Computer Organization & Architecture

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August 5, 2020

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Textbook References

- Text Book:
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- Reference Books:
  1. A.S. Tanenbaum, Structured Computer Organization, 5^{th} ed. Prentice Hall, 2005.
  2. D.A. Patterson and J.L. Hennessy, Computer Architecture: Hardware/Software Interface, 4^{th} ed. Morgan Kaufmann, 2011.

Introduction

- Computers have became a part and parcel of our daily life.
  - They are everywhere (embedded system)
  - Laptops, tablets, mobile phone, intelligent appliances
- It is required to understand how a computer work.
  - What are there inside a computer?
  - How does it work?
- What is Computer Architecture & Organization?
- Distinguish b/w Computer Architecture and Computer Organization.

CA vs CO

- **Computer Architecture**
  1. What?
  2. Computer Architecture deals with functional behavior of computer system.
  3. The view of computer as presented to software designer.
  4. Comprises logical functions such as instruction sets, registers, data types and addressing modes.
  5. Computer Architecture deals with giving operational attributes of the computer or processor to be specific.
  6. Also called as instruction set architecture (ISA).
- **Computer Organization**
  1. How?
  2. Computer Organization deals with structural relationship.
  3. The actual implementation of a computer in hardware.
  4. Consists of physical units like circuit designs, peripherals and adders.
  5. Computer Organization is realisation of what is specified by the computer architecture.
  6. Frequently called as microarchitecture.

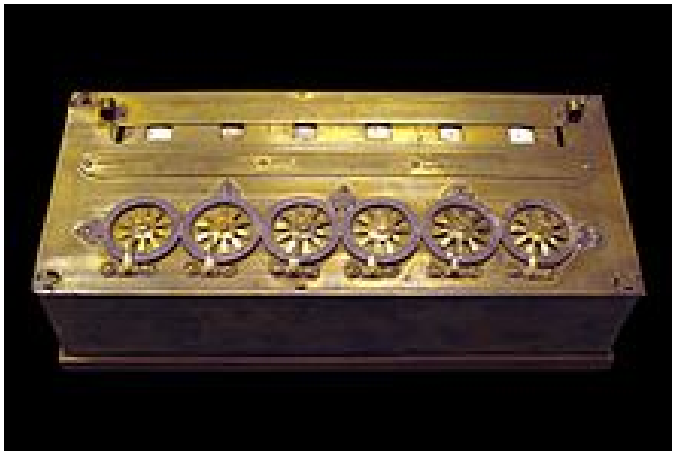
Analogy?

Historical Perspective

- Constant quest of building automatic computing machines have driven the development of computers.
  - Initial Efforts: mechanical devices like pulleys, levers, gears.
  - During world war II: mechanical relays for computation
  - Vacuum tubes developed: first electronic computer (ENIAC)
  - Semiconductor transistors developed: journey of miniaturization
    - $SSI \rightarrow MSI \rightarrow LSI \rightarrow VLSI \rightarrow ULSI \rightarrow$ .....Billions of transistors

PASCALINE (1642)

- First mechanical calculator invented by B. Pascal
- Could add and subtract two numbers directly, and multiply and division by repetition.



