation strategy. An MMU peripheral was needed. Faggin doesn't feel this is the right solution. Upcoming graphical apps will require more than 128kB. But he accepts Peuto's idea. After all also Intel 8086 used memory segmentation.
- Z8001 is introduced in the market. Olivetti adopts it for M20
- Due to 16-bit address space and incomplete compatibility with Z80 it lost. At this time Zilog has 1100 employees. As executive VP, Ralph Ungermaann has lots of arguments to Faggin. Faggin asks the board to choose among them two. The board chairman Ben Sykes calls Manny Fernandez as the new CEO.
- Intel 8088 uP, 16-bit
- Atari 400/800 8-bit computers
- IBM 3279 color terminal
- TI T99/4A, home computer. It will be a flop for its high cost. The TMS9900, 16-bit, 3MHz CPU had many bugs
- October, VisiCalc released for the Apple II by VisiCorp. The creator is Daniel Bricklin
- David Crane left Atari and co-founded Activision, along with Miller, Jim Levy, Bob Whitehead, and Larry Kaplan. His games won many awards while he was at Activision.
- SQL
- A group of Apple engineers visits the Xerox's PARC. Steve Jobs has the opportunity to appreciate the Alto's networking, OOP and GUI. Adele Goldberg was told to give a demo of Alto to Steve and Bill Atkinson
- SQL language is released

1980

- Sinclair ZX80, 4KB Rom 1KB Ram, £99.95
- Pac-Man an arcade game is developed by Namco. The designer is Toru Iwatani
- Wilfred Corrigan leaves Fairchild to set up LSI Logic

IBM chooses intel 8086 rather than z8000 for political reasons (ee was a ibm competitor)
Apple chooses for mac mot 68000, w linear addr. Another defeat fir z8000

- Olivetti develops Linea 1, a new industrial software development platform, based on Unix-like OS (MOS, or COSMOS IV, or GCOS4), email and file transfer. Concurrent Pascal is the language of choice. L1 is based on RISC Zilog Z8000
- July, William Lowe of IBM presents the feasibility for a IBM PC. The project is assigned to Don Estridge. The first decision is to use Intel 8088. For the OS they ask to Bill Gates of Microsoft, who grabs the deal and buys the OS from Seattle Computer Company for \$75k. The new OS is called MS-DOS
- Elserino Piol meets Mike Markulla proposing Olivetti as a european partner of Apple. During the next meeting Michael Scott reported that Jobs and Wozniak had rejected the deal
- December. Exxon wants Zilog Inc. to be part of Exxon Office Systems. Zilog becomes and Exxon subsidiary. Faggin leaves his role of President and CEO of Zilog and becomes chairman of Zilog in NY
-

1981

- Sinclair ZX81, con basic FP, 8KB Rom
- In MOS Technologies Al Charpentier rilascia il VIC-II, chip grafico (VDP) ispirato al TMS9918. La logica degli sprite occupa 2/3 del chip
- Gordon Campbell and George Perlegos leave Intel to set up SEEQ
- Robert Swanson and Robert Dobkin leave National Semiconductors to set up Linear Technology
- Commodore VIC-20 by Yash Terakura (first released in Japan as VIC 1001)(6502-based), 3.5/5KB Ram, 8/20KB Rom, very low price (299\$); 6560, or VIC (Video Interface Chip, audio e video), grafica gestita a caratteri (8x8) e modalità multicolor per avere più colori anche se con meno risoluzione; 22 columns
- Satori Uata (oggi CEO Nintendo) inizia sui Commodore PET e crea nella sua HAL Laboratories i primi giochi per il VIC20. Capolavori come una conversione di Pacman
- May. Federico Faggin leaves Zilog.
- August, IBM launches the first PC, the 5150. It uses 8088 a 8-bit version of 8086 which is 16-bit. Existing and current home machines contained 8-bit processors. Even though the 5150 had been designed for business users, it was seen by many observers as the beginning of the end of the era of 8-bit microcomputing. PC is an open system, more than Apple II. It was initially a winning choice, but in the long term will open to cloning. IBM was a B2B company, Apple a B2C. The PC was a social innovation
- Xerox introduces Xerox Star, the first commercial computer with mouse and GUI. 25000 units will be sold

