LECTURE NOTES
ON
COMPUTER ARCHITECTURE
AND
ORGANIZATION

AGNI DATTA

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Contents

Chapter 1

INTRODUCTION TO SYSTEM ARCHITECTURE AND ORGANISATION

1.1 System Architecture

A system architecture is a conceptual model that specifies the structure, behaviour, and additional perspectives of a system. An architectural description is a formal description and representation of a system that is arranged in such a manner that it allows for reasoning about the system's structures and actions. A system architecture can be made up of system components and created subsystems that will function together.
In summary,

1. The architecture of a computer system can be considered as a catalogue of tools or attributes that are visible to the user such as instruction sets, number of bits used for data, addressing techniques, etc.
2. Controls the logical aspects of a computer system.
3. The architecture refers to those attributes of the system visible to the programmer.

1.2 System Organisation

Organization of a computer system defines the way system is structured so that all those catalogued tools can be used. The significant components of Computer organization are ALU, CPU, memory and memory organization.
In summary,

1. Organization of a computer system defines the way system is structured so that all those catalogued tools can be used.
2. Physical aspects of computer system
3. Computer organization is used to study the basic computer hardware structure and behaviour of digital computers.

1.2.1 Importance of Computer Organization and Architecture

These are a few important points,

- ⋆ Computer Architecture and Organisation is necessary to understand the designing and functioning of the various components to process information digitally.
- ⋆ Computer Architecture and Organisation study focuses on the interface between hardware and software.
- ⋆ Computer Architecture and Organisation tells the way of operating hardware components and their interconnections in computer.
- ⋆ Computer Architecture and Organisation provides an organized way of working with different hardware components together in one place.
- ⋆ Computer Architecture and Organisation provides detailed knowledge of the system components, Circuit designs, Structure of Instruction, Computer arithmetic, Assembly programming, processor control, logical design, and performance method.
- ⋆ Computer Architecture and Organisation proves that different computer organizations can use the same architecture. For example, Intel and AMD make x86_64 CPU (processor is of 64 bits), but INTEL makes its organization on x86_64, and AMD makes its own, which means the processor is 64 bits. Still, internal circuits, working, interconnections will be different.
- ⋆ Computer Architecture and Organisation subject helps the computer engineers to understand the components functioning, working, characteristics, performance, and their interactions.

1.3 Types of Computers

A computer is a machine that can be configured to automatically perform arithmetic or logical functions. Programs are general collections of operations that modern computers could do. These programmes allow computers to execute a variety of activities. A computer system is a "complete" computer that comprises the necessary hardware, operating system (main software), and peripheral devices for "full" functioning. This word can also apply to a collection of computers that are linked and work together, such as a computer network or a computer cluster.
The four basic types of computers are as under:

1.3.1 Supercomputers

A supercomputer is designed to do activities that require extensive numerical computations, such as weather forecasting, fluid dynamics, nuclear simulations, theoretical astrophysics, and complicated scientific computations. A supercomputer is a computer that is at the cutting edge of current processing capability, notably computation speed. The word “supercomputer” is very flexible, and the speed of today’s supercomputers tends to become representative of tomorrow’s average computer. FLOPS, or floating-point calculations per second, are the units of measurement for supercomputer processing speeds.
Calculating complicated mathematical equations in real numbers is an example of a floating-point procedure. Supercomputers are the most powerful in terms of computing capabilities, memory capacity and speed, I/O technology, and topological concerns such as bandwidth and latency, but they are highly expensive and not cost-effective for batch or transaction processing. These computers were created in the 1970s and are the fastest and most powerful computers available.

1.3.2 Mainframe Computers

The term mainframe computer was used to distinguish between the conventional, big, institutional computer designed to serve numerous users and the smaller, single-user computers. These computers are capable of handling and processing massive volumes of data in a short period of time. Mainframe computers are utilised in big organisations such as the government, banks, and companies. They are measured in MIPS (million instructions per second) and can handle hundreds of millions of users concurrently.

