

Computer Organization & Architecture

Lecture #12

Organization and Architecture

Computer Architecture

Those attributes of the system that are visible to a programmer. Those attributes that have a direct impact on the execution of a program.

- Instruction sets
- Data representation – number of bits used to represent data
- Input/Output mechanisms
- Memory addressing techniques

Computer Organization

The operational units and their interconnections that realize the architectural specifications. Those hardware attributes that are transparent to the programmer.

- Control signals
- Interfaces between the computer and peripherals
- Memory technology

Structure and Function

A computer is a complex system; contemporary computers contain millions of electronic components. How, then, can one clearly describe a computer? The key is to recognize the hierarchical nature of most complex systems. A hierarchical system is a set of interrelated subsystems where each subsystem is a hierarchical structure.

At each level, the system consists of a set of components and their interrelationships. At each level, a designer is concerned with structure and function:

Structure – the way in which components relate to each other.

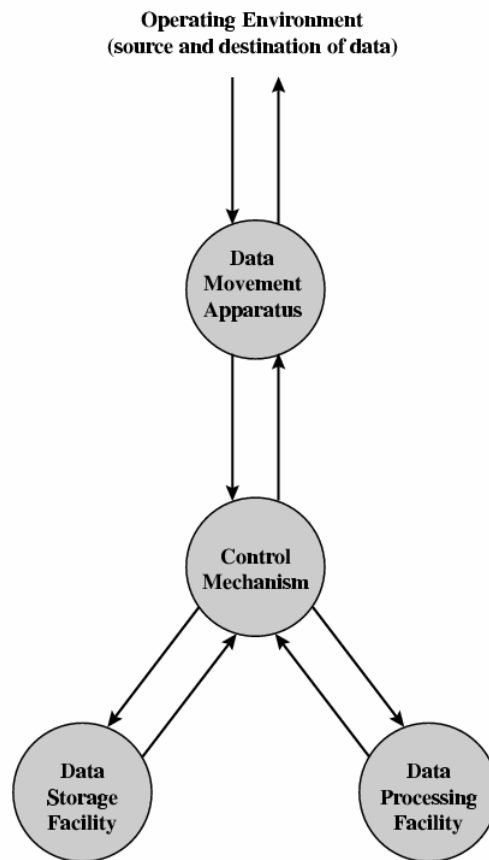
Function – the operation of individual components as part of the structure.

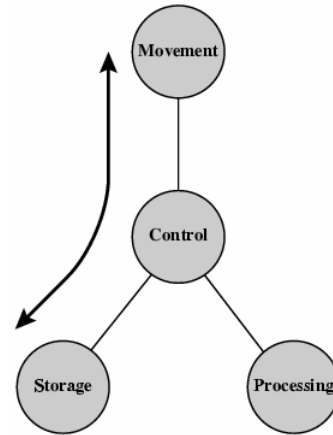
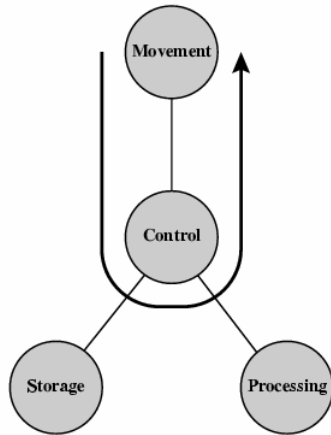
Function

The four basic functions of a computer are:

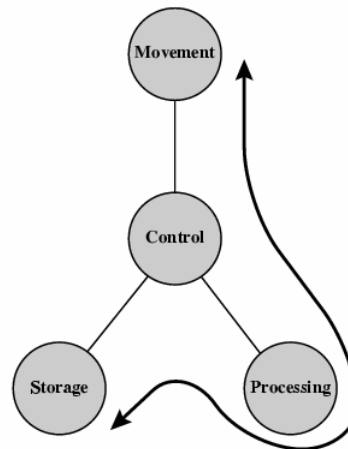
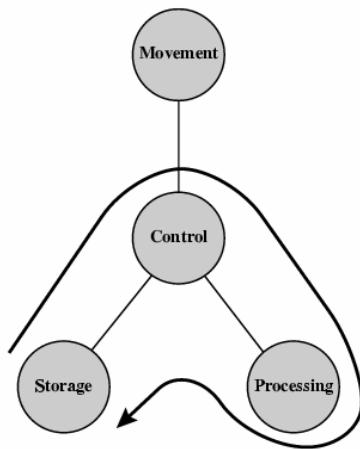
- **Processing data**
- **Storing data**
- **Moving data between the computer and the outside world**
- **Control the operations above**

Show below is a functional view of the computer.





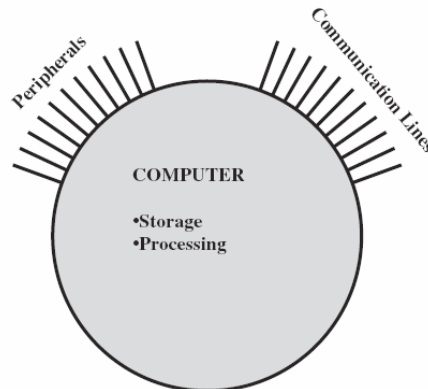
- Above on the left is an example of transferring data from one peripheral or communications line to another.
- Above on the right is an example of the computer as a storage device for the external environment either being written to or read from.



- Above on the left is an example of data being processed from storage.
- Above on the right is an example of data being processed from the external environment.

