History of Modern Computing
Section 1

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Lesson Outline

- Definition of a computer
- Types of Computers
  - Digital vs. Analog
  - Scientific vs. Commercial
- Boolean Algebra
- Binary Arithmetic
- Circuits
  - Half-adder
- Relays
Lesson Outline

◆ Developments prior to 1950

• George Boole
• Herman Hollerith
  • Tabulating Machine Company
  • Computing, Tabulating and Recording Company
  • The genesis of IBM
• Conrad Zuse and the Z1
• Alan Turing and Colossus
• Howard Aiken and the Mark I
• John Atanasoff and the Atanasoff-Berry Computer (ABC)
• Eckert & Mauchly, and the ENIAC, EDVAC, and UNIVAC
• John von Neumann
• Jay Forrester and the Whirlwind
• Early IBM Computers
Definition of a Computer

- A photo of early computers:
Definition of a Computer

What is considered a (general-purpose) computer?

- Ability to compute at high speed
  - But simple calculators can do this
- Ability to make simple decisions
  - …and modify behavior based on data
- Programmability
- Input and Output
Types of Computers

- Analog (rare today)
- Digital

- Scientific
  - High-speed calculations
  - Floating point arithmetic
  - Small I/O requirements

- Commercial
  - I/O speeds more important than calculation speed
  - Fixed point (decimal)

- This difference is becoming less of a distinction as the speeds and capabilities of all computer types grows.
Binary Arithmetic

“There are only 10 kinds of people in the world, those who understand binary, and those who don’t.”

• Binary is Base 2 arithmetic:

<table>
<thead>
<tr>
<th></th>
<th>Decimal</th>
<th>Binary</th>
</tr>
</thead>
<tbody>
<tr>
<td>Base</td>
<td>10</td>
<td>2</td>
</tr>
<tr>
<td>Digits</td>
<td>0-9</td>
<td>0-1</td>
</tr>
</tbody>
</table>

• Evaluate the following number: 1001
  - Decimal: \((1\times10^3) + (0\times10^2) + (0\times10^1) + (1\times10^0) = (1\times1000) + (0\times100) + (0\times10) + (1\times1) = 1000 + 0 + 0 + 1 = 1001_{10}\)
  - Binary: \((1\times2^3) + (0\times2^2) + (0\times2^1) + (1\times2^0) = (1\times8) + (0\times4) + (0\times2) + (1\times1) = 8 + 0 + 0 + 1 = 9_{10}\)

\[
\begin{array}{c|c|c}
2^0 & = & 1 \\
2^1 & = & 2 \\
2^2 & = & 4 \\
2^3 & = & 8 \\
2^4 & = & 16 \\
2^5 & = & 32 \\
2^6 & = & 64 \\
2^7 & = & 128 \\
2^8 & = & 256 \\
2^9 & = & 512 \\
2^{10} & = & 1,024 \\
2^{11} & = & 2,048 \\
2^{12} & = & 4,096 \\
2^{13} & = & 8,192 \\
2^{14} & = & 16,384 \\
2^{15} & = & 32,768 \\
2^{16} & = & 65,536 \\
2^{17} & = & 131,072 \\
2^{18} & = & 262,144 \\
2^{19} & = & 524,288 \\
2^{20} & = & 1,048,576 \\
2^{21} & = & 2,097,152 \\
2^{22} & = & 4,194,304 \\
2^{23} & = & 8,388,608 \\
2^{24} & = & 16,777,216 \\
2^{25} & = & 33,554,432 \\
2^{26} & = & 67,108,864 \\
2^{27} & = & 134,217,728 \\
2^{28} & = & 268,435,456 \\
2^{29} & = & 536,870,912 \\
2^{30} & = & 1,073,741,824 \\
2^{31} & = & 2,147,483,648 \\
2^{32} & = & 4,294,967,296 \\
\end{array}
\]
Boolean Algebra

Around the 1850s, the British mathematician George Boole invented a new form of mathematics:
- Represented logical expressions in a mathematical form now known as Boolean Algebra
- Inputs and Outputs are True and False
  - We’ll use: True=1  False=0
- Some Boolean Truth Tables:
Circuits

- Gates (Electrical/Electronic Logic Operations)
- The basic building blocks of electronic circuits
  - AND Gate
  - OR Gate
  - XOR Gate
  - NOT (Invert) Gate
  - NOR, NAND
    - Inverted output of OR, AND
    - Same as gate followed by NOT gate
    - ...and others, but less important
Circuits

- **Half Adder Circuit**
  - Has no carry input
    - What is the output of the upper part of the circuit?

- **Full Adder has carry-in**
  - Combine two half-adders
    - Cascade Adders
    - OR the two Carry outputs for final Carry-out
Circuits

• Two-bit Wide Full Adder with Carry-out
Relays

- Typical Simple Relay:

- Can we make an AND Gate from this?
- An Inverter?
- An OR Gate?
Buggy Relays?

Photo # NH 96566-KN  First Computer "Bug", 1945

0800  Andam started.
      Andam stopped.
1000  Andam checked.

13°C (032) MP-NC
      (034) PRO = 2.130476415
      Cond. = 2.130476415

Relays 6-2 in 033 failed special speed test.
In relay
Relays changed.

1100  Started Cosine Tape (Sine chest).

1525  Started Multi-Adder Test.

1545  Relay #70 Panel F
       (moth) in relay.

First actual case of bug being found.

