A Brief History of Computer Science

CSCE 181, Yoonsuck Choe

- Slides with dark blue background header: Prof. Jennifer Welch's slides from Spring 2010 CSCE 181.
- Slides with blank background: Yoonsuck Choe

More Sources

- James Burke, *Connections*, MacMillan: London, 1978.
- Photos taken by Yoonsuck Choe at the Computer History Museum in Mountainview, CA. December 2011.

Sources

- Schneider and Gersting, *An Invitation to Computer Science*
  - primary source
- Slides from Prof. John Keyser
- American University's Computing History Museum
  - http://www.computinghistorymuseum.org/
- Virginia Tech's History of Computing website:
  - http://ei.cs.vt.edu/~history
- Computer History Museum
  - http://www.computerhistory.org/
- IEEE Annals of the History of Computing (Journal)
  - http://www.computer.org/portal/site/annals/index.jsp
- Andrew Hodges' website about Alan Turing
  - http://http://www.turing.org.uk/turing/index.html

Early Mathematics & Computation

- Babylonians and Egyptians, > 3000 yrs ago
  - numerical methods for generating tables of square roots, multiplication, trig
  - Applications: navigation, agriculture, taxation
- Greeks, > 3000 yrs ago
  - geometry and logic
- Indians, ~ 600 AD
  - started using placeholders and a decimal number system, similar to modern
  - idea spread to Middle East
- Arabs and Persians ~ 800 AD
  - algorithms

A Famous Arab Mathematician

Abu Jafar Mohammed Ibn Musa Al-Khowarizmi

- In early 800s AD
- Worked at center of learning in Baghdad
- Wrote book: *Hisab Al Jabr Wal-Mugabalah*
- Described how to compute several practical problems, including linear and quadratic equations
- Translated into Latin, spread throughout Europe
- Solidified number system in use now: "Arabic numerals"
- Al Jabr gives us the word "algebra"
- Al-Khowarizmi gives us the word "algorithm"

fig. from Donald Knuth's website

Early Computing Devices

fig from http://www.ee.ryerson.ca/~elf/abacus

- Abacus
- About 3000 BC
- Different types, developed over time
- Common wire/bead: about 500 BC
- Some still in use today
- John Napier's Bones
- 1617: Sticks with numbers on them
- Use to do 4 basic arithmetic operations
- William Oughtred's Slide Rule
- 1622: Sticks with logarithmic scale, slide along
- Much more complex calculations
- Used well into 20th century (replaced by handheld calculator)

More Early Computing Devices

- Blaise Pascal
- 1642: First numerical calculating machine (addition and subtraction)
- Gottfried Leibniz
- 1673: 4-function mechanical calculator (addition, subtractions, multiplication, division)

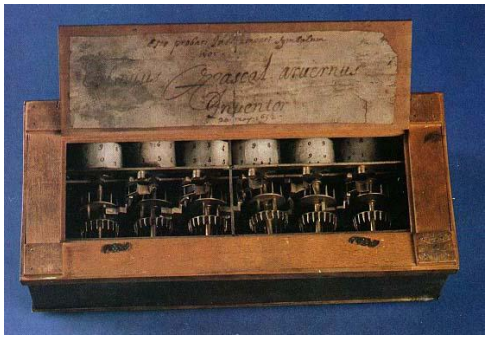


fig from http://www.tcf.ua.edu/AZ/ITHistoryOutline.htm

- Used cogs and gears
- Showed mechanization can simplify and speed up numerical calculations

Are These Devices Computers?

- Not considered general-purpose computers
- They lack
- memory
- ability to be programmed

First Programmable Device with Memory

- A loom!
- Used to weave cloth with patterns
- Invented by Joseph Jacquard, France, 1804
- Automated loom using punched cards to create pattern
- hole in card at a certain place causes change in the weave at corresponding place in the fabric