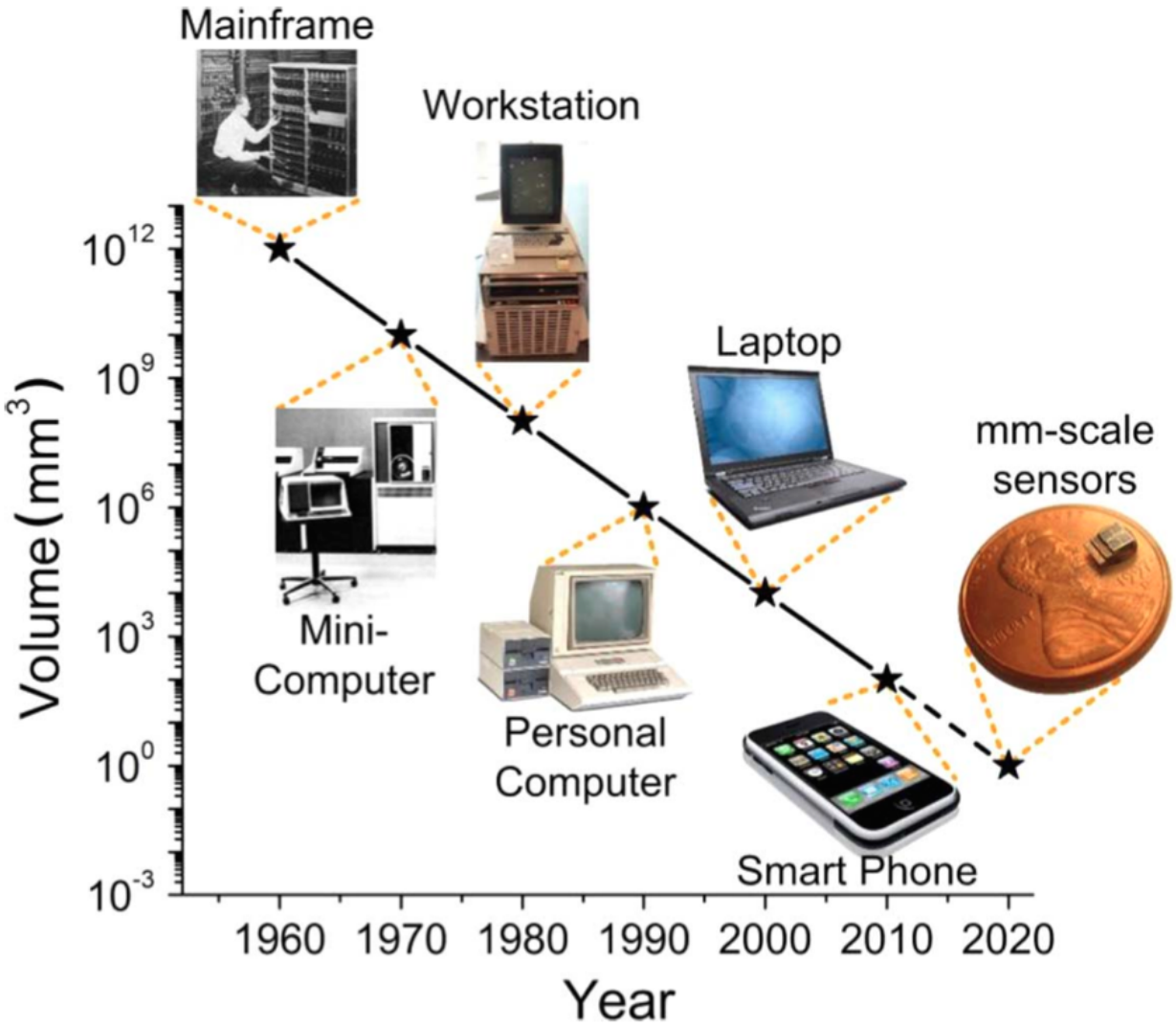
ENIAC (Electronic Numerical Integrator And Calculator)

- First electronic computer, developed at University of Pennsylvania.
- Used 18000 vacuum tubes
  weighted 30 tons
  occupied a
  $30ft \times 50ft$ space.

Computer Generations

Generation	Main Technology	Representative Systems
First (1945-54)	Vacuum tubes, relays	Machine & assembly language ENIAC, IBM-701
Second (1955-64)	Transistors, memories, I/O processors	Batch processing systems, HLL IBM-7090
Third (1965-74)	SSI and MSI integrated circuits Microprogramming	Multiprogramming / Time sharing IBM 360, Intel 8008
Fourth (1975-84)	LSI and VLSI integrated circuits	Multiprocessors Intel 8086, 8088
Fifth (1984-90)	VLSI, multiprocessor on-chip	Parallel computing, Intel 486
Sixth (1990 onwards)	ULSI, scalable architecture, post-CMOS technologies	Massively parallel processors Pentium, SUN Ultra workstations

Evolution of the Types of Computer System



Evolution of the Types of Computer System

- Embedded Computers
  - used for a specific purpose tasks.
  - integrated into a larger device or system to automatically monitor and control a physical process or environment.
  - have the widest spread of processing power and cost.
  - applications include industrial and home automation, appliances, telecommunication products, and vehicles.
- Personal Computers
  - widespread use in homes, educational institutions, and business and engineering office settings, primarily for dedicated individual use.
  - support a variety of applications such as general computation, document preparation, etc.
  - classifications of personal computers:
    - Desktop computers
    - Workstation computers
    - Portable and Notebook computers

Evolution of the Types of Computer System

- Servers and Enterprise systems
  - shared by a potentially large number of users
  - host large databases and provide information processing for a government agency or a commercial organization.
- Supercomputers and Grid computers
  - offer the highest performance.
  - most expensive and physically the largest category of computers.
  - used for the highly demanding computations needed in weather forecasting, engineering design and simulation, and scientific work.
  - Grid computers provide a more cost-effective alternative.

