Introduction to Algorithms

Adhi Harmoko S, M.Komp
A “Universal” Machine

- Programmability
- Binary Code (everything stored as “0” or “1”)
- Program and Data are represented in the same form
- Electronic Components
# Early Computing History in a Nutshell

<table>
<thead>
<tr>
<th>Year</th>
<th>Event</th>
<th>Features</th>
</tr>
</thead>
<tbody>
<tr>
<td>200 BC - today</td>
<td>Abacus</td>
<td>-</td>
</tr>
<tr>
<td>~1670</td>
<td>Leibniz’ “Rechenmaschine”</td>
<td>Fixed calculations +, -, *, /, sqrt</td>
</tr>
<tr>
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<td>Jacquard’s Loom</td>
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<td>First program (Bernoulli-Numbers)</td>
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Leibniz’s Step Reckoner

- Gottfried von Leibniz 1670
- Add, subtract, multiply, divide, square roots
Jacquard’s punch card

- Joseph Marie Jacquard 1804
- punch cards used to operate loom
Babbage’s analytical engine

- Charles Babbage (1791-1871)
- Programmable, but mechanical.
- Data+Program separate
One of the first Programmers

- Lady Ada Augusta Byron, Countess of Lovelace (1815-1952) (1791-1871)
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- First universal programmable machine
## The Ancestors

### Binary code

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<th>Year</th>
<th>Model</th>
<th>Type</th>
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<tr>
<td>1886</td>
<td>Hollerith Punch Cards</td>
<td></td>
</tr>
<tr>
<td>1936</td>
<td>Zuse Z1</td>
<td>Relais</td>
</tr>
<tr>
<td>1941-1944</td>
<td>Zuse Z3/Z4</td>
<td>“Plankalkül”</td>
</tr>
<tr>
<td>1944</td>
<td>Mark I</td>
<td>Partly mechanic</td>
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### Electronic

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<tr>
<td>1943</td>
<td>Colossus</td>
<td>Not universal</td>
</tr>
<tr>
<td>1946</td>
<td>Eniac</td>
<td>Programmable with <em>Re-wiring</em></td>
</tr>
<tr>
<td>1949</td>
<td>Manchester Universal Computer</td>
<td>Cathode-Ray Tube Memory</td>
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### Integration:
- Fully electronic
- Binary
- Programmable
- Universal
Hollerith’s Tabulating Machine

- Herman Hollerith (1860-1929)
- Invented a punched card device to help analyse the 1890 US census data
- Founded “Tabulating Machine Company” 1896
- 1924 – Tabulating Machine Company merges with others to form IBM
Konrad Zuse

- 1936: Z1 first binary computer using Erector Set parts, keyboard and lights for output (relay memory)
- 1938: Z2 – using punched tape and relays

Z3: fully binary, fully programmable, but partly mechanical
Colossus

- 1943 British Colossus – (1,500 vacuum tubes)
  - Decipher enigma coded messages at 5,000 chars/sec
  - At peak, 10 machines ran 24 hours a day in Bletchley Park

A German enigma coding machine

Fully electronic, but not universally programmable
Harvard Mark 1

- 1943-44 Aiken at Harvard/IBM “Mark 1” – first electromechanical digital computer (electromagnetic relays – magnets open and close metal switches) (recreation of Analytical Engine)
  - 8 ft tall, 50 ft long, 1 million parts
  - 323 decimal-digit additions per sec
  - storage for 72 23-digit numbers.

Universal, fully programmable But partly mechanical
ENIAC (1946)

- 18,000 tubes, 1500 sq ft
- Programmed by wire plugs into panels
  - 5,000 decimal-digit additions/sec
  - 20 10-decimal digit “accumulators”

Von Neumann and ENIAC

Fully electronic, programmable But extensive-wiring required
Experminental MUC (1949)

- 1941 Von Neumann proposes EDVAC – Electronic Discrete Variable Computer
- Computer should
  - Use binary
  - Have stored programs
  - Be function-oriented
- Team Members from Bletchley Park and EDVAC/ENIAC collaborate at Manchester
- Add CRT display memory

First fully electronic universal computer
How do we solve problems?

- We "just do"
- Guesswork-and-luck
- Trial-and-error
- Experience (possibly someone else's)
- "Scientifically"
The Problem-solving Process

1. Problem
2. Analysis
3. Problem specification
4. Design
5. Algorithm
6. Implementation
7. Program
8. Compilation
9. Executable (solution)
The Problem-solving Process

Problem

"Doctor, my head hurts"

Problem specification

Patient has elevated pressure in anterior parietal lobe.

Analysis

Design

Algorithm

Implementation

Program

Executable (solution)

1. Sterilize cranial saw
2. Anaesthetize patient
3. Remove top of skull
4. Get the big spoon...
5. etc., etc.

 sterilize(saw,alcohol);
raise_hammer();
lower_hammer(fast);
start(saw);
/* etc. etc. */
Algorithm – Working Definition

- A sequence of instructions describing how to do a task
- Unambiguous
- Executable
- Terminating
- If you can't find an algorithm, the computer can't solve your problem
Algorithm -- Examples

- A cooking recipe
- Assembly instructions for a model
- The rules of how to play a game
- VCR instructions
- Description of a martial arts technique
- Directions for driving from A to B
- A knitting pattern
- A car repair manual
- Recipe for Almond and honey slice
- Recipe for Arroz con pollo
Almond and Honey Slice

- 1/2 quantity Shortcrust Pastry
- 185 g unsalted butter
- 100 g castor sugar
- 5 tablespoons honey
- 50 ml cream
- 50 ml brandy or any other liqueur or spirit
- 300 g flaked almonds

Preheat oven for 200° C
Line a 30 cm × 20 cm baking tray with baking paper, and then with pastry
Bake blind for 20 minutes, then remove weights and foil
Turn oven up to 220° C.
Bring remaining ingredients to a boil, stirring.
Spread evenly over pastry.
Bake until topping is bubbling and has caramelised evenly, about 15 minutes.
Cool before cutting into fingers or squares.
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Instructions are given in the order in which they are performed ("executed")
A sequence of instructions describing how to do a task (or process)
Components of an Algorithm

- Variables and values
- Instructions
  - Sequences
  - Procedures
  - Selections
  - Repetitions

*Also required: Documentation*
Values

- Represent quantities, amounts or measurements
- May be numerical or alphabetical (or other things)
- Often have a unit related to their purpose
- Example:
  - Recipe ingredients
Almond and Honey Slice

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Variables

- Are **containers** for **values** – places to store values
- Example:

  **Variable**
  
  This jar **can contain**
  
  **Values**
  
  10 cookies
  50 grams of sugar
  3 slices of cake
  etc.
Restrictions on Variables

- Variables may be restricted to contain a specific type of value
Components of an Algorithm

✓ Values and Variables
- Instruction (a.k.a. primitive)
  - Sequence (of instructions)
  - Procedure (involving instructions)
  - Selection (between instructions)
  - Repetition (of instructions)
- Documentation (beside instructions)