1600  Andam started.

1700  Closed down.
Developments up to 1950

❖ George Boole:
  • 1850s - Boolean Algebra invented

❖ Herman Hollerith:
  • 1889 - Invented punch-card based electromechanical adding and sorting machines
  • 1890 - Tabulated US census years more quickly than if done by hand
  • 1896 - Founded Tabulating Machine Company (TMC)
  • 1900 - Tabulated US census again
Early Hollerith Punch-card Equipment
Developments up to 1950

- **The birth of IBM**
  - 1911: TMC Merged with
    - Computing Scale Company of America, and
    - International Time Recording Company
    - Created Computing Tabulating Recording Company (CTR)
  - 1914: CTR hired Thomas J. Watson (Sr.)
  - 1924: Watson renamed the company “International Business Machines”
Developments up to 1950

- **Konrad Zuse**
  - 1934 - Begins work on a circuits in his bedroom
  - 1936-1938 – Completes the Z1 in his parents’ apartment
  - 1941 - Completes the Z3, arguably the world’s first automatic, program-controlled, working computer, destroyed during WWII
  - 1944 – Completes the Z4, first used at ETH in Zurich, in use until 1959
  - Zuse’s company eventually acquired by Siemens

- **Alan Turing “Father of Modern Computer Science”**
  - 1936 - Computability and the “Turing Machine”
  - 1940s - Works on bombe, Colossus, at Bletchley Park

- **Claude Shannon**
  - 1937 - Writes master's thesis on machine logic
    "possibly the most important, and also the most famous, master's thesis of the century"
  - 1949 – Builds first chess computer at MIT
Zuse Z1
Zuse Z4
The Colossus at Bletchley Park
Developments up to 1950

- **Vannevar Bush**
  - 1925-30 - Designs early large scale analog computer, Integraph
  - 1945 - Essay “As We May Think”, describes Memex machine

- **Howard Aiken**
  - 1930 - Conceives of large-scale digital calculator for Harvard
  - 1939 - Engages IBM to build it
  - 1944 - Harvard Mark I (IBM ASCC) installed

- **John Atanasoff**
  - 1937-42 - With Grad Student Clifford Berry, designs and builds Atanasoff-Berry Computer (ABC) at Iowa State College
  - Eventually awarded credit for first Electronic Digital Computer

- **Grace Murray Hopper**
  - 1944 - Starts work on programming the Harvard Mark I
  - 1949 - Joins Eckert-Mauchly Computer Company (more later)
Vannevar Bush’s Differential Analyzer

An early analog computer
Atanasoff-Berry Computer (ABC)
Harvard Mark I (a.k.a. IBM ASCC)
Developments up to 1950

- **J. Presper Eckert & John Mauchly**
  - 1941 - Mauchly visits John Atanasoff at Iowa State
  - 1943-45 - Design and build ENIAC at U. Penn.’s Moore School
  - 1945-46 - Work on design of EDVAC
  - 1946 - Leave Moore School over in argument over patents, found company that becomes Eckert-Mauchly Computer Company
  - 1947 - Pick name “UNIVAC” for their computer
  - 1950 - E-MCC acquired by Remington Rand, is Univac Division

- **John von Neumann**
  - 1944 - Learns of ENIAC and EDVAC, joins projects
  - 1945 - “First Draft of a Report on the EDVAC”

- **Jay Forrester**
  - 1944 - Project leader for Whirlwind project at MIT
  - 1946 - Proposes digital (rather than analog) system for ASCA
  - 1949 – Whirlwind online; First use of ferrite core memory
ENIAC
# First 5 Operational Digital Computers

<table>
<thead>
<tr>
<th>Computer</th>
<th>Nation</th>
<th>Year</th>
<th>Binary?</th>
<th>Electronic?</th>
<th>Programmable?</th>
<th>Turing Complete?</th>
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<tbody>
<tr>
<td>Zuse Z3</td>
<td>Germany</td>
<td>1941</td>
<td>Binary</td>
<td>Electro-Mechanical</td>
<td>Yes, paper tape</td>
<td>Yes</td>
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<tr>
<td>Atanasoff-Berry (ABC)</td>
<td>USA</td>
<td>1942</td>
<td>Binary</td>
<td>Electronic</td>
<td>No</td>
<td>No</td>
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<tr>
<td>Colossus</td>
<td>UK</td>
<td>1944</td>
<td>Binary</td>
<td>Electronic</td>
<td>Partially, rewiring</td>
<td>No</td>
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<tr>
<td>Harvard Mark I</td>
<td>USA</td>
<td>1944</td>
<td>Decimal</td>
<td>Electro-Mechanical</td>
<td>Yes, paper tape</td>
<td>Yes</td>
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<tr>
<td>ENIAC</td>
<td>USA</td>
<td>1946</td>
<td>Decimal</td>
<td>Electronic</td>
<td>Partially, rewiring</td>
<td>Yes</td>
</tr>
</tbody>
</table>

**Note**: Adapted from Wikipedia article on Harvard Mark I
Whirlwind
IBM 604 Calculator (1948)

IBM 604 (shown at right with a 407 Accounting Machine). The 604 was IBM’s first mass-produced electronic computing machine. Operators using plugboards could program up to 60 steps using the four basic arithmetic operations plus square root.
IBM Card Programmed Calculator (1948)

The Card-Programmed Electronic Calculator (with 604 in the center) was the first digital computer in the space program and was instrumental in the development of the U.S. Army Redstone missile.
Developments up to 1950

- I/O Devices
  - Cards
  - Tape (metal)
  - Tape (punched)
  - Typewriters
  - Teletypes
  - Magnetic Drums
Developments up to 1950

- Programming
  - Plug panels
  - Plug boards
  - Card
  - Tape

Plug Board from the IBM CPC