# History of Computers: Part 2. Modern Computers

Damian Gordon

# Alan Turing

- **Alan Mathison Turing**
- Born 23 June 1912
- Died 7 June 1954
- Born in London, England
- Creator of the modern computer

# Bletchley Park

- During the Second World War, Turing was a main participant in the efforts at Bletchley Park to break German ciphers. He contributed several insights into breaking both the Enigma machine and the Lorenz SZ 40/42, and was, for a time, head of Hut 8, the section responsible for reading German naval signals.

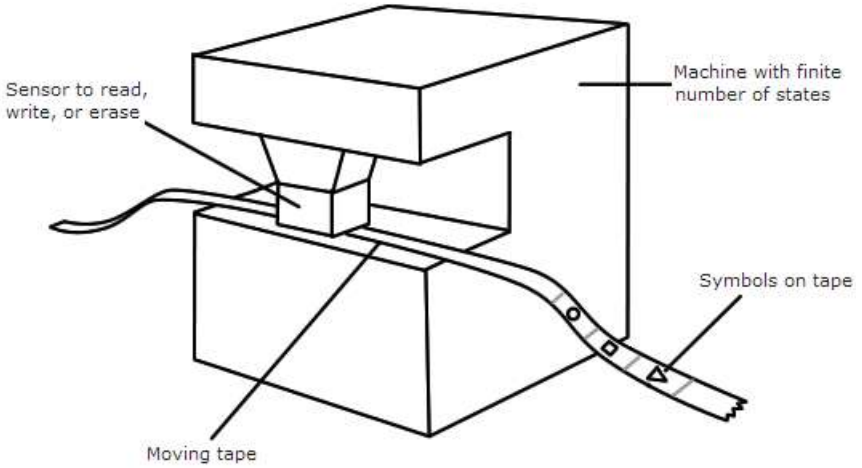
# "*On Computable Numbers, with an Application to the Entscheidungsproblem*"

- Before the war, Alan Turing's 1936 paper proved enormously influential in computer science in two ways.
  - Its main purpose was to prove that there were problems (namely 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 (Except for the limitations imposed by their finite memory stores, modern computers are said to be Turing-complete, which is to say, they have algorithm execution capability equivalent to a universal Turing machine.)

1936AD

# Turing Machine

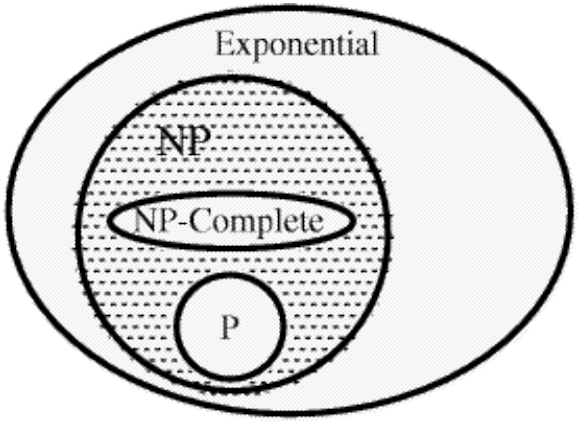
- a theoretical device that manipulates symbols on a strip of tape according to a table of rules. Despite its simplicity, a Turing machine can be adapted to simulate the logic of any computer algorithm, and is particularly useful in explaining the functions of a CPU inside a computer.




A Turing Machine

# Complexity Theory: P versus NP

- The **P versus NP problem** is a major unsolved problem in computer science.
- Informally, it asks whether every problem whose solution can be efficiently checked by a computer can also be efficiently *solved* by a computer.
- The general class of questions for which some algorithm can provide an answer in polynomial time is called "class P" or just “P”
- P is polynomial time.
- An algorithm is said to be polynomial time if its running time is "tractable", "feasible", "efficient", or "fast".
- The abbreviation NP refers to "nondeterministic polynomial time".
- In an equivalent formal definition, NP is the set of decision problems where the "yes"-instances can be recognized in polynomial time by a non-deterministic Turing machine.




- The complexity class P is contained in NP, but NP contains many important problems, the hardest of which are called NP-complete problems, for which no polynomial-time algorithms are known. The most important open question in complexity theory, the P = NP problem, asks whether such algorithms actually exist for NP-complete, and by corollary, all NP problems. It is widely believed that this is not the case.

# Alan Turing Apology

- Turing's homosexuality resulted in a criminal prosecution in 1952 — homosexual acts were illegal in the United Kingdom at that time — and he accepted treatment with female hormones (chemical castration) as an alternative to prison.
- He died in 1954, several weeks before his 42nd birthday, from cyanide poisoning.
- An inquest determined it was suicide; his mother and some others believed his death was accidental.
- On 10 September 2009, following an Internet campaign, then-British Prime Minister Gordon Brown made an official public apology on behalf of the British government for the way in which Turing was treated after the war.

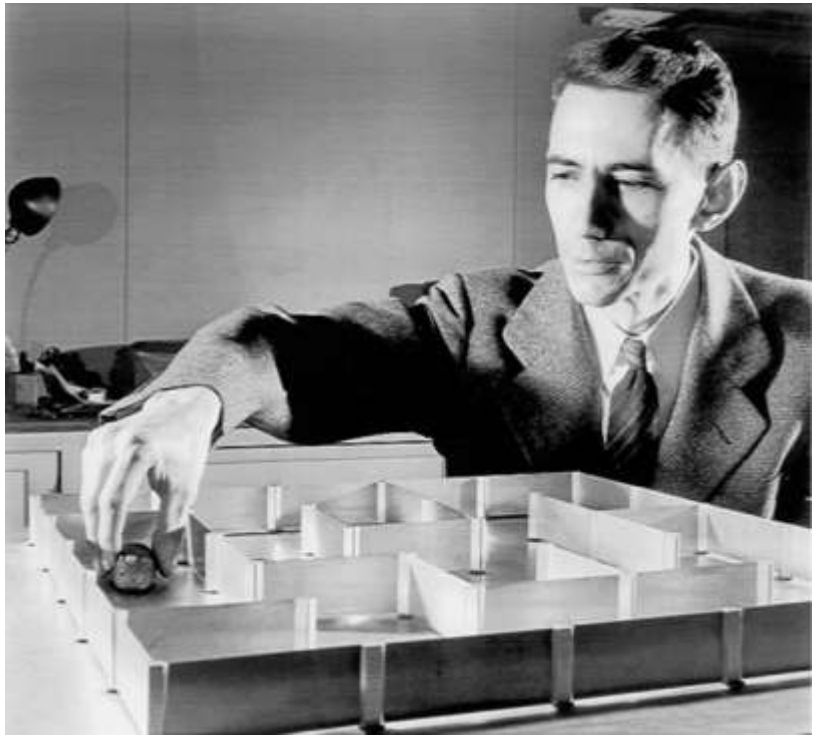
# Claude Shannon

- Born April 30, 1916
- Died February 8, 1957
- Born in Petoskey, Michigan
- an American mathematician, electronic engineer, and cryptographer known as "the father of information theory"

