Sri SAI RAM ENGINEERING COLLEGE
INSTITUTE OF TECHNOLOGY
West Tambaram, Chennai - 44

Sairam INSTITUTIONS

SAIRAM DIGITAL RESOURCES

YEAR III SEM V

EC8552

COMPUTER ARCHITECTURE AND ORGANIZATION

COMPUTER ORGANIZATION & INSTRUCTIONS

Basics of Computer System

- Evolution
- Computer Architecture Definition
- Components of computer
- Basic Terms

ELECTRONICS & COMMUNICATION ENGINEERING

NBA NAAC (A+) nirf

What is Computer Architecture?

Set of rules and methods that describe the functionality, organization and implementation of computer systems

- **Structure:** Static arrangement of the parts
- **Organization:** Dynamic interaction of the parts and their control
- **Implementation:** Design of specific building blocks

Computers have become part and parcel of our lives.

- They are everywhere.
  Eg: Laptops, tablets, mobile phones, intelligent appliances.
- It is required to understand how a computer works.
- What are there inside a computer?
- How does it work?

Computer Organization

- Design of the components and functional blocks using which computer systems are built.
  Analogy: civil engineer's task during building construction (cement, bricks, iron rods, and other building materials).

Computer Architecture

- How to integrate the components to build a computer system to achieve a desired level of performance.
  Analogy: Architect's task during the planning of a building

- PC
- WorkStations
- Minicomputer
- Microcomputer
- Main Frame
- Super Computer

EVOLUTION OF COMPUTERS

- First Generation Computers
- Second Generation Computers
- Third Generation Computers
- Fourth Generation Computers
- Fifth Generation Computers

First Generation Computers(1945-54) (Vaccum Tube Based)

- Mechanical Calculator - Blaise Pascal-16th Century
- Charles Babbage's Analytical Engine-19th Century
  - 8000 Parts
  - 5 Tons
  - 11 Feet

ENIAC-Presper Eckert and William Mauchly-University of Pennsylvania

Vaccum Tube

18,000 Vaccum tubes,30 Tons, 30*50 Feet

- HARVARD MARK -I -1944
- UNIVAC(Universal Automatic Computer)
- EDVAC(Electronic Discrete Variable Automatic Computer)

Second Generation Computers(1959-65) (Transistor Based)

- Transistors-Bell Labs-1947
- Magnetic Core -Primary Memory
- Magnetic Disk-Secondary Storage Device
- FORTRAN,COBOL were Introduced

Features

- Small Size,Reliable
- Less Heat,Less Electricity
- Faster,Supported M/C and Assembly Languages
  - IBM 1620,IBM 360,IBM 7094..

Third Generation Computers(1965-74) (IC Based)

- Integrated Circuits - Jack Kilby
- Remote Sharing,Multiprogramming Operating System,Time Sharing were Introduced
- FORTRAN II,COBOL,PASCAL were Introduced

Features

- Small Size,IC used
- Less Heat,Less Electricity
- Faster,Supported High Level Languages
    - IBM 360 series,Honeywell 6000 series,IBM 370/168

Fourth Generation Computers(1971 - 80) (VLSI Based)

- VLSI Circuits
- Real time Networks,Distributed Operating System were used
- First Apple computer-Steve Jobs-1976
- Microprocessors were introduced.
- C,C++,DBASE were Introduced

Features

- Very Cheap,Reliable,Portable
- Pipelining Processing were introduced
- Concept of Internet were introduced
  - **DEC 10,STAR 1000,CRAY 1,CRAY X,APPLE MACINTOSH**

Fifth Generation Computers(1980 - till date) (ULSI Based)

- ULSI,Sophisticated and Modern
- Parallel Processing, Artificial Intelligence S/W
- C,C++,JAVE,.NET are used

Features

- User Friendly,Very powerful,Compact size
- Parallel processing
- Concept of Internet were introduced
  - laptop,ultra book,note book computers

Classification in Computer Architecture

- Based on Program and Data storage
  - a) Von-Neumann architecture
  - b) Harvard architecture

- Based on Instruction Set Architecture
  - a)RISC- Reduced Instruction Set Architecture
  - b)CISC-Complex Instruction Set Architecture