1982

- Sinclair ZX Spectrum
- Commodore 64, \$595 (6510-based, very similar to 6502); 6581, o VIC2 (video): Grafica gestita a bitmap e sprite. Era stato progettato per una game console (Commodore Max); Palette di 16 colori, 40 colonne; La generazione del segnale era YC (composito), e in NTSC vi era una resa migliore rispetto a PAL; SID (audio): con envelope generator progettato da un musicista Bob Yannes; 3 canali indipendenti; Micro-Soft Basic 2.0 (MBasic) in 8kB ROM; OS in 8kB ROM; Inaugura l'informatica di massa o personale
- Donkey Kong (?) is released by Nintendo
- Adobe is founded in 1982 by John Warnock and Charles Geschke. At PARC John had invented the laser printer, which allowed to print the graphic features you got on the screen. It was the beginning of word processing and desktop publishing
- August. Simple Mail Transfer Protocol (SMTP) is defined in RFC 821
- Intel 80186, 55000 transistor, 25MHz

- Intel 80286, 134000 trans, 25MHz, 16MB
- Atari 5200
- Olivetti M20 PC. The OS is PCOS
- Billy Joy founds Sun Microsystems
- US antitrust legislation forced the breakup of AT&T and Bell Laboratories, with the consequence that, since AT&T no longer held a monopoly on the telephone system, the company was permitted to market UNIX OS
- The surge of interest in the IBM PC quickly led to compatible machines from rival vendors, who took Microsoft's own-brand version of the operating system, licensed to IBM, and combined it with Intel processor technology and a compatible third-party Bios to produce "IBM clones" that would run applications and utilities written for the 5150. Up to 100 companies would eventually produce PC clones
- May. Cygnet Technology in Sunnyvale (CA) is co-founded by Federico Faggin with initial funding of VC Merryl Lynch and Bay Partners. The focus is on voice-data convergence solution for IBM PC

1978-83

- Apple Lisa (68000-based). It was not a commercial success mainly because too expensive. Since 1981 Microsoft works on Lisa software, and Bill Gates conceives the big gamble. Job's fights IBM, but Bill was the true enemy

1979-84

- Sinclair QL, (68008-based)
- Apple Macintosh, for the "Person In The Street" (PITS). Dal 1981 JS subentra a Jef Raskin, che dal 1979 lavorava a un computer da meno di \$1k, sostituendo il 6809 con il 68000. The team: Steve Jobs, Andy Hertzfeld, Joanna Hoffman, Susan Kare, Burrell Smith, Bill Atkinson, Chris Espinosa, Bud Tribble, Howard, Steve Capps, George Crow, Bruce Horn, Bob Belleville, Donn Denman, Larry Kenyon, Caroline Rose. Mac is presented on January 24. Sales were strong from its initial release on January 24, 1984, and reached 70,000 units on May 3, 1984. In the long run it failed the competition with PCs, because of its cost \$1k more than a PC and scarcer software. MacPaint and MacWrite were bundled with the Mac, while PCs had also spreadsheets, word processing and databases
- Susan Kare fu la grafica che dal 1982 disegnò molte icone del Mac. Il cestino e il simbolo del tasto Command sono suoi. Fu tra i primi 10 dipendenti della NeXT

1983

- VIC-20 reaches 1 million units sold
- Commodore cuts the price of C64 to \$200 to beat TI
- A large scale recession in the video game industry begins and will last until 1985, primarily in North America. The crash was attributed to several factors, including market saturation in the number of game consoles and available games, and waning interest in console games in favor of personal computers.
- T.J.Rodgers and Lowell Turiff leave AMD to set up Cypress
- June, Microsoft Japan announces MSX, a computing platform aimed for standardization of the 8-bit home computer market. Nishi's relationships with industrial Japanese giants (Canon, Hitachi, NEC, Sony, Toshiba, etc.) would become important in the mid-1980s, as a number of them were looking for a way to enter the home computer market. The idea to standardize came from the home video market, where the bruising battle between VHS and Betamax was proving the value of consistency. The standard was based on HW (Zilog Z80, Texas Instruments TMS9918 video chip, cartridges as a mass storage system) and SW (Microsoft BASIC)
- Domain Name System (DNS) is developed. It will be revised numerous times since its inception
- 4.2BSD is released implementing TCP/IP protocol stack
- 4.2BSD is released. It introduces the sockets APIs, the notion of symbolic link, and more
- SunOS, the UNIX variant based on 4.2BSD, is released by Sun Microsystems

