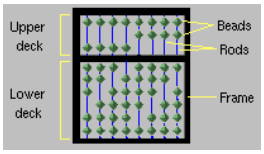
The History of Digital Computers

from the abacus to personal computers

Origins of Digital Computers

- Abacus, first developed in Babylonia 3,000-5,000 years ago
- Early computing devices designed to aid numeric computation
- Euclid: Earliest known mathematical algorithms (300 B.C.)
  - Greatest common divisor of two positive integers



Early Calculating Machines

William Oughtred 1621

- Slide rule, did not become obsolete for nearly 350 years (pocket calculator in 1970)
- July 20, 1969

1609 - Galileo confirms Heliocentric solar system

Early Calculating Machines

William Schickard (1592–1635) a 3 function mechanical calculator (+ - *)

- Separate units, intermediate results, awkward
- Killed by Plague, Notes lost for years

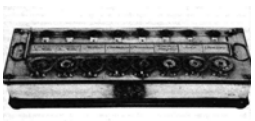
Figure 1. The Wilhelm Schickard calculator of 1623–1624, showing a front view from an elevated position. The middle section is the adding machine with the result windows. The adding machine's base contains dials, which are used to enter the partial products that are taken from the multiplication unit above. Notice the stylus on the right-hand side, which is used to operate the calculator. The calculator's pedestal shows the memory unit's dials. (Photo courtesy of IBM Germany.)

Blaise Pascal

Blaise Pascal (1623–1662)

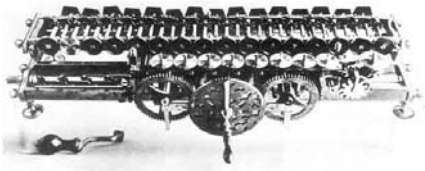
- Addition and subtraction
- He was 19 years old (1642)
- Commercial failure
  - Expensive and delicate

Pascaline



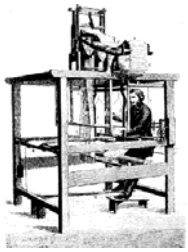
Gottfried Leibniz

- G. W. F. Leibniz (1646–1716)
- First full-featured mechanical calculator (+-*/)
- *Stepped Reckoner*, full-featured calculator
- "Leibniz wheel" for multiplication



Industrial Revolution

- Embodiment of skills in machines
  - Replacement of human expertise
- Joseph-Marie Jacquard – Jacquard's Loom (1801)
- Punched card system to aid weavers
- "Programmed" pattern woven in fabric

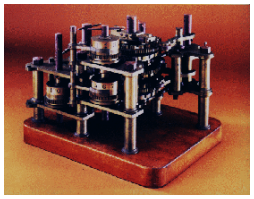


Charles Babbage (1791–1871)

- First true pioneer of modern digital computing machines
- Designed two prototype calculating machines
- Difference Engine
- Analytical Engine

Difference Engine

- 1822
- automated both the computation of tables and their printing
- employed the method of differences to calculate polynomials
- special-purpose calculating machine



Analytical Engine

- 1833
- Ada Lovelace
  - Suggested "programming" machine
  - Wrote first algorithms for a computer
- Programmable, general purpose calculating machine
- Programmed by punched cards based on Jacquard loom

Legacy of Babbage/Lovelace

- *Designed* the first, general-purpose digital computing device
- Ideas and achievements were overlooked by successors
- "tinkering", funding prevented success

Handling the "Information Explosion"

- Rapid evolution towards a general-purpose, fully electronic computing device
  - Morse's telegraph (idea of electronic information) 1838
  - 1880 census
  - Early computers
  - Military computers

Herman Hollerith

- 1880 Census disaster
- Used punched cards for tabulating data
  - Electro-mechanical operation
- 1890 Census finished in 6 weeks
- Formed Tabulating Machine Company
  - evolved into International Business Machines

1838 – Morse invents telegraph

1876 - Bell invents telephone

1883 - Edison invents lightbulb

Konrad Zuse (1910–1995)

- Designed a series of automatic general-purpose computing machines (Z1, Z2, Z3, Z4)
- Electro-mechanical devices
  - Electro-mechanical relays(switches)
- Binary internal encoding
- Z3 (1941) was programmed using punched 35mm film
- Multiply only took 3 seconds!
- Realized Babbage's Analytical Engine vision

1930's WWII

John V. Atanasoff (1903–1995)

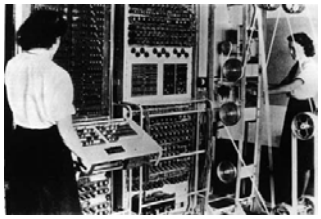
vacuum tube from the early 1900's

- Built the ABC machine with Clifford Berry in 1939 at Iowa State Univ.
- First all electronic digital computing machine
- Special-purpose: solving simultaneous linear equations
- not fully automatic; may not have fully worked

Alan M. Turing (1912–1954)

- Special-purpose electronic digital computer broke the code for the Enigma machine (1943)
- Later: COLOSSUS - one of the world's earliest programmable electronic digital computers.
- Proposed a simple abstract universal machine model for defining computability (1936)
- Devised the "Turing hypothesis" for AI