• How is a computer different from a calculator?
  – They have similar circuitry inside (e.g. for doing arithmetic).
  – In a calculator, user has to interactively give the sequence of commands

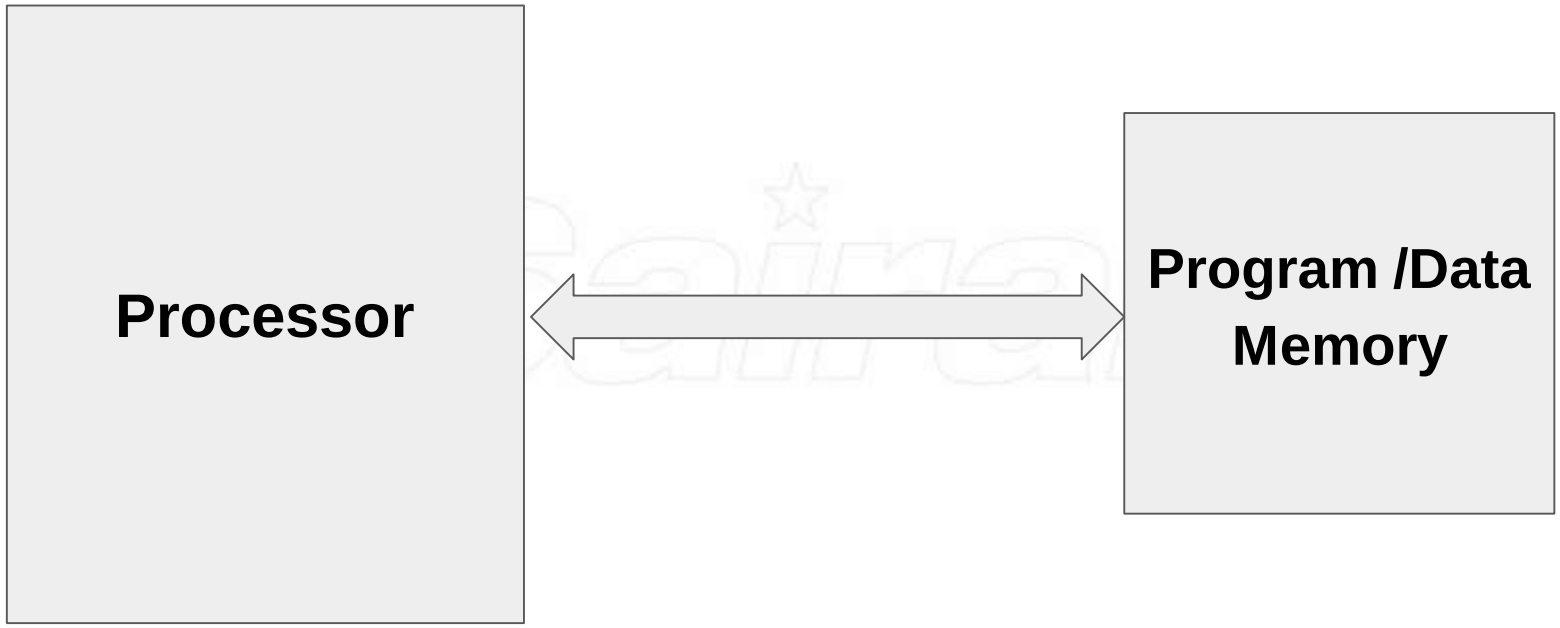
Von-Neumann Architecture
(Princeton Architecture)

- Instructions and data are stored in the same memory module.
- More flexible and easier to implement.
- Suitable for most of the general purpose processors.

General Disadvantage:

- The processor-memory bus acts as the bottleneck
- All instructions and data are moved back and forth through the common bus.

Von-Neumann Architecture



Harvard Architecture

- **Separate memory for program and data.**

  Instructions are stored in program memory and Data are stored in data memory.