1938AD

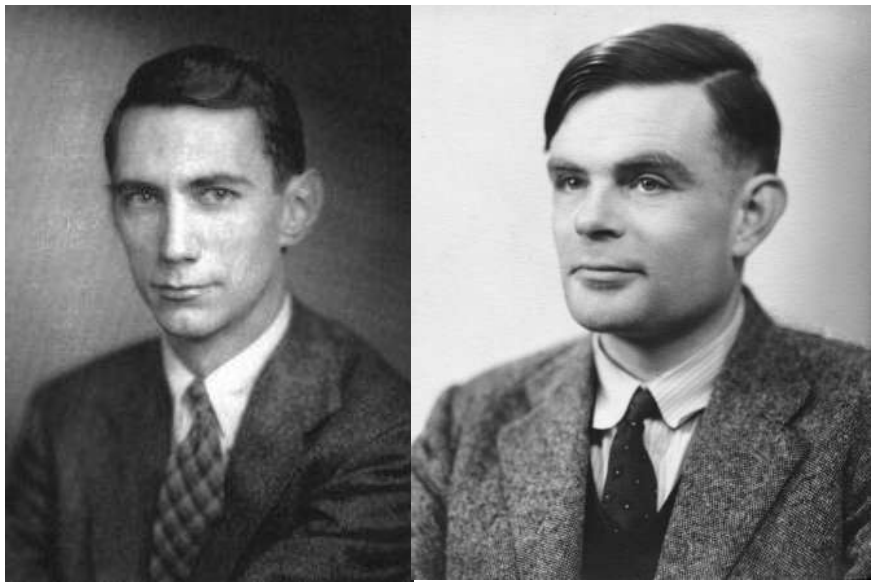
# Shannon and Boolean Logic

- Shannon published *A Symbolic Analysis of Relay and Switching Circuits*, was published in the 1938 issue of the Transactions of the American Institute of Electrical Engineers, where he pointed out the usefulness of Boolean logic.
- In this work, Shannon proved that Boolean algebra and binary arithmetic could be used to simplify the arrangement of the electromechanical relays then used in telephone routing switches, then turned the concept upside down and also proved that it should be possible to use arrangements of relays to solve Boolean algebra problems.
- Exploiting this property of electrical switches to do logic is the basic concept that underlies all electronic digital computers.



# Claude Shannon and Alan Turing

- For two months early in 1943, Shannon came into contact with Alan Turing. Turing had been posted to Washington to share with the US Navy's cryptanalytic service the methods used by the British Government Code and Cypher School at Bletchley Park to break the ciphers used by the German U-boats in the North Atlantic.
- He was also interested in the encipherment of speech and to this end spent time at Bell Labs.
- Shannon and Turing met every day at teatime in the cafeteria.
- Turing showed Shannon his seminal 1936 paper that defined what is now known as the "Universal Turing machine" which impressed him, as many of its ideas were complementary to his own.



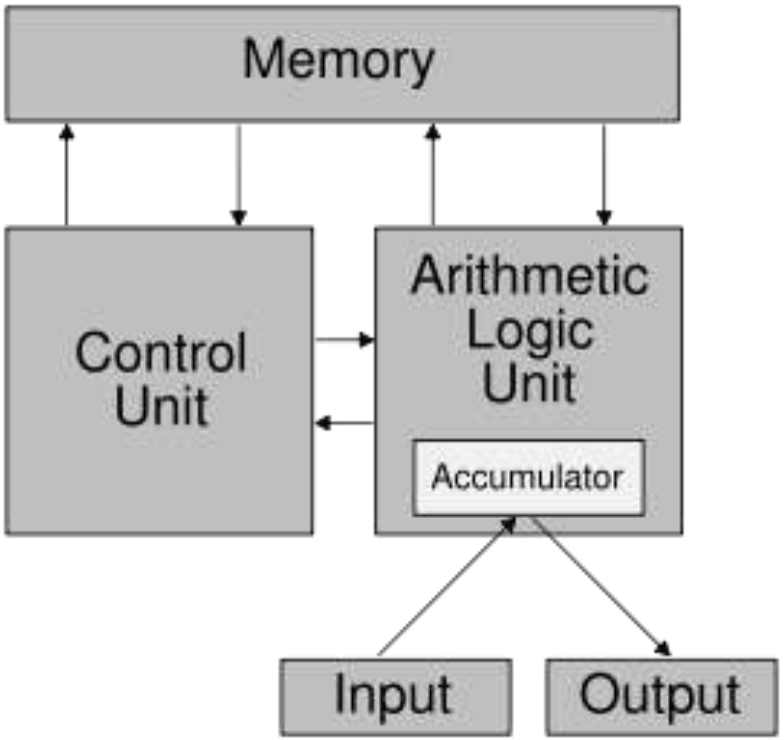
# John von Neumann

- Born December 28, 1903
- Died February 8, 1957
- Born in Budapest, Austria-Hungary
- A mathematician who made major contributions to set theory, functional analysis, quantum mechanics, ergodic theory, continuous geometry, economics and game theory, computer science, numerical analysis, hydrodynamics and statistics.

1941AD

# Von Neumann architecture

- The von Neumann architecture is a design model for a stored-program digital computer that uses a central processing unit (CPU) and a single separate storage structure ("memory") to hold both instructions and data.
- Such computers implement a universal Turing machine and have a sequential architecture.



1941AD

# First Generation Computers

- Uses Vacuum Tubes
- Vacuum tubes are glass tubes with circuits inside.
- Vacuum tubes have no air inside of them, which protects the circuitry.