- Federico Faggin is board's member of Logitech

1984

- Jack Tramiel quits Commodore. It is the beginning of the end. In the same year 35 employees left the company. Commodore sells 500000+ computers per month. Marketshare 2500000, IBM 1500000, Apple 300000
- Texas Instruments announces 1000 workers in its Consumer Division are get fired. The 99/4A is get sold by dealers for \$49.9
- Warner sold the home computing and game console divisions of Atari to Jack Tramiel, under the name Atari Corporation for \$240 million
- Cygnet presents Communication Cosystem at the PC-Fair in SF, where it is awarded as the most innovative product in the field. The product featured electronic mail and file transfer, plus a number of software application packages. 5000 would be sold the 1st year, far less then expected 15000. Faggin meets Steve Jobs who makes many compliments for the product but dislikes it occupies so much space on the desktop.
- Olivetti M24 compatible PC. Processor is Intel 8086 and operative system is Microsoft MS-DOS
- 25% of Olivetti stocks is sold to AT&T for Lire 430B
- Bernard Vonderschmitt leaves Zilog to set up Xilinx
- AT&T is broken in 7 baby-bells
- UNIX sources royalty-free sharing ends. The UNIX System V becomes a commercial product. Only Berkeley University continues to develop his licensed version BSD (Berkeley Software Distribution)
- Richard Stallman of MIT announces the GNU ("GNU's Not Unix") Project. He set to work on creating a UNIX-compatible OS that assured software freedom for all. Stallman's outlook was a moral one, and *free* was defined in a legal sense (as in *freedom*), rather than a financial sense (as in *price*). At the time the use of BSD still required a license from AT&T, and users could not freely modify and redistribute the AT&T code that still formed part of BSD

1985

- Intel 80386, 32-bit, 275k trans, 40MHz, 4GB addr
- S.Jobs ousted by Apple
- Amiga 1000
- Commodore 128, the last 8-bit uComputer, 8502 (primary cpu, an enhanced version of 6510) plus Z80, 128MB, 88 column graphics, BASIC 7.0, 5.7M sold. "Go 64" or by pressing the commodore key at power-up you can enter the C64 mode. The Z80 allows running CP/M OS.
- S.Jobs founded NeXT
- George Perlegos and Tsung-Ching Wu leave SEEQ to set up Atmel
- After leaving Zilog, Faggin creates his second startup, Cygnet Technologies, Inc. There he conceived the Communication Cosystem, a device which sat between a computer and a phone line and allowed transmission and receipt of both voice and data, managing many personal productivity tools
- Richard Stallman starts the Free Software Foundation (FSF). Software Free is software that grants users freedom to run, modify and redistribute copies of it, either for commercial or noncommercial purposes

1986

- Federico Faggin and Carver Mead set up Synaptics to create artificial neural networks with floating gate MOS transistors (patent US4802103). Faggin is initially CTO. In 1987 Faggin is determined to find a new general purpose learning-based architecture. Then he proposes to involve Mead as chairman. The VC agrees with the reorganization. In 1991 they release I1000, the first single-chip optical character recognizer. In 1994 they introduced the touchpad, followed by early touchscreens.
- Olivetti develops L2, based on Motorola 68000
- The partnership of Kazuhiko Nishi and Bill Gates dissolves and Microsoft set up its own

- Japanese software subsidiary
- 4.3BSD is released
- March. Everex Corporation acquires Cygnet

1987

- Amiga 500, 2000
- PERL, an interpreted and dynamic high level language, is created by Larry Though. Code, borrowing elements from C and UNIX scripting languages, looks complex but it is compact and powerful.
- Honeywell Information Systems Italia (HISI) becomes Honeywell Bull
- Richard Stallman releases GCC, the GNU Compiler Collection
- MS spreadsheet Excel's initial release
- Carver Mead is president of board of Synaptics
- Honeywell Information Systems Italia (HISI) introduces DPS6000/200, the last evolution of Linea GCOS. 10000 will be sold worldwide until 1990



1988

- NeXT cube
- R.Noyce directs the American semiconductor industry association, to overwhelm the threatening Japanese semiconductor industry. Also he heads SEMATECH, a big consortium of 14 American semiconductor manufacturers plus the Department of Defense
- First version of the POSIX standard, aimed to promote application portability at the source code level of the UNIX system call and C library function API

1989

- Intel 80486, 150MHz, 4gb
- Guido Van Rossum starts an open, object oriented, high level language, called Python
- September, NeXT presents NeXTSTEP 1.0
- Honeywell Bull becomes Bull Italia
- American National Standards Institute (ANSI) C standard (X3.159-1989)
- January. The FSF announces the release of GNU GPL (General Public Licence) version 1