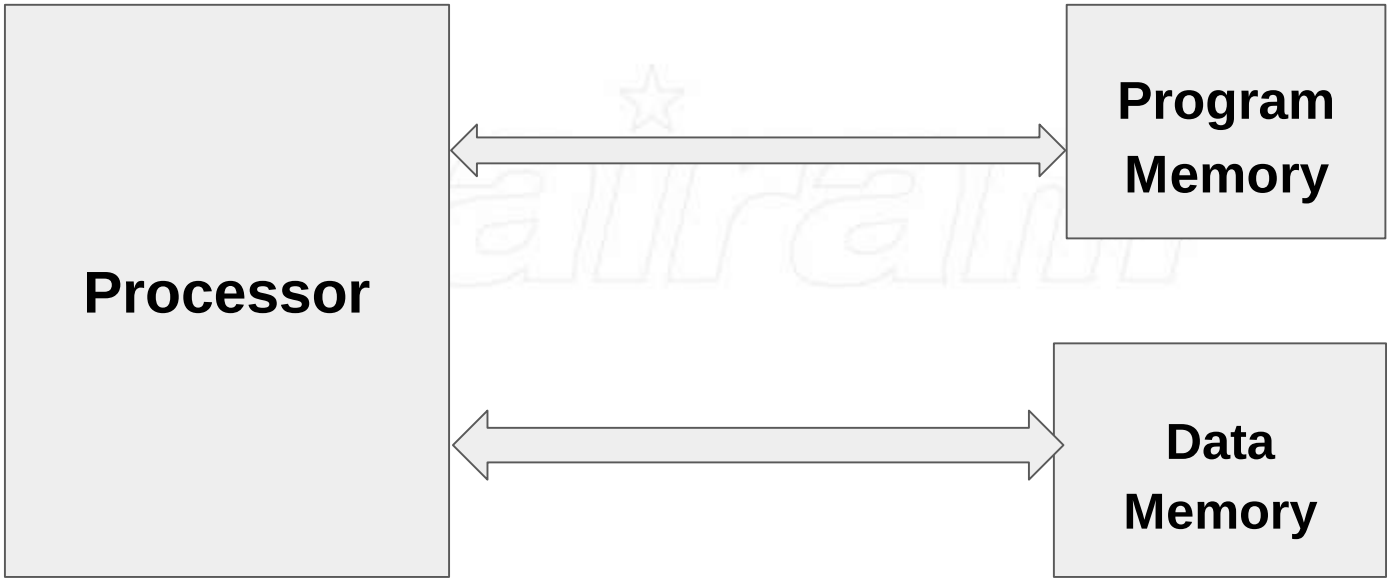
Advantages

- Instruction and data accesses can be done in parallel.
- Some microcontrollers and pipelines with separate instruction and data caches follow this concept.