# Konrad Zuse

- Born 22 June 1910
- Died 18 December 1995
- Born in Berlin, German Empire
- He created the world's first functional program-controlled, the Z3
- also designed the first high-level programming language, Plankalkül ("Plan Calculus"), first published in 1948

# 1941AD

# The Z3

- The world's first working programmable, fully automatic computing machine.
- It was Turing-complete, and by modern standards the Z3 was one of the first machines that could be considered a complete computing machine, although it lacked the conditional branch operation.
- The Z3 was built with 2,000 relays, implementing a 22 bit word length that operated at a clock frequency of about 5–10 Hz.[
- Program code and data were stored on punched film.
- The Z3 was completed in Berlin in 1941. The German Aircraft Research Institute used it to perform statistical analyses of wing flutter.
- The original Z3 was destroyed in 1943 during an Allied bombardment of Berlin.
- Zuse asked the German government for funding to replace the relays with fully electronic switches, but funding was denied during World War II as "not war-important".
- A fully functioning replica was built in the 1960s by Zuse's company, Zuse KG, and is on permanent display in the Deutsches Museum.

# John Vincent Atanasoff

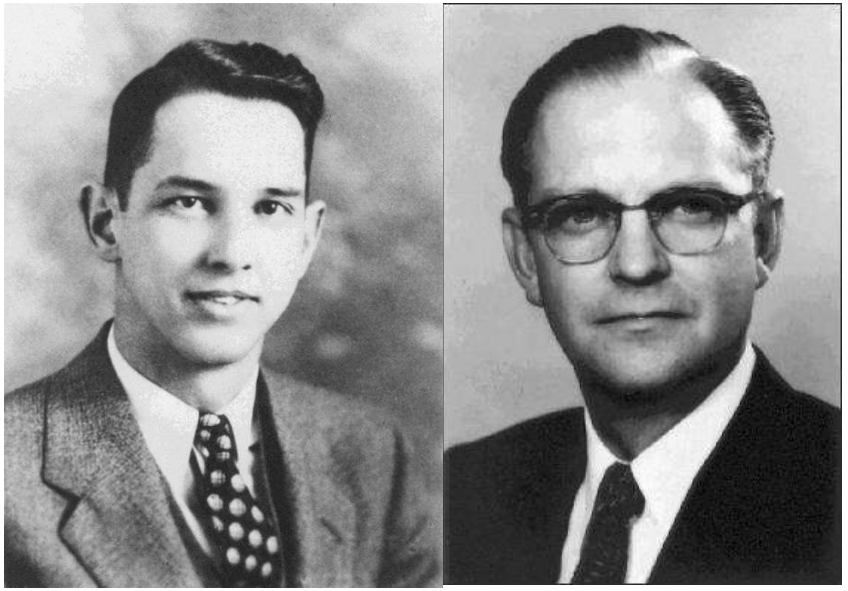
- Born October 4, 1903
- Died June 15, 1995
- Born in Hamilton, New York
- Co-inventor of the the Atanasoff-Berry Computer.
- The 1973 decision of the patent suit *Honeywell v. Sperry Rand* named him the inventor of the first automatic electronic digital computer.

# Clifford Berry

- Born April 19, 1918
- Died October 30, 1963
- Born in Gladbrook, Iowa
- Co-inventor of the the Atanasoff-Berry Computer.
- The 1973 decision of the patent suit *Honeywell v. Sperry Rand* named him the inventor of the first automatic electronic digital computer.

# Atanasoff-Berry Computer

- From the beginning of his college years, Clifford Berry's record as a student of electrical engineering was impressive.
- He received his B.S. in Electrical Engineering in 1939.
- Professor Harold Anderson was a professor of electrical engineering and one of John Atanasoff's best friends.
- He was also one of the many people that was impressed by Clifford Berry's brilliance and capacity.
- Thus, when Atanasoff asked him if he could recommend a graduate student in electrical engineering to assist him in his computer-machine project, Professor Anderson immediately thought of Clifford Berry.

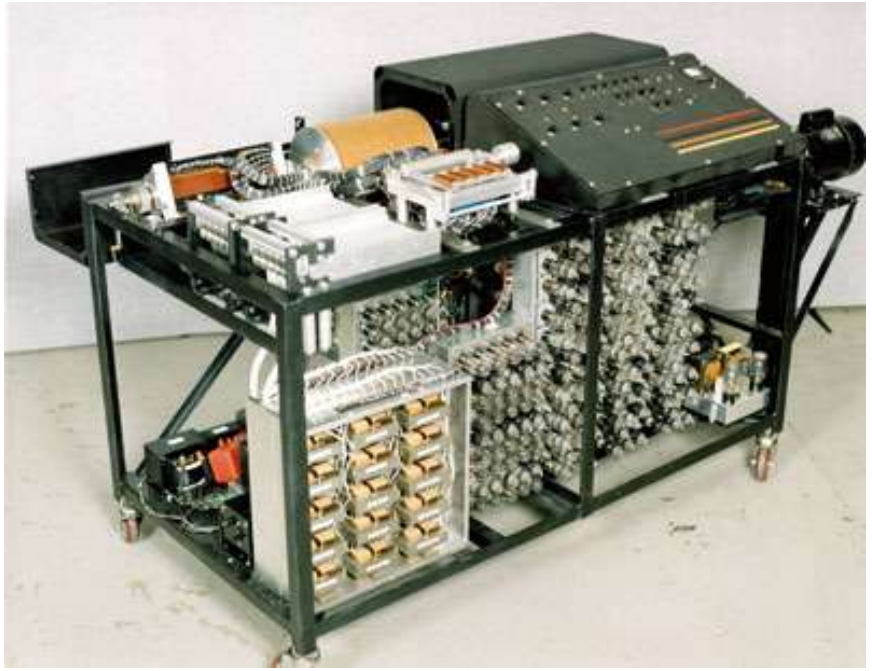


- When Clifford Berry called Professor Atanasoff to tell him that he was interested in the job, John Atanasoff realized that he was dealing with an unusual young man.
- So, on a morning in the spring of 1939, the two brilliant men had their first conversation about the concepts and the basic problems they would have to solve in the construction of the prototype of an electronic digital computer.

1942AD

# Atanasoff–Berry Computer

- The first fully electronic digital computer.
- he machine was not programmable, being designed only to solve systems of linear equations.
- It was successfully tested in 1942. However, its intermediate result storage mechanism, a paper card writer/reader, was unreliable, and when Atanasoff left Iowa State University for World War II assignments, work on the machine was discontinued.
- The ABC pioneered important elements of modern computing, including binary arithmetic and electronic switching elements, but its special-purpose nature and lack of a changeable, stored program distinguish it from modern computers.



