Computer System: User’s View

Computer System Components: High Level View

Input | Computer | Output

Computer System: Motherboard Level

Computer Components: Interconnection

CPU

CPU Organization
Memory

- Address: 0000000000
- Content: 01010101010010101

I/O CPU

- Address: 0000000001
- Content: 01110101010010101

- Address: 1111111110
- Content: 01010101011110101

- Address: 1111111111
- Content: 11010111010010101

I/O Module

- I/O Devices

Input/Output

Computer Systems Hierarchy

- User
- Application Software
- Operating System
- Assembly Language
- Machine Code
- Electronic Signal

- Computer
- Instructions
- Results

A program: A sequence of instructions describing how to perform a certain task.

Computer Systems Hierarchy

- Machine Language:
  - A computer’s primitive instructions form a language which enables humans to communicate with computers
  - Machine languages are simple, but difficult to use.

Computer Systems Hierarchy

- Human Language
- Machine Language

Interpretation/Translation

Difficult to implement
**Computer Systems Hierarchy**

**Level 0**  
Digital logic level  
A group of 1-bit memories combined to form registers. A register can hold 8 bits, 16 bits, 32 bits or 64 bits etc.

**Computer Systems Hierarchy**

**Level 1**  
Microstructure level  
Registers - 16 bits, 32 bits etc  
ALU - Arithmetic Logic Unit  
Microprograms

**Computer Systems Hierarchy**

**Level 2**  
Instruction Set Architecture

**Computer Systems Hierarchy**

**Level 2**  
Instruction Set Architecture

**Computer Systems Hierarchy**

**Level 3**  
Operating System  
Hybrid level  
Most of its instructions are in ISA level - directly carried out by microprograms or hardwired control  
Also there are  
A set of new instructions  
Different memory organization  
Run two or more programs concurrently etc

**Computer Systems Hierarchy**

**Level 4**  
Assembly language level  
- Symbolic form of the underlying language  
- A method to write programs for level 1, 2, and 3  
- Easier to use than machine language  

**Assembler**  
A program translates the assembly language into level 1, 2, or 3 language and interpreted by the appropriate virtual or actual machine.
Computer Systems Hierarchy

Level 5 - High level language

Application programmers

BASIC, C, C++, C#, etc

Compiler

Translator which translates a high level language to level 4 and 3 languages

A (Very) Brief History of Computers (I)

The first Generation - Vacuum Tubes (1945 -1955)

ENIAC (1943 - 1946)

- Designed for calculating range tables of aiming artillery
- Consisted of 18,000 tubes, 1500 relays, weighed 30 tons, consumed 140 KW
- Central machine
- Cool liquid was circulated by a ring of 30 vacuum tubes.
- Designed for artillery range tables, but could perform complex calculations to help determine the feasibility of H bomb - general purpose computer
- Programmed with multi-position switches and jumper cables.

John von Neumann (1945 -1952) more later …

- Originally a member of the ENIAC development team.
- First to use binary arithmetic
- Architecture consists of : Memory, ALU, Program control, Input, Output
- Stored-program concept - main memory stores both data and instructions

A (Very) Brief History of Computers (II)

Vacuum Tubes

ENIAC

A (Very) Brief History of Computers (III)


IBM System/360
- Extremely reliable with multi-user capability
- Designed for both scientific and commercial computing
- First to offer mini- and micro-systems
- First to offer microprogramming
- DEC PDP-11
- Was to System/360 what PDP-8 was to 7090

The Fourth Generation - VLSI (1980 - ?)

- Lead to PC revolution
- High performance, low cost

Evolution of Intel Microprocessor

<table>
<thead>
<tr>
<th>Year</th>
<th>Model</th>
<th>CPU Speed</th>
<th>Transistor Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>1970</td>
<td>4004</td>
<td>108 KHz</td>
<td>2,300</td>
</tr>
<tr>
<td>1972</td>
<td>8008</td>
<td>200 KHz</td>
<td>3,500</td>
</tr>
<tr>
<td>1974</td>
<td>8080</td>
<td>2 MHz</td>
<td>6,000</td>
</tr>
<tr>
<td>1978</td>
<td>8086</td>
<td>5 MHz, 8 MHz</td>
<td>29,000</td>
</tr>
<tr>
<td>1979</td>
<td>8088</td>
<td>10 MHz</td>
<td>29,000</td>
</tr>
</tbody>
</table>
Moore’s Law

Computers double in power roughly every two years, but cost only half as much

The IAS (von Neumann) Machine

- Stored Program concept
- Main memory storing programs and data
- ALU operating on binary data
- Control unit interpreting instructions from memory and executing
- Input and output equipment operated by control unit

Almost all of today’s computers have the same general structure as the IAS - referred to as von Neumann machines.

The IAS Machine: Memory

IAS Memory:
- 1000 storage locations (words), each 40 bits
- Both data and instruction are stored in the memory

The IAS Machine: Control Unit

The control unit operates the machine by fetching instructions from memory and executing them ONE at a time.
The IAS Machine: Instruction Cycle

The IAS operates by repetitively performing an instruction cycle.

Two sub-cycles:

- During the fetch cycle, the opcode of the NEXT instruction is loaded into the IR and the address portion is loaded into the MAR.

- Once the opcode is in the IR, the execute cycle is performed. Control circuitry interprets the opcode and executes the instruction by sending out appropriate control signals to cause data to be moved or an operation to be performed by the ALU.