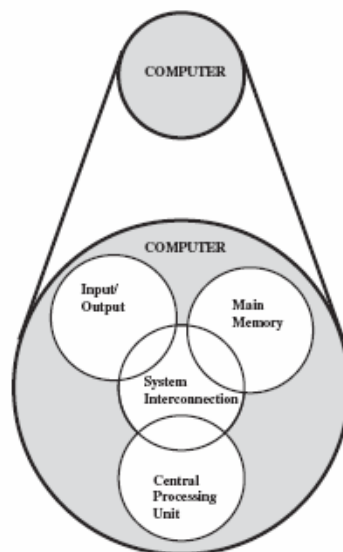
Structure

Shown below is a very simple depiction of a computer:



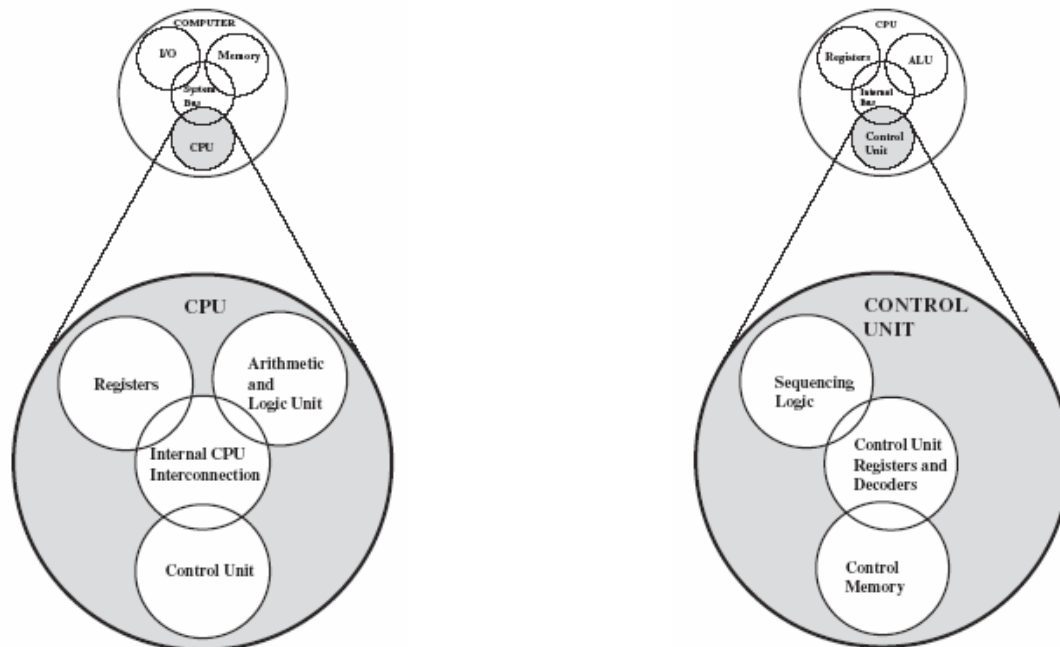
The four main internal structural components of a computer are:

- **Central processing unit (CPU)** – controls the operation of the computer and performs its data processing functions.
- **Main memory** – stores data.
- **Input/Output (I/O)** – moves data between the computer and its external environment.
- **System interconnections** – some mechanism that provides for communication among CPU, main memory, and I/O.



Probably the most interesting and in some ways the most complex component of the computer is the CPU. The CPU's major structural components are as follows:

- **Control unit** – controls the operation of the CPU and hence the computer.
- **Arithmetic and logic unit (ALU)** – performs the computer's data processing functions.
- **Registers** – provides storage internal to the CPU.
- **CPU interconnections** – some mechanism that provides for communication among the control unit, ALU, and registers.



- Above on the left the structure of the CPU is shown.
- Above on the right the structure of the control unit is shown using a microprogrammed implementation. A microprogrammed control unit operates by executing microinstructions that define the functionality of the control unit.

Why Study Computer Organization and Architecture?

The IEEE/ACM Computer Curricula 2001 [JTF01], prepared by the Joint Task Force on Computing Curricula of the IEEE (Institute of Electrical and Electronics Engineers) Computer Society and ACM (Association for Computing Machinery), lists computer architecture as one of the core subjects that should be in the curriculum of all students in computer science and computer engineering. The report says the following:

The computer lies at the heart of computing. Without it most of the computing disciplines today would be a branch of theoretical mathematics. To be a professional in any field of computing today, one should not regard the computer as just a black box that executes programs by magic. All students of computing should acquire some understanding and appreciation of a computer system's functional components, their characteristics, their performance, and their interactions. There are practical implications as well. Students need to understand computer architecture in order to structure a program so that it runs more efficiently on a real machine. In selecting a system to use, they should be able to understand the tradeoff among various components, such as CPU clock speed vs. memory size.

1. Suppose a graduate enters the industry and is asked the most cost-effective computer for use throughout a large organization. An understating of the implications of spending more for various alternatives, such as larger cache or a higher processor clock rate, is essential to making the decision.
2. Many processors are not used in PCs or servers but in embedded systems. A designer may program a processor in C that is embedded in some real-time or large system, such as an intelligent automobile electronics controller. Debugging the system may require the use of a logic analyzer that displays the relationship between interrupt requests from engine sensors and machine-level code.
3. Concepts used in computer architecture find application in other courses. In particular, the way in which the computer provides architectural support for programming languages and operating system facilities reinforces concepts from those areas.