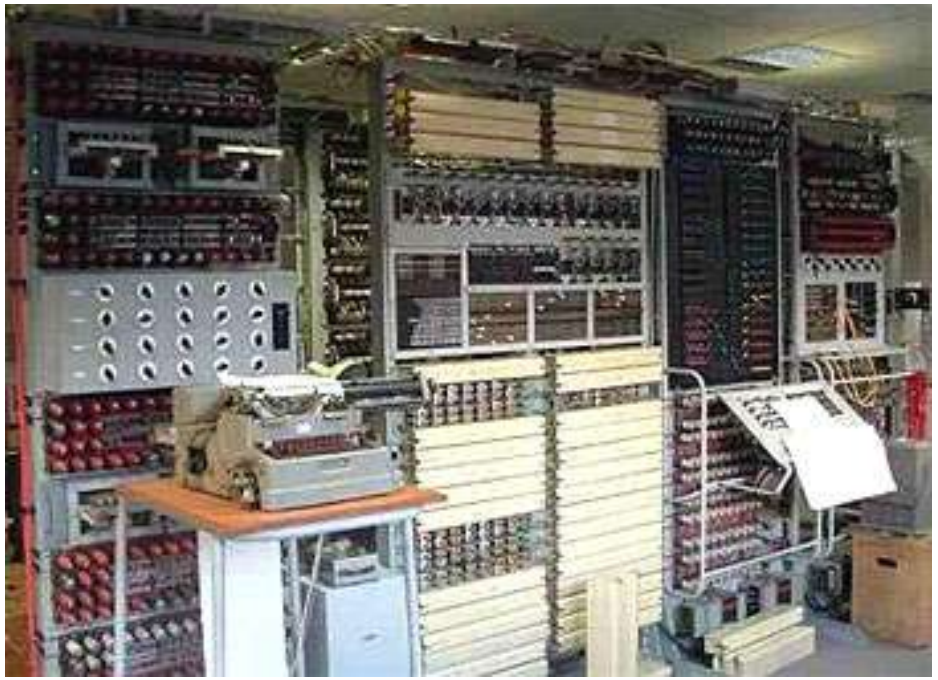
# Tommy Flowers

- **Thomas Harold Flowers**
- Born 22 December 1905
- Died 28 October 1998
- Born in Poplar, London
- An English engineer who during World War II designed *Colossus*, the world's first programmable electronic computer, to help solve encrypted German messages.

1943AD

# Colossus computer

- Tommy Flowers had worked with Alan Turing in Bletchley Park, where they tried to develop various decryption devices.
- Flowers created the Colossus computers for the cryptanalysis of high-level German communications, part of the operation of Colossus was to emulate the Lorenz machine.



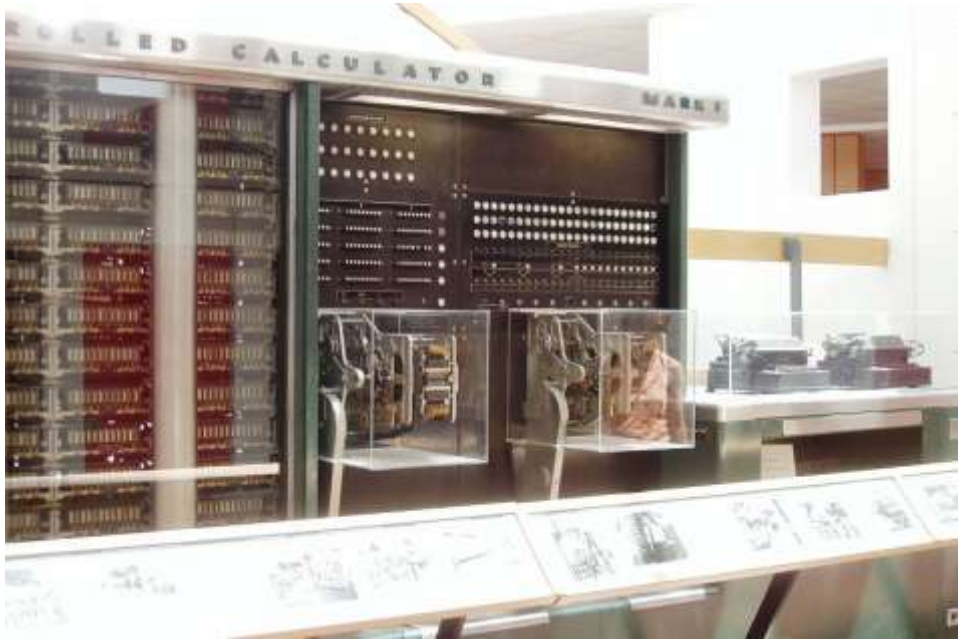
# Howard H. Aiken

- **Howard Hathaway Aiken**
- Born March 8, 1900
- Died March 14, 1973
- Born in Hoboken, New Jersey
- He envisioned an electro-mechanical computing device that could do much of the tedious work for him.
- With help from Grace Hopper and funding from IBM, the machine was completed in 1944.

1944AD

# Harvard Mark I

- The IBM Automatic Sequence Controlled Calculator (ASCC), called the Mark I by Harvard University was an electro-mechanical computer.
- It was devised by Howard H. Aiken, built at IBM and shipped to Harvard in February 1944.
- It began computations for the U.S. Navy Bureau of Ships in May and was officially presented to the university on August 7, 1944.
- It was very reliable, much more so than early electronic computers.



# Grace Hopper

- **Rear Admiral Grace Murray Hopper**
- Born December 9, 1906
- Died January 1, 1992
- Born in New York City, New York
- Computer pioneer who developed the first compiler for a computer programming language