Disadvantages

- The processor-memory bottleneck remains

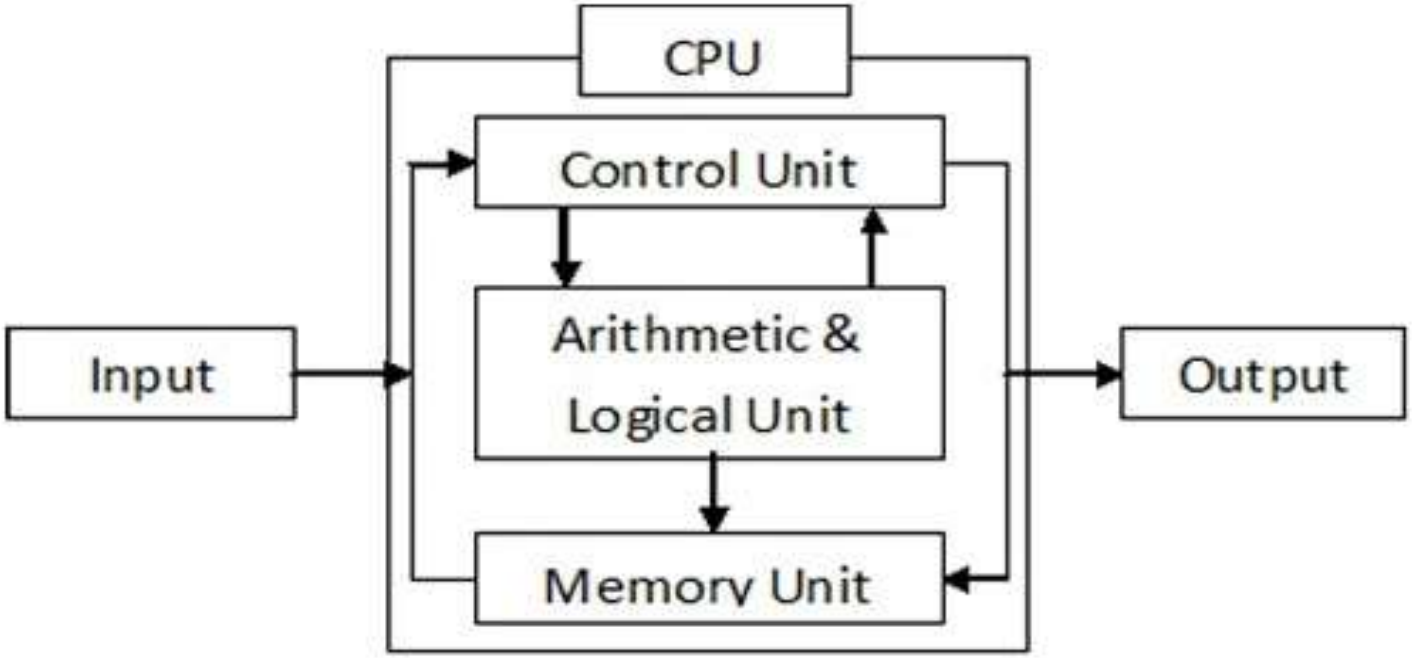
Harvard Architecture



Von-Neumann	Harvard
Single memory to be shared by both code and data	Separate memories for code and data.
Processor needs to fetch code in a separate clock cycle and data in another clock cycle. So it requires two clock cycles.	Single clock cycle is sufficient, as separate buses are used to access code and data.
Higher speed, thus less time consuming.	Slower in speed, thus more time-consuming.
Simple in design.	Complex in design.

CISC	RISC
Larger set of instructions. Easy to program	Smaller set of Instructions. Difficult to program
Simpler design of compiler, considering larger set of instructions.	Complex design of compiler.
Many addressing modes causing complex instruction formats.	Few addressing modes, fix instruction format.
Emphasis is on hardware.	Emphasis is on software.
Pipelining is not possible.	Pipelining of instructions is possible, considering single clock cycle.
Memory-to-memory: "LOAD" and "STORE" incorporated in instructions	Register to register: "LOAD" and "STORE" are independent instructions

Components of a Computer



Components of a Computer System

- **Central Processing Unit (CPU)**.
  Control Unit
  Arithmetic Logic Unit (ALU)

- All instructions and data are stored in **memory.**

- An instruction and the required data are brought into the **processor** for execution.

- **Input and Output devices** interface with the outside world.

Inside the Processor

- All calculations happen inside the ALU.
- The Control Unit generates sequence of control signals to carry out all operations.
- The processor fetches an instruction from memory for execution.
- An instruction specifies the exact operation to be carried out.
- It also specifies the data that are to be operated on.
- A program refers to a set of instructions that are required to carry out some specific task (e.g. sorting a set of numbers)..

What is the role of ALU?

- It contains several registers, some general-purpose and some special purpose, for temporary storage of data.

Arithmetic Section

It contains circuitry to carry out arithmetic operations like addition,subtraction, multiplication, division, etc.

Logic Section

It contains circuitry to carry out logic operations, Comparing,Selecting,Matching and merging of data like AND, OR, NOT, shift, compare, etc.

- During instruction execution, the data (operands) are brought in and stored in some registers, the desired operation carried out, and the result stored back in some register or memory

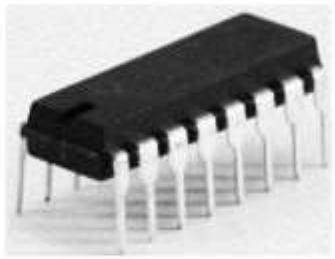
What is the role of control unit?

- Acts as the nerve center that senses the states of various functional units and sends control signals to control their states.
- To carry out a specific operation (say, R1 = R2 + R3), the control unit must generate control signals in a specific sequence.
    - Enable th intputs of registers R2 and R3.
    - Select the addition operation.
    - Store the output of the adder circuit into register R1.
    - When an instruction is fetched from memory, the operation (called opcode) is decoded by the control unit, and the control signals issued.

