An Incomplete History of Computation
Charles Babbage 1791-1871
Lucasian Professor of Mathematics,
Cambridge University, 1827-1839
First computer designer

Ada Lovelace 1815-1852
First computer programmer
Difference Engine

- Can compute any 6th degree polynomial
- *Speed:* 33 to 44 32-digit numbers per minute!

*Now the machine is at the Smithsonian*

Adapted from Arvind and Asanovic’s MIT course 6.823, Lecture 1
Analytic Engine

The first conception of a general purpose computer

1. The *store* in which all variables to be operated upon, as well as all those quantities which have arisen from the results of the operations are placed.
2. The *mill* into which the quantities about to be operated upon are always brought.

An operation in the *mill* required feeding two punched cards and producing a new punched card for the *store*.

*An operation to alter the sequence (i.e., a branch) was also provided!*
Analytic Engine

1833: Babbage’s paper was published
  - conceived during a hiatus in the development of the difference engine

1871: Babbage dies
  - The machine remains unrealized.

• Ada Lovelace gets less credit than she deserves --
  She essentially invented programming.

It is not clear if the analytic engine could be built even today using only mechanical technology

Adapted from Arvind and Asanovic’s MIT course 6.823, Lecture 1
Harvard Mark I

• Built in 1944 in IBM Endicott laboratories
  – Howard Aiken – Professor of Physics at Harvard
  – Essentially mechanical but had some electro-magnetically controlled relays and gears
  – Weighed 5 tons and had 750,000 components
  – A synchronizing clock that beat every 0.015 seconds

Performance:

  0.3 seconds for addition
  6 seconds for multiplication
  1 minute for a sine calculation

Broke down once a week!

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Electronic Numerical Integrator and Computer (ENIAC)

- Inspired by Atanasoff and Berry, Eckert and Mauchly designed and built ENIAC (1943-45) at the University of Pennsylvania
- The first, completely electronic, operational, general-purpose analytical calculator!
  - 30 tons, 72 square meters, 200KW
- Performance
  - Read in 120 cards per minute
  - Addition took 200 μs, Division 6 ms
  - 1000 times faster than Mark I
- Not very reliable!

Application: Ballistic calculations

angle = f (location, tail wind, cross wind, air density, temperature, weight of shell, propellant charge, ... )
To this point…

• Physical configuration specified the computation a computer performed

The Difference Engine

ENIAC
Electronic Discrete Variable Automatic Computer (EDVAC)

- ENIAC’s programming system was external
  - Sequences of instructions were executed independently of the results of the calculation
  - Human intervention required to take instructions “out of order”

- Eckert, Mauchly, John von Neumann and others designed EDVAC (1944) to solve this problem
  - Solution was the stored program computer
    - “program can be manipulated as data”

- First Draft of a report on EDVAC was published in 1945, but just had von Neumann’s signature!
  - In 1973 the court of Minneapolis attributed the honor of inventing the computer to John Atanasoff

Adapted from Arvind and Asanovic’s MIT course 6.823, Lecture 1
And then there was IBM 701

IBM 701 -- 30 machines were sold in 1953-54

IBM 650 -- a cheaper, drum based machine, more than 120 were sold in 1954 and there were orders for 750 more! - eventually sold about 2000 of them

Users stopped building their own machines.

Why was IBM late getting into computer technology?

IBM was making too much money!
Even without computers, IBM revenues were doubling every 4 to 5 years in 40’s and 50’s.
Compatibility Problem at IBM

By early 60’s, *IBM had 4 incompatible lines of computers!*

701  □  7094
650  □  7074
702  □  7080
1401 □  7010

Each system had its own
- Instruction set
- Peripherals: magnetic tapes, drums and disks
- Programming tools: assemblers, compilers, libraries,...
- market niche: business, scientific, etc....
IBM 360 : Design Premises

Amdahl, Blaauw and Brooks, 1964


• Breaks the link between programmer and hardware
• Upward and downward, machine-language compatibility across a family of machines
• General purpose machine organization, general I/O interfaces, storage > 32K
• Easier to use (answers-per-month vs. bits-per-second)
• Machine must be capable of supervising itself without manual intervention → OS/360 (simple OS’s in IBM 700/7000)
• Built-in hardware fault checking and locating aids to reduce down time

... the use of the “ISA” as a compatibility layer was a $175 billion project (2011 dollars)

The Amdahl .. from Amdahl’s Law.
The Brooks .. from The Mythical Man-Month.

Adapted from Arvind and Asanovic’s MIT course 6.823, Lecture 3