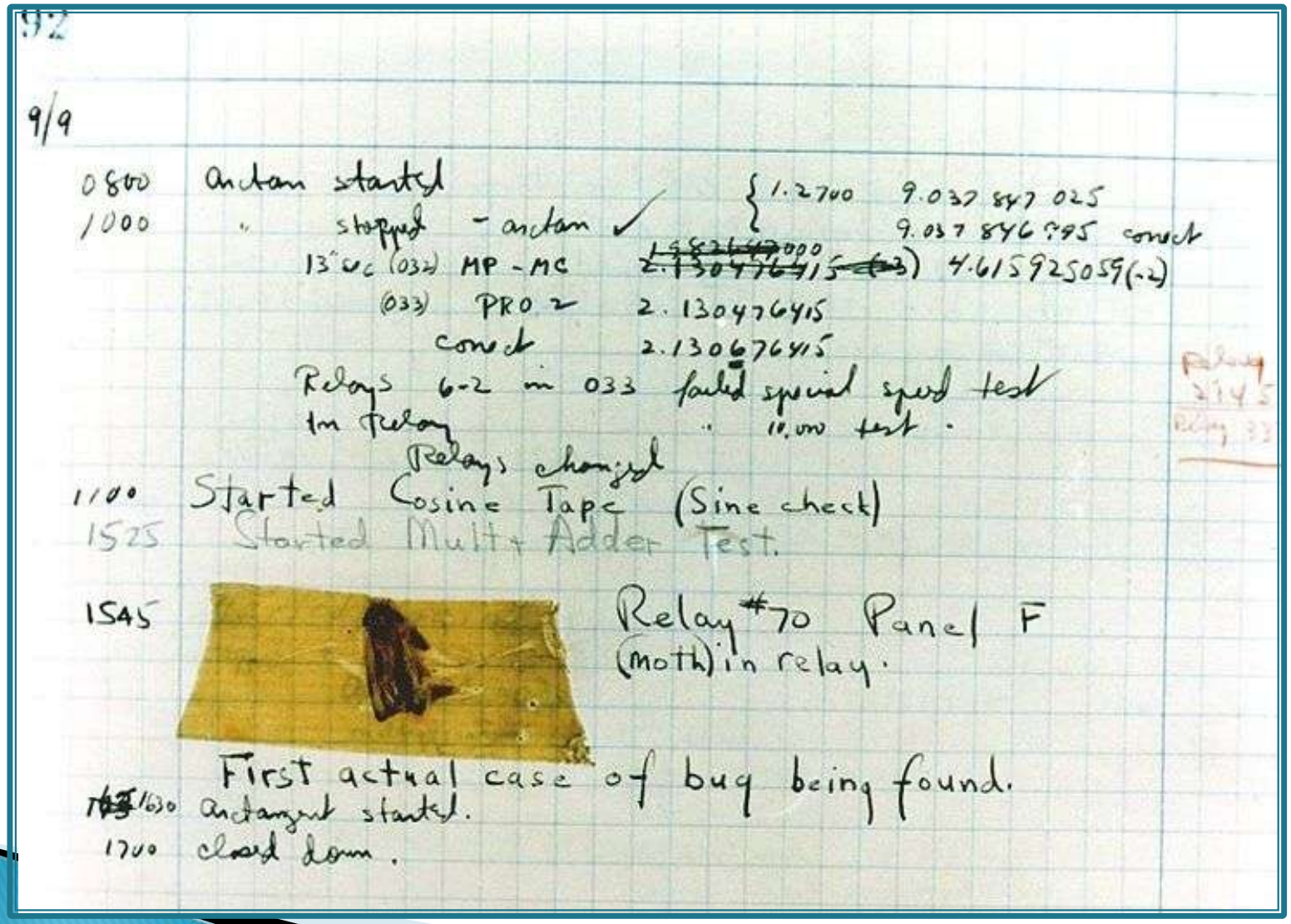
1945AD

# The First Bug

- Grace Hopper served at the Bureau of Ships Computation Project at Harvard University working on the computer programming staff.
- A moth was found trapped between points at Relay #70, Panel F, of the IBM Harvard Mark II Aiken Relay Calculator while it was being tested at Harvard University, 9 September 1945.
- The operators affixed the moth to the computer log, with the entry: "*First actual case of bug being found*".
- Grace Hopper said that they "*debugged*" the machine, thus introducing the term "*debugging a computer program*".

# 1945AD

# The First Bug



9/9

0800 Arctan started
1000 " stopped - arctan ✓
13 wc (032) MP - MC 1.2700 9.037 847 025
9.037 846 795 correct
~~2.130476415~~ 4.615925059(-2)
(033) PRO 2 2.130476415
correct 2.130676415
Relays 6-2 in 033 failed special speed test
In relay " 11.00 test.
Relays changed
1100 Started Cosine Tape (Sine check)
1525 Started Multy Adder Test.
1545 Relay #70 Panel F
(moth) in relay.
First actual case of bug being found.
1700 closed down.

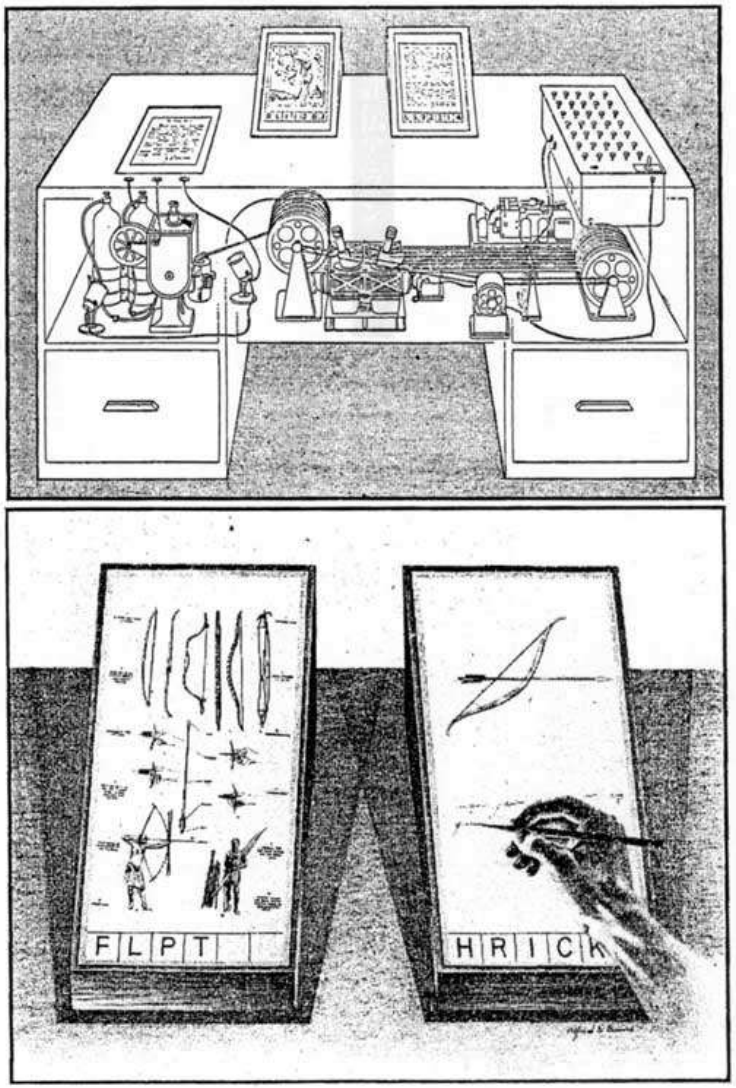
# Vannevar Bush

- Born March 11, 1890
- Died June 28, 1974
- Born in Everett, Massachusetts
- American engineer, science administrator, and the first presidential science advisor
- He is known for his work on analog computing, his political role in the development of the atomic bomb as a primary organizer of the Manhattan Project, and the idea of the Memex machine