Types of Memory

- **CACHE MEMORY**
- **MAIN MEMORY**
  - **RAM**
    - SRAM
    - DRAM
  - **ROM**
    - PROM
    - EPROM
    - EEPROM
- **SECONDARY MEMORY**
- **FLASH MEMORY**

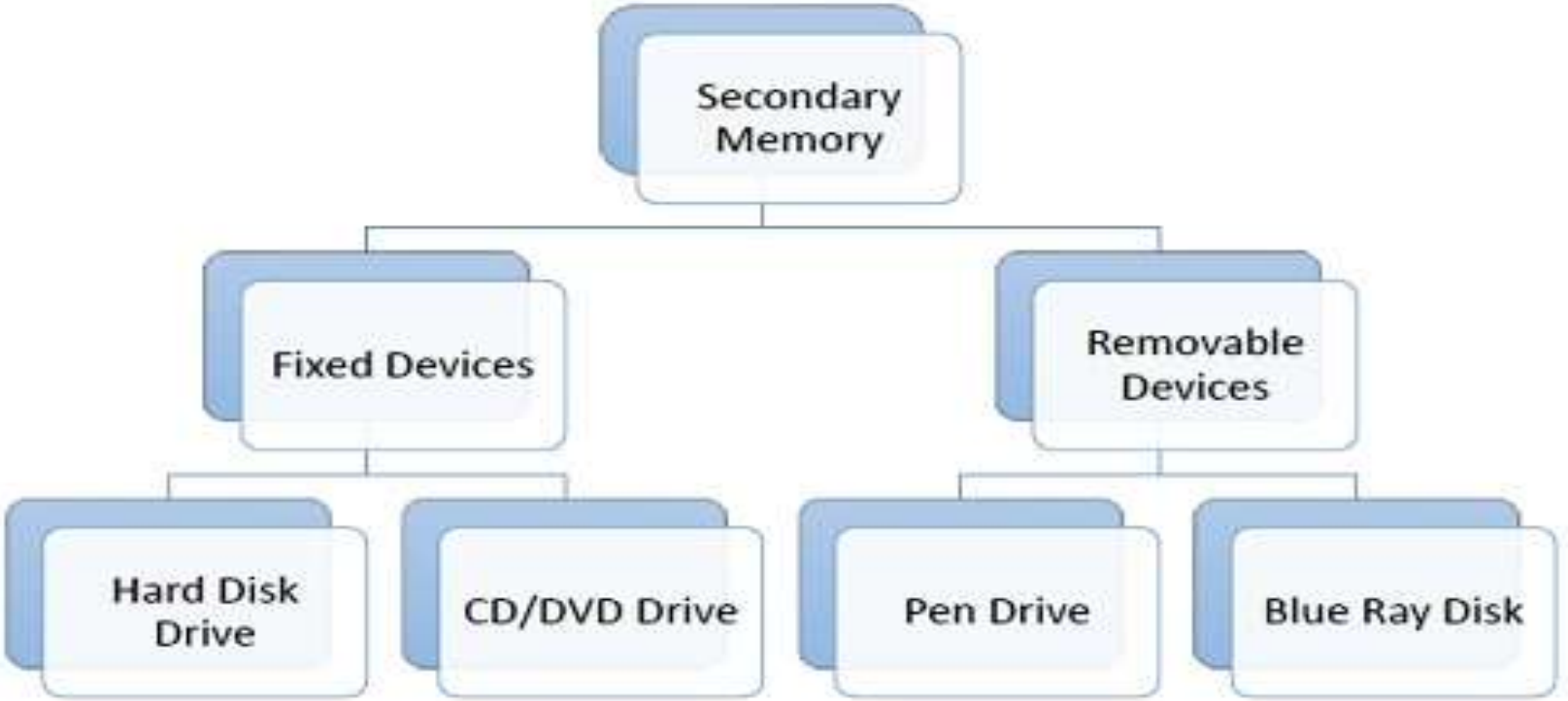
Vs



EPROM
Erasable Programmable Read-Only Memory

EEPROM
Electrically Erasable Programmable Read-Only Memory

Secondary Memory




Flash


Floppy Disk


Zip Disk


CD + RW


CD + R


DVD + RW


DVD + R


Storage Tape


Smart Media


Removable Hard – Drive

Micro Drive


Memory Stick

Secondary Storage Devices


Smart Cards


Online Storage Site


PC Card

EC8552

Types of Memory ...contd

• **Primary or Main memory**, stores the active instructions and data for the program being executed on the processor.

