Computer Architecture Notes

Networks:

Networks consist of number of computers connected to each other so that they may share information and also may share resources such as printers.

Computer Architecture:

The way in which the various components of computer connected to each other is known as computer architecture.

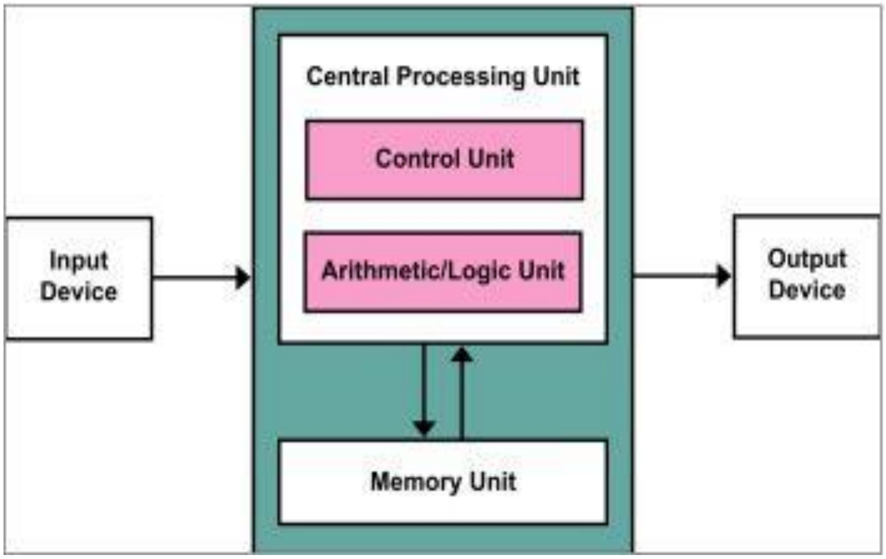
Von Neumann Architecture:

In 1951, Von Neumann and his team proposed a new idea upon which modern general computers are based. The key elements of Von Neumann Architecture are that the data and programs both are stored in main memory.

Logical Units:

The logical units of Von Neumann architecture includes:

- Stored Programs
- CPU
- Memory
- Input and Output Devices.



Hardware:

The physical parts of the computer are known as hardware. It can be touched by us. Computer cannot perform any task without hardware. It can be replaced. It is not effected by computer viruses.

Software:

The set of programs that enables the computer to perform specific task is known as software. It cannot be touched by us. Software is not executed without hardware. It can be reinstalled. It is affected by computer viruses.

Types of Hardware:

1. Memory:

- The data stored in a memory cell are called the **contents** of the cell.
- The ability to store programs as well as data is called the **stored program concept.**
- All the program's instructions must be stored in main memory before they can be executed.
- We can change the computer's operation by storing a different program in memory.
- Each value in memory is represented by a particular pattern of 0's and 1's.

Types of Memory:

I. RAM:

It stands for Random Access Memory. It is volatile memory. It is also known as temporary memory. It means all the data stored in RAM will be automatically lost, when power is witched off.

II. ROM:

It stands for Read Only Memory. It is not volatile memory. It is also known as permanent memory. It means all the data stored in RAM will be stored permanently.

2. Secondary Storage Unit:

The units such as disk or flash drives that retrain data even when power to drive is off

Most personal computers used two types of secondary storage devices such as hard drives and optical drives.

3. CPU:

It is the most important part of a computer and it is also known as brain of the computer. It is also known as Processor or Microprocessor. It process or manipulates data according to given instructions and converts them into useful information.

Component of CPU:

CPU has two components:

i. **Arithmetic & Logic Unit (ALU):** It is further divided into two components:

- ❖ Arithmetic Unit (AU): Perform all arithmetic operations such as +, - , / , *, %.
- ❖ Logic Unit (LU): Perform all logical operators such as a>b, 3<4.

ii. **Control Unit (CU):**

- ❖ It controls all activities of computer.
- ❖ It fetches instructions and data from the main memory.
- ❖ Decode instructions.
- ❖ Execute instructions

Types of Software:

1. System Software:

The type of software that is concerned with the computer itself

Operating Software: Software that controls interaction of user and computer hardware and that manages allocation of computer resources.