# 1945AD

# The Memex Machine

- Tthe theoretical proto-hypertext computer system Bush proposed in his 1945 The Atlantic Monthly article "*As We May Think*".
- The memex is a device in which an individual compresses and stores all of their books, records, and communications which is then mechanized so that it may be consulted with exceeding speed and flexibility.
- A document can be given a simple numerical code that allows the user to access it after dialling the number combination. Documents are also able to be edited in real-time.
- This process makes annotation fast and simple.
- The memex has influenced the development of subsequential hypertext and intellect augmenting computer systems




# 1946AD

# ENIAC

- ENIAC (Electronic Numerical Integrator And Computer) was the first general-purpose, electronic computer.
- It was a Turing-complete, digital computer capable of being reprogrammed to solve a full range of computing problems.
- ENIAC was designed to calculate artillery firing tables for the United States Army's Ballistic Research Laboratory, but its first use was in calculations for the hydrogen bomb.
- When ENIAC was announced in 1946 it was heralded in the press as a "Giant Brain".
- It boasted speeds one thousand times faster than electro-mechanical machines, a leap in computing power that no single machine has since matched. This mathematical power, coupled with general-purpose programmability, excited scientists and industrialists.

1948AD

# Curta Calculator

- The Curta is a hand-cranked mechanical calculator.
- It has an extremely compact design, a small cylinder that fits in the palm of the hand.
- It can be used to perform addition, subtraction, multiplication, division, and, with more difficulty, square roots and other operations.
- The Curta's design is a descendant of Gottfried Leibniz's Stepped Reckoner and Thomas's Arithmometer, accumulating values on cogs, which are added or complemented by a stepped drum mechanism.

1952AD

# A-0 Complier

- The **A-0 system** (*Arithmetic Language version 0*), written by Grace Hopper in 1951 and 1952 for the UNIVAC I, was the first compiler ever developed for an electronic computer.
- The A-0 functioned more as a loader or linker than the modern notion of a compiler.
- A program was specified as a sequence of subroutines and arguments.
- The subroutines were identified by a numeric code and the arguments to the subroutines were written directly after each subroutine code.
- The A-0 system converted the specification into machine code that could be fed into the computer a second time to execute the program.

1956AD

# Second Generation Computers

- Uses transistors
- The first transistor was demonstrated on Dec. 23, 1947, at Bell Labs by William Shockley.
- This new invention consisting of P type and N type semiconductive materials (in this case germanium) had completely revolutionized electronics.

first transistor

Examples of transistor

# Ted Nelson

- Born 1937
- Born in New York City, New York
- A sociologist, philosopher, and pioneer of information technology.
- Nelson founded Project Xanadu in 1960 with the goal of creating a computer network with a simple user interface.
- He coined the terms "hypertext" and "hypermedia" in 1963 and published it in 1965.

1960AD

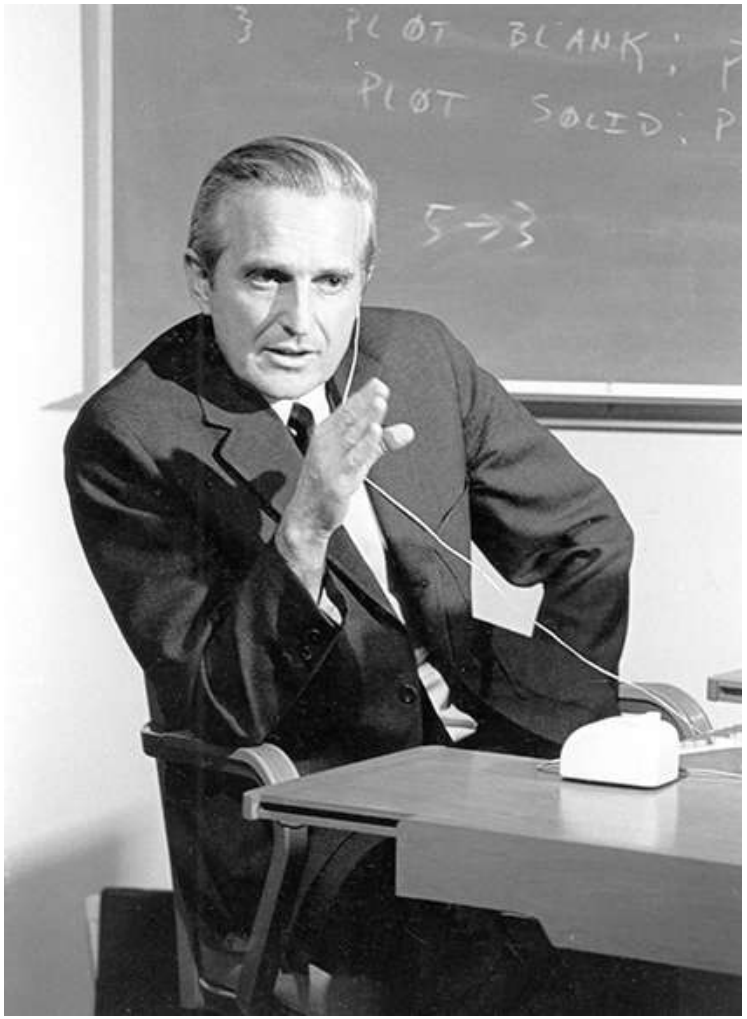
# Project Xanadu

- During his first year as a graduate student at Harvard, Ted Nelson began implementing the system which contained the basic outline of what would become Project Xanadu: a word processor capable of storing multiple versions, and displaying the differences between these versions.
- In Nelson founded Project Xanadu in 1960 with the goal of creating a computer network with a simple user interface.
- On top of this basic idea, Nelson wanted to facilitate nonsequential writing, in which the reader could choose his or her own path through an electronic document. He built upon this idea in a paper to the ACM in 1965, calling the new idea "zippered lists". These zippered lists would allow compound documents to be formed from pieces of other documents, a concept named *transclusion*.
- Nelson claims some aspects of his vision are in the process of being fulfilled by the World Wide Web, but he dislikes the World Wide Web, XML and all embedded markup — regarding the Web as a gross over-simplification of his original vision:

- "*HTML is precisely what we were trying to PREVENT— ever-breaking links, links going outward only, quotes you can't follow to their origins, no version management, no rights management.*" – Ted Nelson

# Douglas Engelbart

- Born January 30, 1925
- Born in Portland, Oregon
- An inventor and early computer pioneer.
- He is best known for inventing the computer mouse, as a pioneer of human-computer interaction whose team developed hypertext, networked computers, and precursors to GUIs.