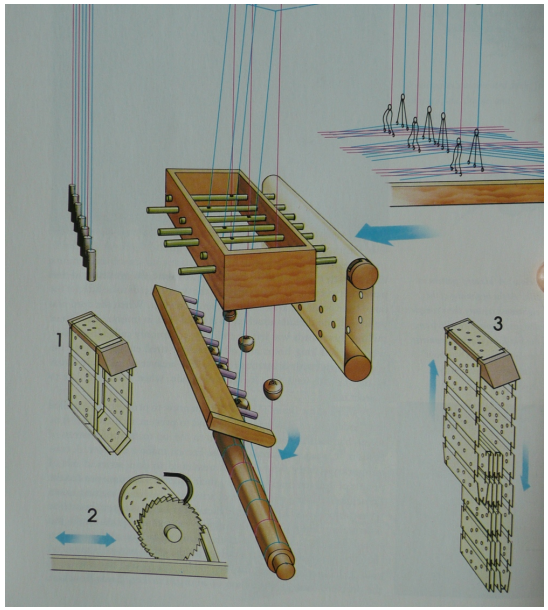
fig from Wikipedia, Jacquard loom entry

Jacquard Loom

- Memory: the cards
- Programmable: change the cards
- Capture human expertise in a machine
- Target of Luddite movement
- riots against Industrial Revolution
- threatened craft guilds

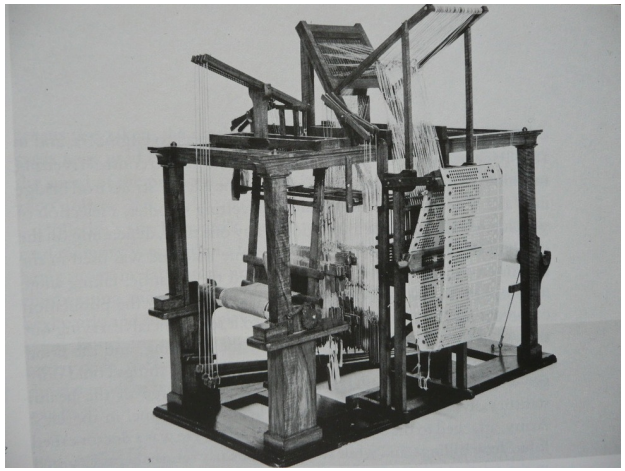
fig from britannica.com

Programmable Loom (1/2)



Burke (1978)

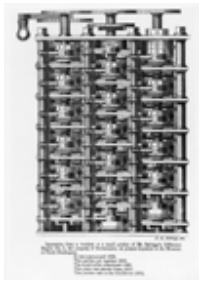
Programmable Loom (2/2)



Burke (1978)

Charles Babbage & Difference Engine

- England, 1822-1830: Designed and worked on a "Difference Engine" for calculations
  - Compute tables of logarithms
  - Never finished it: current manufacturing technology not able to provide required precision in cogs and gears
  - Others later built one: 7 feet by 11 feet, 3 tons, 4000 moving parts



figs from cbi.umn.edu/about/babbage.html

Charles Babbage & Analytical Engine

- 1833: Designed the "Analytical Engine"
  - Could not get funding, since never finished first machine, but fully designed
    - to be steam-powered
  - This was the **first general purpose computer**!
  - Separate storage from calculation
  - Familiar parts:
    - mill <=> ALU
    - store <=> memory
    - operator <=> control unit
    - output <=> input/output
  - Used punched cards

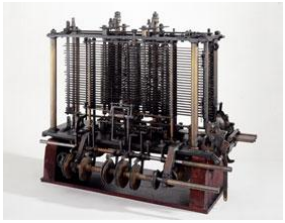


fig from www.sciencemuseum.org.uk

Ada Lovelace

- Augusta Ada Byron, Countess of Lovelace
  - Daughter of poet Lord Byron
  - Friend of Charles Babbage
- Translated, edited, and commented on document describing Babbage's Analytical Engine

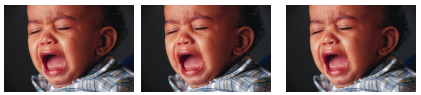
fig from women.cs.cmu.edu/ada

- Described its potential as a general purpose computer
  - Wrote "programs" that could be run on it. As a result, she is often considered the world's first computer programmer.
  - Wrote about potential uses, even for computer music

Following Babbage

- General purpose computing waited
- Instead, several different specific devices
- Most computational devices still mechanical
- Typewriters (1868)
- Adding machines (1875) and calculators
- Cash registers (1879)