• **Secondary memory,** used as a backup and stores all active and inactive programs and data, typically as files.

- The processor only has direct access to the primary memory.
- In reality, the memory system is implemented as a hierarchy of several levels.
- Objective is to provide faster memory access at affordable cost

Memory Unit

- Bit-0 or 1
- Nibble- 4 bits
- Byte-8 bits
- Word- 32 bits(In General)
- ½ word-16bits
- Double word- 64 bits
- Kilo byte-1024 Bytes
- Mega byte-1024 KB
- Giga bytes-1024 MB
- Tera byte-1024 GB
- Peta byte-1024 TB

Input Unit

- Used to feed data to the computer system from the external environment.
- Data are transferred to the processor/memory appropriate encoding.

Common input devices

- Keyboard
- Mouse
- Joystick
- Camera
- Scanner

Input Devices

Output Unit

- Used to send the result of some computation to the outside world.

Common output devices

- LCD/LED screen
- Printer and Plotter
- Speaker / Buzzer
- Projection system

Output Devices

Basic Terms

- **System Software:** Software that provides services that are commonly useful, including operating systems, compilers, loaders and assemblers.
- **Operating System:** Supervising Program that manages the resources of a computer for the benefit of the programs that run on that computer.
- **Compiler:** A Program that translates high-level language statements into assembly language statements.
- **Binary digit** :Also called a **bit**. One of the two numbers in base 2 (0 or 1) that are the components of information.
- **Instruction :** A command that computer hardware understands and obeys.
- **Assembler :** A program that translates a symbolic version of instructions(Assembly language program) into the binary version.
- **Assembly language:** A symbolic representation of machine instructions. Instructions are written using Mnemonics.
- **Machine language:** A binary representation of machine instructions.

Basic Terms ...contd

- **High level Programming Language:** A portable language such as C, C++, Java or Visual Basic that is composed of words and algebraic notation that can be translated by a compiler into assembly language.
- **Input Device :** A mechanism through which the computer is fed information, such as a keyboard.
- **Output device:** A mechanism that conveys the result of a computation to a user, such as a display, or to another computer.
- **Liquid crystal display:** A display technology using a thin layer of liquid
- polymers that can be used to transmit or block light according to whether a charge is applied.
- **Active matrix display:** A liquid crystal display using a transistor to control the transmission of light at each individual pixel.
- **Pixel :**The smallest individual picture element. Screens are composed of hundreds of thousands to millions of pixels, organized in a matrix.

Basic Terms ...contd

- **Flash memory:** A nonvolatile semiconductor memory. It is cheaper and slower than DRAM but more expensive per bit and faster than magnetic disks.

- Access times are about 5 to 50 microseconds and cost per gigabyte in 2012 was $0.75 to $1.00.

- **Local area network (LAN) :**A network designed to carry data within a geographically confined area, typically within a single building.

- **Wide area network(WAN):** A network extended over hundreds of kilometers that can span a continent.

Basic Terms ...contd

- **Integrated circuit:** Also called a **chip.** A device combining dozens to millions of transistors.
- **Central processor unit(CPU) :**Also called processor. The active part of the computer, which contains the datapath and control and which adds numbers, tests numbers, signals I/O devices to activate, and so on.
- **Datapath:** The component of the processor that performs arithmetic operations.
- **Control :**The component of the processor that commands the datapath, memory, and I/O devices according to the instructions of the program.
- **Memory:** The storage area in which programs are kept when they are running and that contains the data needed by the running programs.
- **Dynamic random access memory (DRAM):** Memory built as an integrated circuit; it provides random access to any location. Access times are 50 nanoseconds and cost per gigabyte in 2012 was $5 to $10.