1963AD

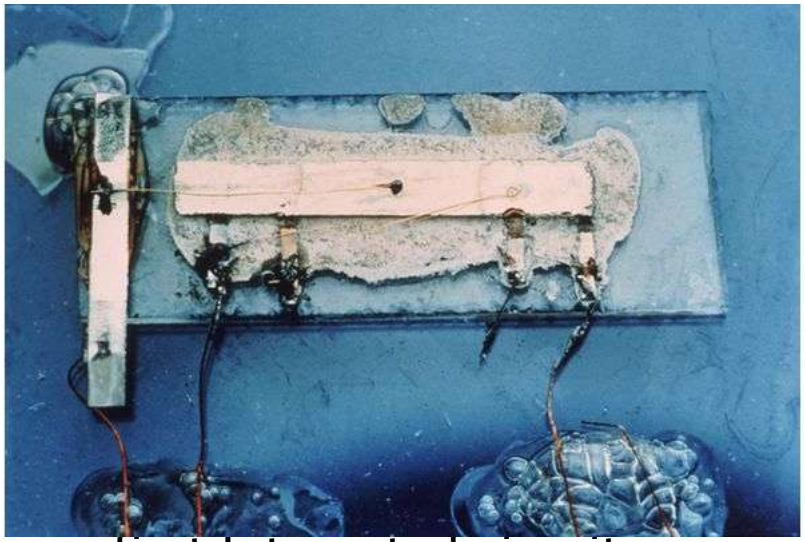
# The Mouse

- In 1945, Engelbart had read with interest Vannevar Bush's article "As We May Think", a call to arms for making knowledge widely available as a national peacetime grand challenge.
- Working at Stanford Research Institute (SRI) in Menlo Park he developed the first prototype mouse in 1963, and applied for a patent in 1967 and received it in 1970, for the wooden shell with two metal wheels.
- In the patent application it is described as an *"X-Y position indicator for a display system"*. Engelbart later revealed that it was nicknamed the "mouse" because the tail came out the end.

1964AD

# Third Generation Computers

- Uses Integrated circuits
- Jack Kilby recorded his initial ideas concerning the integrated circuit in July 1958 and successfully demonstrated the first working integrated circuit on September 12, 1958.
- In his patent application of February 6, 1959, Kilby described his new device as "*a body of semiconductor material ... wherein all the components of the electronic circuit are completely integrated.*"
- Kilby won the 2000 Nobel Prize in Physics for his part of the invention of the integrated circuit. Along with Robert Noyce (who independently made a similar circuit a few months later), Kilby is generally credited as co-inventor of the integrated circuit.



first Integrated circuit

Examples of Integrated circuit

1968AD

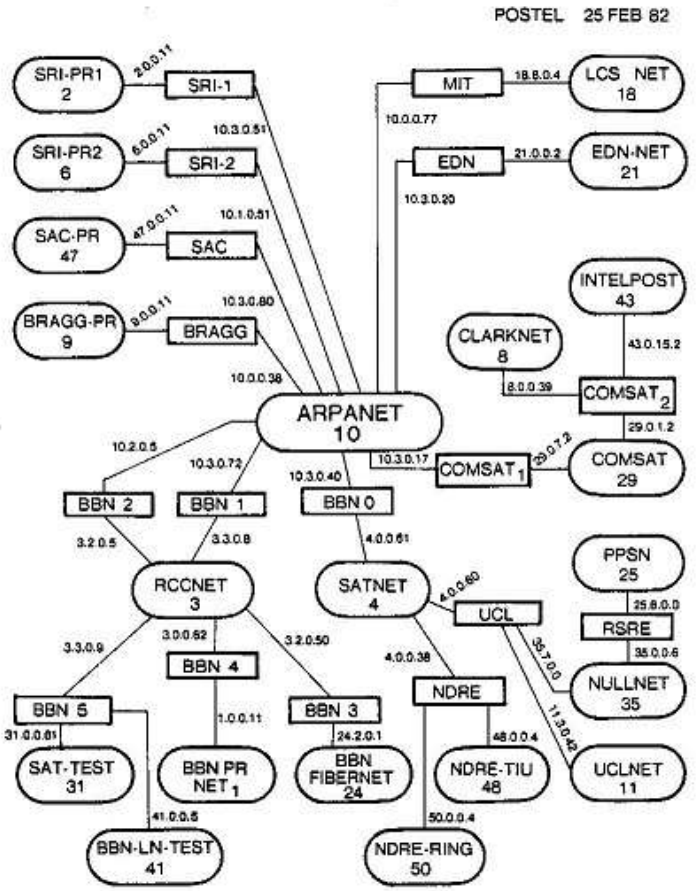
# The Mother of all demos

- The Mother of All Demos is a name given retrospectively to Douglas Engelbart's December 9, 1968, demonstration at the Fall Joint Computer Conference (FJCC) at the Convention Center in San Francisco, in which a number of experimental technologies that have since become commonplace were presented.
- The demo featured the first computer mouse the public had ever seen, as well as introducing interactive text, video conferencing, teleconferencing, email, hypertext and a collaborative real-time editor.

# 1969AD

# The Internet

- The Internet is a global system of interconnected computer networks that use the standard Internet Protocol Suite (TCP/IP) to serve billions of users worldwide.
- It is a network of networks that consists of millions of private, public, academic, business, and government networks, of local to global scope, that are linked by a broad array of electronic and optical networking technologies.