U.S. Census



- Taken every 10 years
- By late 1800s, was becoming more difficult
- 1880 census not tabulated until 1888
- Serious doubt that 1890 census could be finished before time for following census
- Competition held to develop automatic enumeration and tabulation of census data
- A fundamental need for “large-scale” computing

Herman Hollerith

- Herman Hollerith developed tabulating machine
- Developed machines for encoding information on punched cards
- Cards could be sorted and tabulated
- 1890 census completed in 2 years with Hollerith’s machines
- Also saved millions of dollars

fig from www.columbia.edu/acis/history/census-tabulator.html

Further Development

- Work continued on machines to add, tabulate, record.
- Charles Flint: Computing, Tabulating, Recording (CTR) company, followed up on Hollerith’s work.
- Thomas J. Watson renames CTR to International Business Machines (IBM) in 1924.
- Individual machines were created for *each* stage of a process
- For example, separate machines to count, sort.
- Most machines encoded information on punched cards.

fig from www-03.ibm.com/ibm/history/

Encoding Information

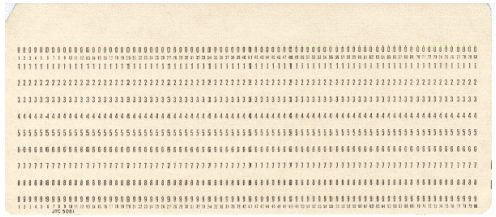


fig from www.columbia.edu/acis/history/census-tabulator.html

- Punched cards were used to store information
- Jacquard’s Loom
- Babbage’s machines
- Hollerith’s tabulating machines
- IBM machines
- Punched cards and punched tape seen as a way of achieving compatibility, transfer of data.

Impact of World War II

- Applications of the 1940's:
  - ballistics tables
  - troop deployment data
  - secret codes

fig from www.diggerhistory.info

- Several research projects, funded by military, focused on developing computers
  - on both sides

Howard Aiken & MARK I (ASCC)

- Funded by Navy and IBM, at Harvard
- 1930's and 40's
- general-purpose programmable computer
- used relays, magnets and gears
- used binary values (0/1) instead of decimal (0 to 9)
- used vacuum tubes and electric current (on/off) instead of 10-toothed gears
- memory: 72 numbers
- speed: 23-digit multiplication in 4 seconds

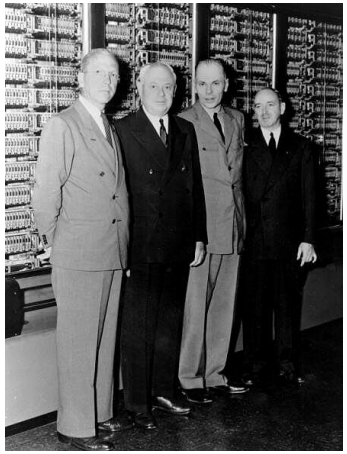


fig from www-03.ibm.com/ibm/history/

Grace Murray Hopper

- Joined Naval Reserve in 1943
- As Lieutenant, became one of the first programmers of the Mark I
- Eventually reached rank of Admiral
- Noted difficulty of programming in machine language
- Wanted way of specifying programming more naturally
- Created the *first* compiler, A-O
- Subsequently created other compilers, became strong proponent of compilers/programming languages
- Developed programming languages, notably COBOL (1959)

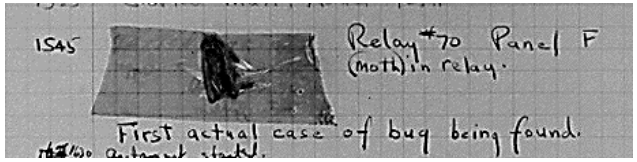
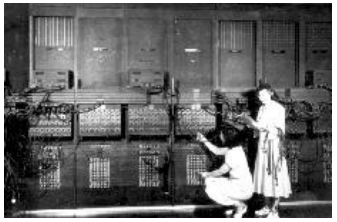