1.3.3 Minicomputers

Minicomputers (abbreviated "minis") are a type of multi-user computer that falls somewhere in the centre of the computing spectrum, between the smallest mainframe computers and the largest single-user systems (microcomputers or personal computers). The name super-mini computer, or simply super-mini, was used to designate more powerful minicomputers with capabilities comparable to mainframes. At a period when most minicomputers (such as the PDP-11, Data General Eclipse, or IBM Series/1) were 16-bit, super-minis (such as the DEC VAX or Data General Eclipse MV/8000) were 32-bit. These traditional minicomputers, found throughout small to medium-sized businesses, laboratories, and embedded in (for example) medical facility CAT scanners for the last few decades of the 20th century, were mostly rack-mounted and connected to one or more terminals or tape/card readers, like mainframes and unlike most personal computers, but mandated less space and electrical power than a typical mainframe. The term "minicomputer" currently refers to higher-end SPARC, POWER, and Itanium-based systems from Oracle Corporation, IBM, and Hewlett-Packard, and the size is now generally smaller, such as a tower case.

1.3.4 Microcomputers

In the late twentieth century, microcomputers became the most popular form of computer. With the introduction of systems based on single-chip microprocessors, the term "microcomputer" was coined. The Altair 8800, released in 1975, was one of the most well-known early system. The word "microcomputer" has almost become obsolete.

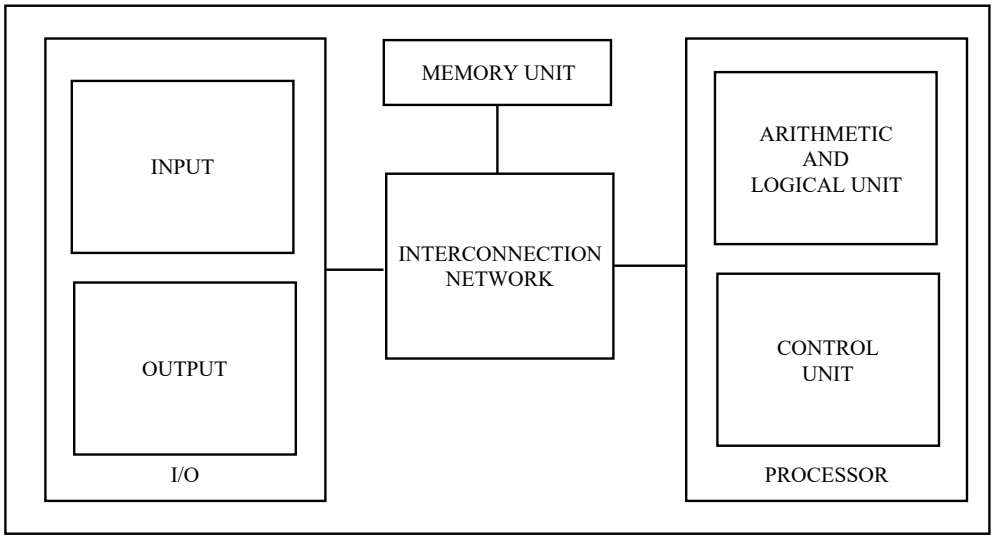
1.3.5 Comparison of Processors

MICRO COMPUTER	MINI COMPUTER	MAINFRAME COMPUTER	SUPER COMPUTER
A microcomputer is a small relatively inexpensive computer with a microprocessor as its central processing unit (CPU).	It was first developed by IBM in mid 1960. Also called midrange computer.	It is type of computers that generally are known for their large size, amount of storage, processing power and high reliability. It first appeared in 1940.	It consists of tens of thousands of processor that are able to perform billions and trillions of calculations or computations per seconds.
It includes a microprocessor, memory, and I/O devices.	It may content one or more processors, support multiprocessing and tasking and generally resilient to high workloads.	Used by large organizations for mission-critical applications required for high volume data processing. Ability to run multiple operating system.	Designed for enterprises and organization which need massive computing power.
Example: IBM PC, Apple Macintoshes, Dell Home PC	Example: DEC's,VAX, RANGE	Example: IBM zSeries, System z9	Example: IBM Sequoia, PARAM, Fujitsu Fugaku

Chapter 2

Basic Structure of Computer

2.1 Basic Functional Units



2.1.1 Memory Unit

1. Stores programs and data
2. There are two classes of memory storage units:
   (a) Primary/Main Storage
      i. Primary memory is the computer memory that is directly accessible by CPU. It is comprised of DRAM and provides the actual working space to the processor. It holds the data and instructions that the processor is currently working on.
      ii. Fastest programs must be stored in memory while they are being executed.
      iii. Large number of semiconductor storage cells are present.
      iv. Processed in words addresses, to provide easy access to any word value.
   (b) Secondary/Mass Storage
      i. The contents of the secondary memory first get transferred to the primary memory and then are accessed by the processor, this is because the processor does not directly interact with the secondary memory.
      ii. Much larger storage capacity.
      iii. Much cheaper due to less sophisticated storage cells.