1990

- Microsoft Windows 3.x is released. It makes INM PC and clines more easy to use than the Mac. 30 million copy were sold in the first year.
- Robert Noyce, at age 62, dies for a heart attack
- By Christmas 1990, physicist Berners-Lee has built all the tools necessary for a working

Web: the HTTP protocol, the HTML markup language, the first Web browser, the first HTTP server, the first Web server, and the first Web pages



- Panasonic releases FS-A1ST MSX TurboR, the second-to-last MSX device ever produced

1991

- Apple, IBM and Motorola (AIM) alliance is established to create PowerPC RISC microprocessor architecture. The first implementation was PPC 601 in 1992. At the time, most of the PC industry was based on Windows OS and Intel 80386 and 80486. PowerPC initiative tried to counter the growing Wintel dominance of the PC market.
- MS-DOS 5.0 (verificare)
- The Linux kernel is created by Linus Torvalds, a Finnish student at the University of Helsinki, for his Intel 80386 PC. Torvalds had started with Minix, a small UNIX-like OS developed in the mid-1980s by Andrew Tanenbaum, a university professor in Holland. Over a few months, Torvalds is able to compile and run various GNU programs. By the early 1990s, the GNU project had produced a system that was virtually complete, except for one important component: a working UNIX kernel. Because a significant part of what is commonly known as a Linux system actually derives from the GNU project, Stallman prefers to use the term *GNU/Linux* to refer to the system
- The FSF announces the release of GPLv2. It will last 16 years

1992

- Windows 3.1 is released in US. The new GUI based OS is still launched with a DOS command. The decline of DOS, now at version 6.0, has started
- Federico Faggin and his team at Synaptics devise the capacitive touchpad as a solid state evolution of the trackpad

1993

- Intel 80501 (Pentium), 3.3 m tr, 66mhz, 4gb
- AT&T sells UNIX copyright to Novell
- 4.4BSD is released
- Synaptics develops a touchpad controller chip and proposes a deal to Logitech. The deal aborts.

1994

- PHP (Hypertext Preprocessor) free server-side language is created by R.Lerdorf
- March, Linux 1.0 is released
- Apple releases PowerBook with touchpad
- November. Synaptics releases a touchpad and a touchscreen for the OEM market. Major competitors are Alps and Logitech (which used the Zilog Z8!)

1995

- NeXT releases NeXTSTEP 3.3
- March, Linux 1.2 is released
- August 24, Windows 95 is released
- MSX TurboR is discontinued in Japan. This marks the end of MSX
- SSH protocol is released

1996

- S.Jobs returns to Apple
- June, Linux 2.0 is released

1997

- Intel Pentium II, 7.5 m tr, 300 mhz, 64gb
- February, NeXT is bought by Apple Computer for \$400M.
- Apple NeXTSTEP, based on Mach microkernel and Objective-C language
- Apple Rhapsody (never released to public)
- The google's first web page starts to live
- Carver Mead and Dick Merrill found Foveon, a startup supported by National Semic. and Synaptics to develop a professional digital camera based on a prism and 3 CMOS sensors.

1998

- Tim Cook is hired in Apple as operation executive. He reorganizes the global supply chain. By shrinking planning an execution cycles, he collapsed the inventory from 5 weeks to 2 days
- The first Apple iMac
- Carlo De Benedetti leaves Olivetti
- September, Google is founded by Larry Page and Sergey Brin, then students at Stanford
- OSI (Open Source Initiative) is formed. They chose the term "open source" to dump the moralizing and attitude that had been associated with "free software" and instead promote open source ideas on pragmatic, business-case grounds. The political differences between the Free Software and the Open Source movements are documented on FSF's Web site at <http://www.fsf.org/licensing/essays/free-software-for-freedom.html>.
- Synaptics releases a new version of touchpad based on a custom SOC and OTP memory. The Logitech product is ROM-based, and bug fixing delays puts them out of business

1999

- Intel Pentium III, 9.5 m tr, 600 mhz
- June, Linux 2.2 is released
- Federico Faggin's position at Synaptics changes from CEO to President, a role he will maintain until 2009. The new CEO is Francis Lee from National Semic.

2000

- Intel Pentium 4, 42 m tr, 2ghz
- TI's Jack Kilby wins Nobel Prize in Physics for the invention of IC
- Darwin, UNIX-like OS, is released by Apple

1984-2000

- Mac OS Classic 1,..,9. This is a cooperative (non-preemptive) multitasking environment
- from 2001: Mac OS X 10.x.y, based on Darwin x+4.y. This is a preemptive multitasking environment.