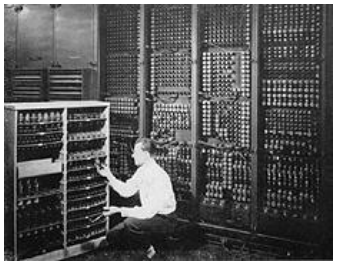
fig from cs.vassar.edu/history/hopper

fig from computerhistory.org

ENIAC

- "Electronic Numerical Integrator and Computer"
- 1940's
- Motivating application: calculate firing tables (how to aim gun depending on distance, wind speed, temp, etc.)
- Funded by Army at Univ. of Penn.
- John Mauchly & Presper Eckert lead designers
- First *fully electronic* general-purpose computer
- Vacuum-tube based
- Required rewiring to change program originally
- 100 feet long, 10 feet high, 30 tons
- 1000 times faster than Mark I





figs from www.library.upenn.edu/exhibits/rbm/mauchly/jwm8b

Other War-Time Projects

- Z1: Germany, Konrad Zuse
- destroyed during WWII before completed
- ABC: Iowa State, John Atanasoff & Clifford Berry
- solve systems of linear equations
- Colossus: England, Alan Turing
- cracked German Enigma code
- shrouded in secrecy until 1970's

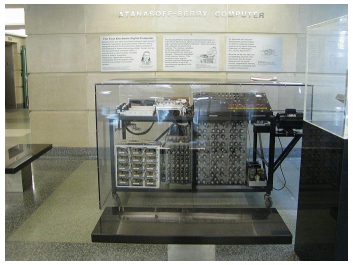
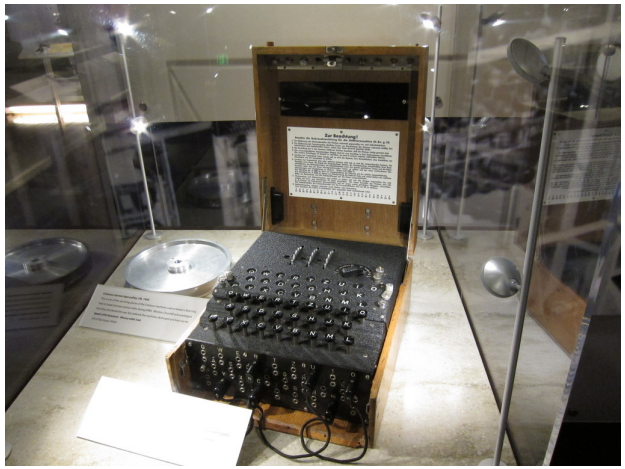


fig from http://en.wikipedia.org/wiki/Atanasoff–Berry_Computer

German Enigma Machine



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Alan Turing led the code cracking effort, which contributed greatly to the allied victory in World War II.

Aspect Still Missing…

- All these projects still missing a key feature of modern computers
- Programming these machines was done externally with
- wires
- connectors
- plugboards
- Memory stored only *data,* not *instructions*
- To change the program, need to rewire
- Ex: 6000 switches on ENIAC

Von Neumann Architecture

fig from mathdl.maa.org

- John Von Neumann, mathematician, physicist, chemist, computer scientist,… at Princeton
- worked on ENIAC
- realized shortcoming
- Key idea:
- encode instructions as binary values and store in memory along with data
- To change program, rewrite sequence of instructions

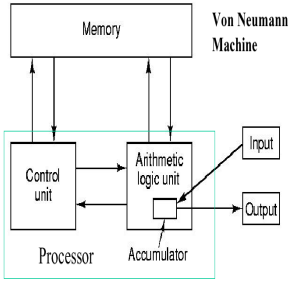


fig from cs.cmu.edu/ref/pgss/lecture/11

Where Did the Idea Come From?

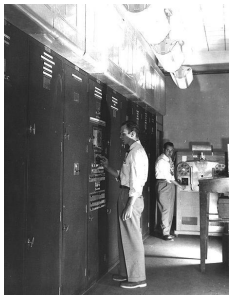
Andrew Hodges credits Alan Turing's work on the concept of the Universal Turing Machine
Notion of one machine for all tasks, although it seems obvious to us now, was not at all obvious:

fig from http://www.turingarchive.org/browse.php/K/7/9-16

> *"If it should turn out that the basic logics of a machine designed for the numerical solution of differential equations coincide with the logics of a machine intended to make bills for a department store, I would regard this as the most amazing coincidence that I have ever encountered."*