Turing and Colossus



Mark I and Mark II

- Mark I
  - Harvard, 1944
  - Commissioned by Navy for weather prediction
  - Special-purpose, electro-mechanical
- Mark II
  - Grace Murray Hopper part of the team

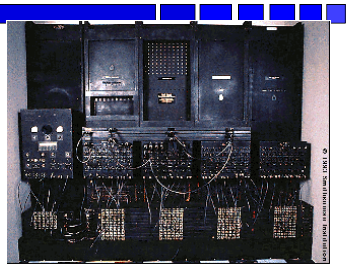
Mauchly and Eckert

- John W. Mauchly (1907–1980) and J. Presper Eckert (1919–) headed the ENIAC team at the Moore School of Engineering, University of Pennsylvania
- ENIAC (Electronic Numerical Integrator And Computer), the first electronic, general-purpose digital computer
- Commissioned by the Army in 1944 for computing ballistic firing tables

ENIAC

- noted for massive scale and redundant design
  - 1,500 sq. ft.
  - 18,000 vacuum tubes
  - 150 kw
- decimal internal coding
- operational in 1946

ENIAC

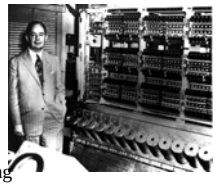


Manual programming of boards, switches, and "function table"

John Von Neumann

- Von Neumann visits the Moore School in 1944
- Prepares a draft for an automatic programmable device

Championed Concepts:
- •Stored program
- •Binary coding
- •Sequential Uniprocessor (Fetch/Decode/Execute)
- •Functional design: Input/Output/Storage/Processing



Since then…

- Hardware evolution
  - Smaller
  - Faster
  - More powerful
  - Less expensive
- Software evolution
  - From 0's and 1's to assembly language
  - Assembly language to high-level language
    - » Fortran, Cobol, Algol, Pascal, Ada, C, C++, Java, next???
  - GUIs
    - » "windows" and "mouse" unveiled in 1968; unused for 10 yrs.

Other Notables

- UNIVAC (1951)
  - First commercial computer, vacuum tubes, failure prone
- John Backus
  - Fortran (1957)
- Grace Hopper
  - Computer languages (COBOL), algorithms
- William Schockley (Bell Labs)
  - Transistor (1947), less power required, smaller & faster
  - Used in computers in late 60's
- Robert Noyce (Fairchild) & Jack Kilby (TI)
  - Integrated Circuit (1959) – transistors on a silicon chip
  - Enabled microprocessors and embedded systems in 70's
    - » Entire CPUs on a single chip
    - » 60,000 ops per second, same power as ENIAC, size of a dime
  - Founded Intel

Other Notables

- VLSI
  - Very large scale integrated circuits
  - More complex circuits, more on a chip
  - Microcomputers in the late 70's
    - » Computers as consumer items
- Jobs and Wozniak
  - 50 Apples built in garage
  - May 1976 Apple 1 sold for $666.66
    - » 4K of RAM
  - Stock $.08 in 1978, $22 in 1980
    - » 24,944% rise
- P=NP?
  - Cook, et al – 70's

Famous Predictions

- "I think there is a world market," IBM chief Thomas Watson famously declared one day in 1943, "for maybe five computers..."
- "Computers in the future may weigh no more than 1.5 tons." -- Popular Mechanics, 1949
- "I have traveled the length and breadth of this country and talked with the best people, and I can assure you that data processing is a fad that won't last out the year." -- Prentice Hall business editor, 1957
- "But what... is it good for?" -- IBM engineer on the microchip, 1968
- "There is no reason anyone would want a computer in their home." -- President, Chairman and founder of Digital Equipment Corporation, 1977

Mainframe

- IBM established the standard for mainframes for decades
- Designed for banks/credit agencies
- Store and manipulate data
- Hundreds of users

Minicomputer

- Smallest computer designed for multiple users
- offered mainframe performance at a fraction of the cost
- Small businesses dozens of users

Supercomputer

- Maximize speed
- High-performance systems used for scientific applications
- Advanced designs
- Control Data Corporation, Cray Research, and others
- Weather forecasting, etc.

Personal Computers

- Microprocessors
- Designed for single user
- "Limited" capabilities

Comparison Shopping

How do they rate in cost and performance?

Year	Name	Performance (adds/sec)	Memory (KB)	Price	Price / Performance (vs UNIVAC)
1951	UNIVAC I	1,900	48	1,000,000	1
1964	IBM 360	500,000	64	1,000,000	263
1965	PDP-8	330,000	4	16,000	10,855
1976	Cray-1	166,000,000	32,768	4,000,000	21,842
1981	IBM PC	240,000	256	3,000	42,105
1991	HP9000	50,000,000	16,384	7,400	3,556,118
1999	Mac G4	1,000,000,000	64,000	2,500	219,263,157

Perspective

- If automobile technology had developed at the same rate as computer technology, a new car today would:
  - Have an engine less than 1 inch across
  - Get 120,000 miles per gallon
  - Have a top speed of 240,000 miles per hour
  - Cost $4