2.1.2 Arithmetic and Logical Unit

In computing, an arithmetic logic unit (ALU) is a combinational digital circuit that performs arithmetic and bitwise operations on integer binary numbers. This is in contrast to a floating-point unit (FPU), which operates on floating point numbers. It is a fundamental building block of many types of computing circuits, including the central processing unit (CPU) of computers, FPUs, and graphics processing units (GPUs).
The inputs to an ALU are the data to be operated on, called operands, and a code indicating the operation to be performed; the ALU's output is the result of the performed operation. In many designs, the ALU also has status inputs or outputs, or both, which convey information about a previous operation or the current operation, respectively, between the ALU and external status registers.

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BASIC OPERATION:
STEP 1: loads the operands into memory
STEP 2: fetches them to the processor
STEP 3: performs the operation in ALU
STEP 4: stores the result back inside the memory or may retain it in the processor
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2.1.3 Control Unit

The control unit (CU) is a component of a computer's central processing unit (CPU) that directs the operation of the processor. It tells the computer's memory, arithmetic logic unit and input and output devices how to respond to the instructions that have been sent to the processor.
It directs the operation of the other units by providing timing and control signals. Most computer resources are managed by the CU. It directs the flow of data between the CPU and the other devices. John von Neumann included the control unit as part of the von Neumann architecture. In modern computer designs, the control unit is typically an internal part of the CPU with its overall role and operation unchanged since its introduction.
The CU manages all computer operations. The CU also generates the timing signals that control I/O transactions. Instead of existing independently, it is generally dispersed throughout the machine.

2.1.4 Input Unit

In computing, an input device is a piece of equipment used to provide data and control signals to an information processing system such as a computer or information appliance. Examples of input devices include keyboards, mouse, scanners, cameras, joysticks, and microphones

Example: In keyboard when a key is pressed, the corresponding letter or digit is automatically translated into its corresponding binary code (UNICODE/ASCII) and transmitted over the cable to the memory/processor.

2.1.5 Output Unit

An output device is any piece of computer hardware equipment which converts information into human readable form. They contain the processed results given by the C.P.U. It can be text, graphics, tactile, audio, and video. Some of the output devices are Visual Display Units i.e. a Monitor, Printer graphic Output devices, Plotters, Speakers etc.

2.2 Information Handled by Computer

2.2.1 Instructions/Machine Instructions

- ⋆ Govern the transfer of information within a computer as well as between the computer and its I/O devices
- ⋆ Specify the arithmetic and logic operations to be performed
- ⋆ Program is a list of instruction that perform a task
- ⋆ Data used as operands by the instructions source program
- ⋆ Encoded in binary code: 0 and 1

2.2.2 Data

- ⋆ Data is to be processed
- ⋆ Compilation of high level language source program in to list of machine instruction (object program)
- ⋆ Information challenged by computer must encoded in suitable form
- ⋆ Each number, character or instruction is encoded as a string of binary digits called bits i.e. (0 or 1)

2.2.3 Basic Operation of a Computer

The basic operations performed by a computer are arithmetic operations, logical operations and storage and relative functions. Basically computer does 5 basic operations that are input, output, process, storing and controlling.
Input is basically taking data from the user, processing is transferring that data into useful information, then that information needs to be stored and controlled and finally output is give to user.

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EXAMPLE OPERATION:
STEP 1: accept an information in the form of program/data through an input unit
STEP 2: store it in the memory
STEP 3: fetch the information stored in the memory, under  program control, into an ALU
STEP 4: where the ALU processes the information
STEP 5: output the processed information through an output  unit
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