Howard Aiken, 1956

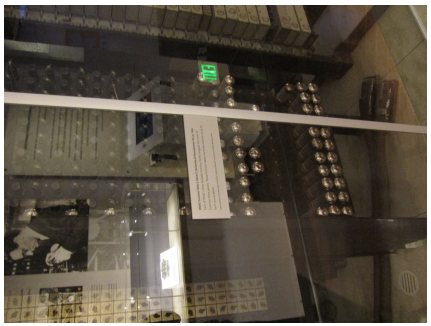
Storing Programs



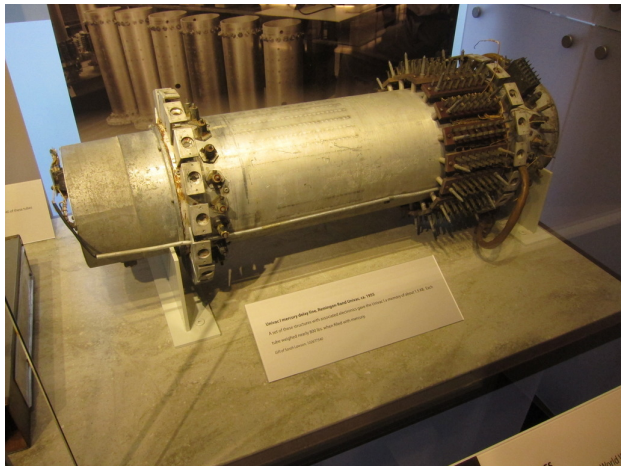
U.S. Army Photo of EDVAC

- EDVAC – Electronic Discrete Variable Automated Calculator
  - John von Neumann described
  - UPenn, 1950
  - Designed before ENIAC operational
  - became commercial UNIVAC I, bought by Census Bureau
- EDSAC – Electronic Delay Storage Automated Calculator
  - Maurice Wilkes, Cambridge
  - Based on EDVAC ideas, but completed first (1949)

UNIVAC and ENIAC



UNIVAC Mercury Delay Line Memory



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1.5Kb, 800 Lb.

The Modern Era, 1950 - Present

- Changes more evolutionary than revolutionary
- Focused on making computers
- faster
- smaller
- cheaper
- more reliable
- easier to use
- Conventionally divided into rough "generations"

First Generation, 1950-1959

- First commercial computers
- First symbolic programming languages
- binary arithmetic
- vacuum tubes for storage
- punched card I/O