2001

- January, Linux 2.4 is released
- Intel net revenues falls from \$33.7M to \$26.5M
- Microsoft releases Windows XP, the successor of Windows 2000

- The first Apple iPod, with 5GB HD

2002

- Foveon develops Foveon X3, where three photodiodes are stacked up in the pixel area. This configuration needs less chip area and relies upon the different spectral absorption of Si at different depths, blue at the surface, then green, and red in depth. At the time Canon and Nikon dominate the market of SRL and DSLR cameras. Nikon used CCD sensors by Sony. Canon used his home-made CMOS sensors.
- Sigma releases Sigma SD9, a DSLR photo camera based on Foveon X3 sensor. Low sensitivity in dark conditions is a limiting factor. This problem would eventually be solved, some years later, with a redesign of the sensor. Sigma will acquire Foveon in 2008

2003

- USB 2.0
- Skype service allows free voice calls, messaging and file sharing through a P2P connected PC
- December, Linux 2.6 is released

2004

- Mac OS X becomes intel x86 compatible (universal binary)
- Ubuntu Linux distribution first appearing
- February 4. Facebook is founded by Mark Zuckerberg and his college roommate and fellow Harvard University student Eduardo Saverin

2005

- Xbox 360 is released by Microsoft
- Intel i3, i5, i7
- Intel Tick-Tock policy. Tick: new manufacturing process, Tock: new microarchitecture
- S.Jobs announces Apple migration to x86 platform

2006

- The first Apple MacBook Pro
- March 21. Twitter is founded by Jack Dorsey, Evan Williams and Biz Stone

2007

- The first Apple iOS and iPhone
- The FSF announces the release of GPLv3
- terminano le attività del LRE Olivetti a Pregnana Milanese

2008

- Apple introduces the App Store
- Spotify AB, a Swedish company, launches Spotify, the audio streaming platform
- Bill Gates leave his role at Microsoft

2010

October. Federico receives the 2009 National Medal of Technology and Innovation, the highest honor conferred by the US government, from President Obama in a White House ceremony

2011

- Federico Faggin and his wife found the Federico and Elvia Faggin Foundation, aimed to investigate the roots of the conscious experience

2012

- October, Google leapfrogs Microsoft in market value (\$249,19 billion)

2013

- Apple iBeacon
- March, Kali Linux 1.0, the most advanced, robust, and stable penetration-testing distribution to date, is released by Offensive Security

2014

- Windows ends security updates for Windows XP

2015

- August, Google creates a new public holding company, Alphabet Inc.
- August, Kali Linux 2.0 is released by Offensive Security

2018

- Apple announces the A12X microprocessor for mobile products. 64-bit, 7-core GPU, 8-core CPU, Neural Engine; 10 billion transistors; 7 nm process, 120 mm²

Olivetti origina Omnitel e Infostrada

Linea LSX basata su Intel 486

The new economy

Sprite: caratteri programmabili sovrapposti alla bitmap e controllati totalmente in hardware.
Avevano 15 colori più il trasparente. Nel 1979 il TMS9918 è il chip video di TI che introduce gli sprite

Vi erano due tipi di sprite, player e missile

Color Clash: artefatti cromatici grafica in modo bitmap dovuto al fatto che in una cella 8x8 non puoi mettere più di due colori

?: Atari 1044D, aka. TIA (Television Interface Adapter)

?: DCS evoluzione del TIA, avevano 256 colori e sprite

?: Nintendo NES

Digital Equipment Corporation (DEC)

Since 1962: PDP-1,8,11,34,70: minicomputers

Motorola: 6800 – 6809 – 68000 – 68040

MOS: 6502 – 6507 – 6510

Intel: 4004 – 8008 – 8080 – 8085 – 8086 – 80186, x286

Zilog: Z80 – Z8000 – Z80000 – Z380

68008: 32b internal, 8b external

68000: 32b internal, 16b external

68020: 32b internal, 32b external

Jack Tremiel

Motivatore incredibile

Vede in Giappone le prime calcolatrici e si butta in quel business

Stanno arrivando i giapponesi

Yash Terakura crea il VIC-20

I primi videogiochi furono creati da giapponesi

Breakout è, dopo Pong, l'arcade game più popolare. È il muro di mattoncini. Ci lavorò anche S. Jobs