Evolution of the Types of Computer System

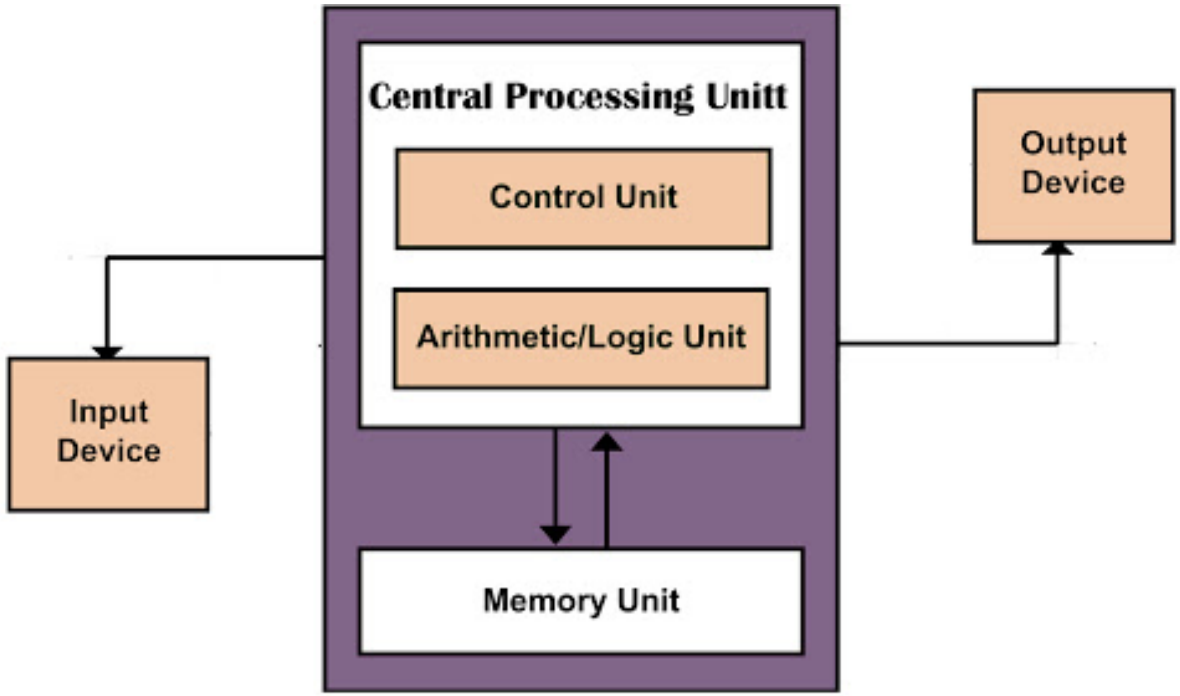
- The future?
  - Large scale IoT based systems.
  - Wearable computing
  - Intelligent objects

Performance

- Measure of the performance?
- How performance is affected?
  1. Technology
  2. Parallelism
     - Instruction-level Parallelism
     - Multicore Processors
     - Multiprocessors

Simplified Block Diagram of Computer System

- All instructions and data are stored in memory.
- An instruction and the required data are brought into processor for execution.
- Input and Output devices are interface with outside. world
- Referred to as Von Neumann architecture.



Von Neumann Architecture

Functional Units

A computer consists of five functionally independent main parts:

- Input unit
- Central Processing Unit (CPU)
  - Arithmetic and Logic (ALU)
  - Control unit
- Memory unit
- Output unit

Input and Output Unit

- Computers accept coded information through input units, e.g. keyboard.
- Input devices: touchpad, mouse, joystick, and trackball.

- Output unit:
  - counterpart of the input unit
  - send processed results to the outside world, e.g. printer
  - sometimes known as input/output (I/O) unit

Memory Unit

The function of the memory unit is to store programs and data.

- Two classes of storage:
  - Primary storage (main memory)
    - Random-access memory (RAM).
    - Cache
  - Secondary storage (secondary memory)
    - magnetic disks
    - optical disks (DVD and CD)
    - flash memory devices

Processor

- Also called Central Processing Unit (CPU)
- Consists of Control Unit and Arithmetic and Logic Unit (ALU)
  - ALU : all calculations (arithmetic and logical)
  - Control unit: generates the timing signals and send control signals to other units and senses their states.
- The processor fetches an instruction from memory for execution
  - Instruction: specifies the exact operation to be carried.
  - Also specifies the data that are to be operated on
  - Program: list of instructions which performs a task
  - Data: Data are numbers and characters that are used as operands by the instructions
  - The instructions and data handled by a computer must be encoded in a suitable format.

Questions & Answers ?