1 + 1 = 10

Second Generation, 1959-1965

- transistors and core memories
- reduced size and cost, increased reliability
- first disks for mass storage
- first high-level programming languages and programmers
- FORTRAN, COBOL
- first operating systems

```
C AREA OF TRIANGLE
      READ INPUT TAPE 5, 501, IA, IB, IC
  501 FORMAT (3I5)
C CHECK THAT SUM OF 2 SIDES IS > THIRD SIDE
      IF (IA) 777, 777, 701
  701 IF (IB) 777, 777, 702
  702 IF (IC) 777, 777, 703
  703 IF (IA+IB-IC) 777, 777, 704
...
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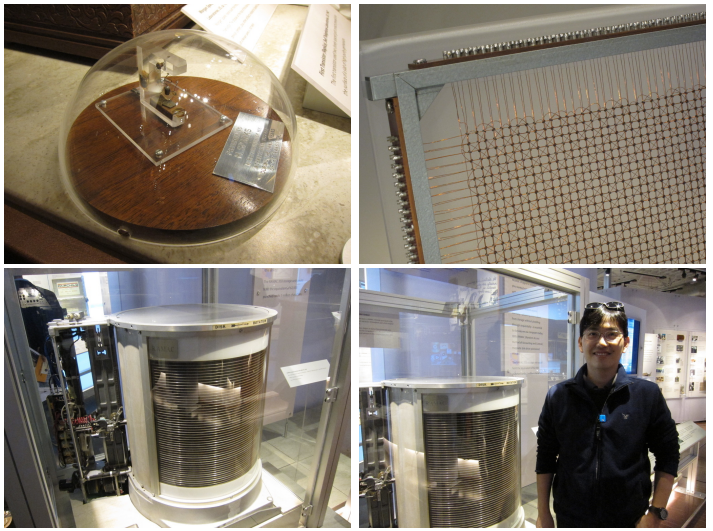
Transistors, Magnetic Core Memory, and Disks



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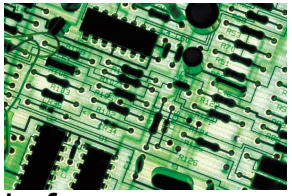
Magnetic Core: Tiny magnetic rings (~ 1mm diameter or less) that held 1 bit.

Third Generation, 1965-1975

- Integrated circuits
- components are photographically etched onto pieces of silicon
- further reduction in size and cost
- first mini-computers
- desk-sized instead of room-sized
- time-shared operating systems
- appearance of software industry
- introduction of computing standards for compatibility



IBM System 360 (Mainframe, 1964)

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Cray-1 (Supercomputer, 1974)

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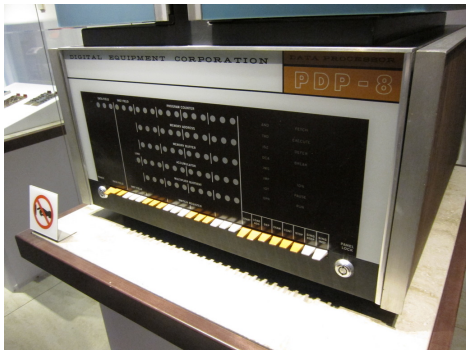
A vector machine super computer by Cray Research.

PDP8 (1965) and VAX 11/780 (1977)



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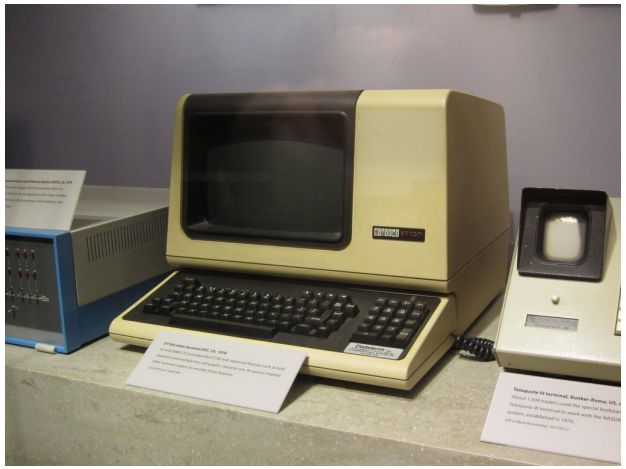
DEC built PDP (UNIX and C were first developed on this), VAX, etc.

VT100 Terminal (DEC)



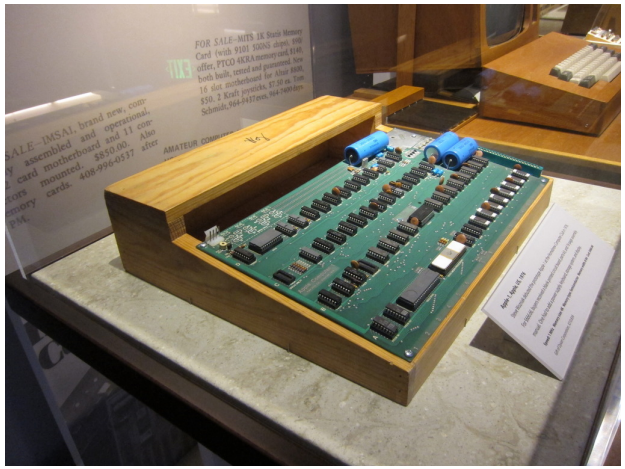
Computer History Museum

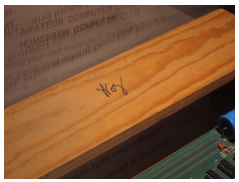
Origin of VT100 terminal emulator standard.

Fourth Generation, 1975-1985

- Very large scale integrated circuits (VLSI)
- complete system on one circuit board
- further reduction in size and cost, increased reliability
- first micro-computer
- desk-top machine, instead of desk-sized
- further growth of software industry
- computer networks
- graphical user interfaces

Apple I (1976)





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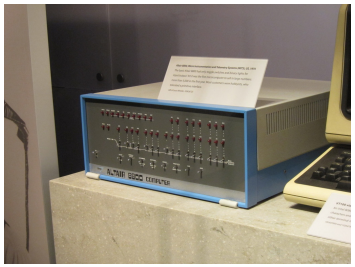