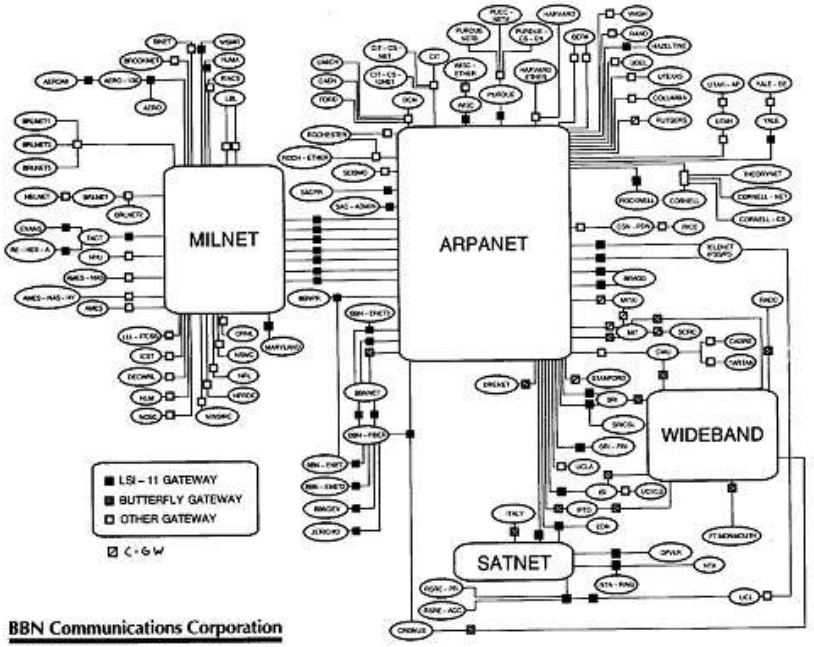



Map of the TCP/IP test network in February 1982

# 1969AD

# The Internet

- The first ARPANET link was established between the University of California, Los Angeles and the Stanford Research Institute on 22:30 hours on October 29, 1969. By December 5, 1969, a 4-node network was connected by adding the University of Utah and the University of California, Santa Barbara. Building on ideas developed in ALOHAnet, the ARPANET grew rapidly. By 1981, the number of hosts had grown to 213, with a new host being added approximately every twenty days.




BBN Technologies TCP/IP internet map early 1986

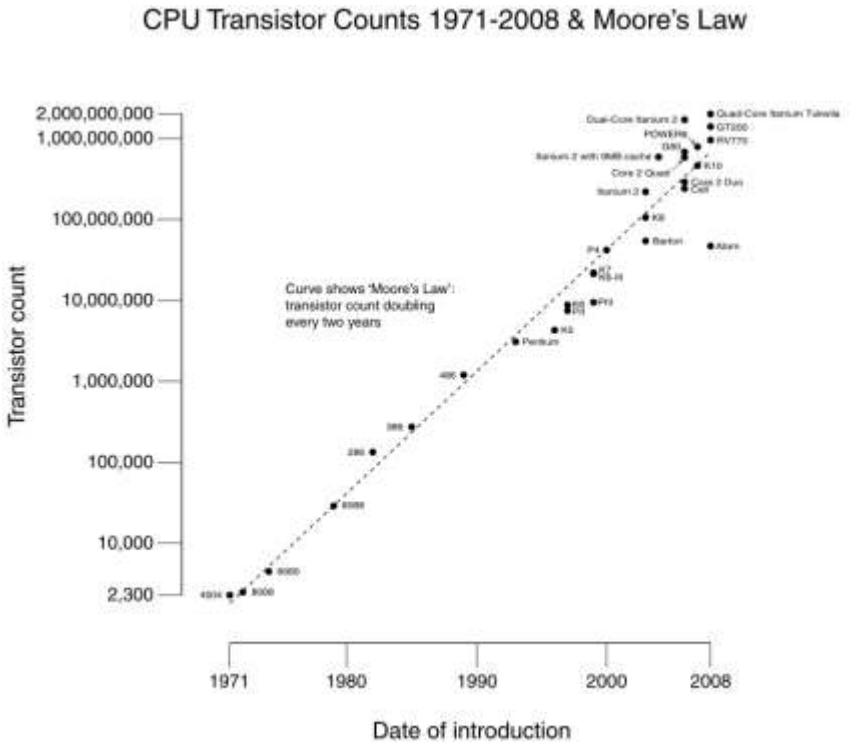
# Gordon Moore

- Born 3 January 1929
- Born in San Francisco, California, USA
- the co-founder (with Robert Noyce) and Chairman Emeritus of Intel Corporation
- Created “Moore’s Law”

1970AD

# Moore's Law

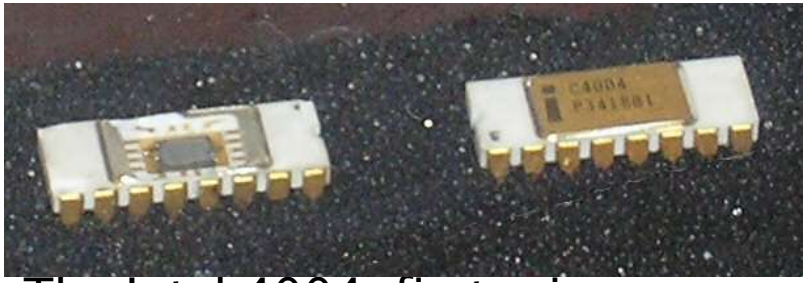
- Chip density about doubles every 18 months
  - also, prices decline
- experts predict this trend might continue until ~2020
- limited when size reaches molecular level
- not really a *law,* more a "rule of thumb" (a practical way to think about something)



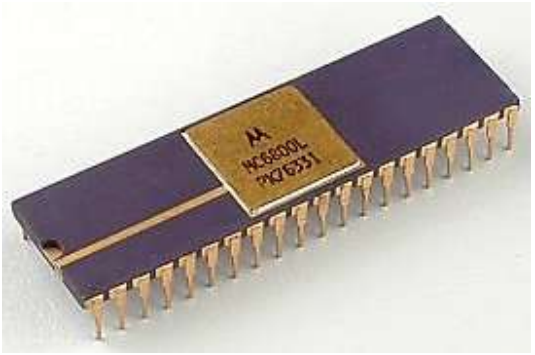
1971AD

# Fourth Generation Computers

- Uses Microprocessors and VLSI (Very Large-Scale Integrated circuits)
- Three projects delivered a microprocessors for calculators at about the same time:
  - Intel's 4004,
  - Texas Instruments (TI) TMS 1000,
  - Garrett AiResearch's Central Air Data Computer (CADC).
- The first microprocessor for computers was the MC6800



The Intel 4004, first microprocessor



Motorola M6800

# Tim Berners-Lee

- Born 8 June 1955
- Born in London, England
- An engineer and computer scientist and MIT professor who invented the World Wide Web

1991AD

# The World-Wide Web

- In 1984 Tim Berners-Lee was working at CERN, and considered its problems of information presentation: physicists from around the world needed to share data, and with no common machines and no common presentation software.
- He wrote a proposal in March 1989 for "a large hypertext database with typed links", but it generated little interest.
- His boss, Mike Sendall, encouraged Berners-Lee to begin implementing his system on a newly acquired NeXT workstation.

1991AD

# The World-Wide Web

- By Christmas 1990, Berners-Lee had built all the tools necessary for a working Web:
  - the HyperText Transfer Protocol (HTTP) 0.9,
  - the HyperText Markup Language (HTML),
  - the first Web browser (named WorldWideWeb, which was also a Web editor),
  - the first HTTP server software (later known as CERN httpd),
  - the first web server (http://info.cern.ch),
  - and the first Web pages that described the project itself.