With Steve “Woz” Wozniak’s signature! (if you remember him only from *Dancing with the Stars* you’re too young! He’s Apple’s co-founder.)

Apple II (1977)

Computer History Museum

Ignited the personal computer craze.

Altair 8800 (1975), TRS-80 (1977), Pet (1977)



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Bill Gates and Paul Allen (Microsoft founders) wrote(??) the Basic interpreter for Altair.

Xerox Alto (1973)

Computer History Museum

First GUI workstation, featureing the mouse.

Mac (1984), Lisa (1983), and NeXT (1990)


Computer History Museum

Steve Jobs' Happy(?) family

IBM PC (1981)

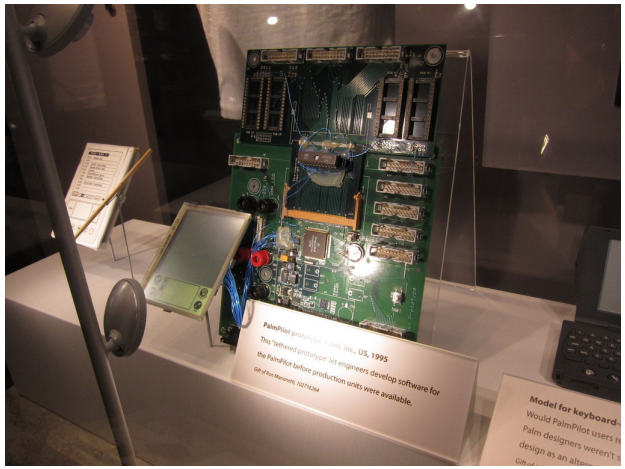
Computer History Museum

IBM gives in.

Fifth Generation, 1985 - ?

- Ultra-large scale integrated circuits (ULSI)
- more than 1,000,000 elements on one chip
- super computers and parallel processors
- laptops and hand-held computers
- wireless computing
- on-line terabyte storage devices
- global networks and distributed systems
- artificial intelligence
- hi-res graphics, visualization, virtual reality
- multimedia user interfaces

Palm Pilot (PDA) Prototype (1995)



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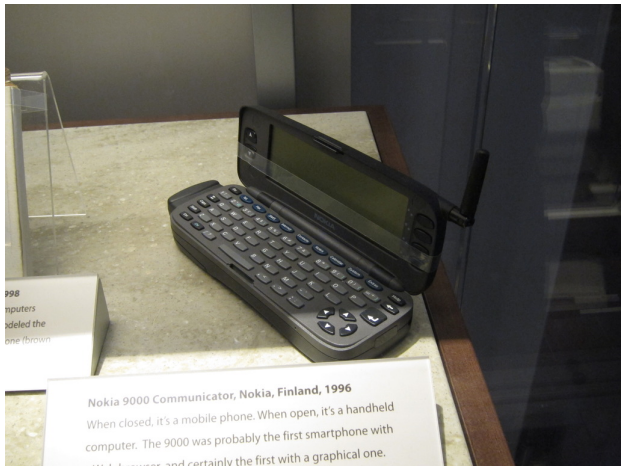
Early commercial success in handheld computing.

Nokia Communicator (1996)



Computer History Museum

First ever smartphone?

1990's and Beyond

- PC vs. Mac
- Emergence of Linux and Open Source
- Internet and World-Wide Web
- Laptops
- Handhelds
- Smartphones
- Tablets
- Social Network (love it or hate it)
- Super computers, cluster machines, cloud computing.
- Demise of the Moore's Law.

The Future?

- Speed of light limitation suggests that it won't be possible to continue the exponential increases in speed with a single processor
  - von Neumann bottleneck of sequentiality
- Solution is *concurrency*, doing more than one thing at a time
  - parallel computing, distributed computing
  - latest buzzword is "multicore"
  - challenge is how to design algorithms to exploit the multiple cores

Other Sources

- If you haven't seen the film "Pirates of Silicon Valley", you should definitely take a look.