2. Application software:

The type of software that is developed by the programmer to perform specific task
A computer can on without Application Software.

Firmware:

- It Falls between S/W and H/W
- Firmware consists of programs that are included in electronic circuits during their manufacture. E.G. Embedded systems.

Advantages of Firmware:

- Faster execution time
- Better system security
- Cost reduction in the area of software development.

Clocked Sequential System:

- Computers are clocked sequential system.
- All activities are synchronized with master clock.
- Operation performed in one clock period is called **Micro-Instruction**.
- A program written using such instructions is called **Micro-Program**.
- Control unit is Micro-Programed.

Programming Language:

A set of words, symbols and codes used to write programs.' is called program language Different programming languages are available for writing different types of programs

There are two types of languages

- High level Languages:
- Two Level Languages

Compiler	**Interpreter**
• Compiler convert a computer program into machine code as a whole	• Interpreter convert a program into machine code statement by
• It creates the object code	• It does not create the object code
• It is fast in execution	• It is slow in execution
• It displays syntax error as a whole	• It displays syntax error on every statement

What is an Assembler?

- An assembler is a program that converts assembly language into machine code.
- It takes the basic commands and operations from assembly code and converts them into binary code

When assembly language is used?

- When memory space is critical.
- For short to medium sized programs
- For more control operations than computation

Responsibilities of Control Unit:

CU performs two tasks

1) Instruction Interpretation

Read an instruction and recognizes the instruction operation code, retrieves the required operands or data items and performs the desired operation by activating the ALU. Finally result is routed to the specified destination

2) Instruction Interpretation

The CU determines the address of the next instruction to be executed during instruction sequencing.

Two Exceptional situations

1) **Branch Instruction**
2) **Subroutine Calls**

Subroutine and Branch Instructions:

- For branch instruction, the control unit jumps to an instruction stored in some arbitrary address B as the next instruction to be executed and continues from the jump address. e.g Goto statement
- The CU begins executing a complete program (Sub-program or procedure) starting at some address S for a subroutine call, and it returns to the next instruction after the subroutine-call instruction, when a return instruction is inserted in the body of the subroutine. e.g functions in C++.

Chapter 2:

Registers:

- Registers are important part of any CPU.
- A CPU with many registers reduces the numbers of visits to the main memory.
- Registers simplified programming tasks and reduces execution time.
- CPU registers are classified into two groups
  - General Purpose Registers
  - Dedicated Registers

General Purpose Registers:

General purpose register can be used to store address or data for an indefinite amount of time.

Dedicated Registers:

Dedicated registers are used to perform some specific task for program execution.

1) **Program Counter (PC):** Holds the address of the next instruction to be executed.
2) **Stack Pointer (SP):** Holds the address of the top element of the stack.
3) **Instruction Register (IR):** Holds the instruction code currently being executed.
4) **Memory Address Register:** Holds the address of the data item to be retrieved from the main memory.
5) **Memory Buffer Register:** Holds the data items retrieved from the main memory.
6) **Status Register:** Hold the condition code flags and other information that describes the status of a running program e.g. negative flag, zero flag etc.

All these are called **dedicated registers**, because they are used by control unit and cannot be accessed by user program.

Buses:

Set of wires that connect the various hardware components of the computer system. It is used to send control signals and data between the processor and other components.

Types of Buses:

Three types of buses are used.

1) **Address Bus:**
   It is used to carry memory address from CPU to other components such as primary storage and input/output devices.
   Address Bus is **unidirectional** because the microprocessor is addressing a specific memory location. No outside device can write into the microprocessor.

2) **Data Bus:**
   Data bus is the most common type of bus. It is used to transfer data between the processor and other components.
   Data Bus is **bidirectional** because microprocessor can read data from memory and write data to the memory.

3) **Control Bus:**
   Control bus is used to carry the control signals between the processor and other components.
   Control Bus is **unidirectional** as it carries the signals from CPU to other components for controlling operations.

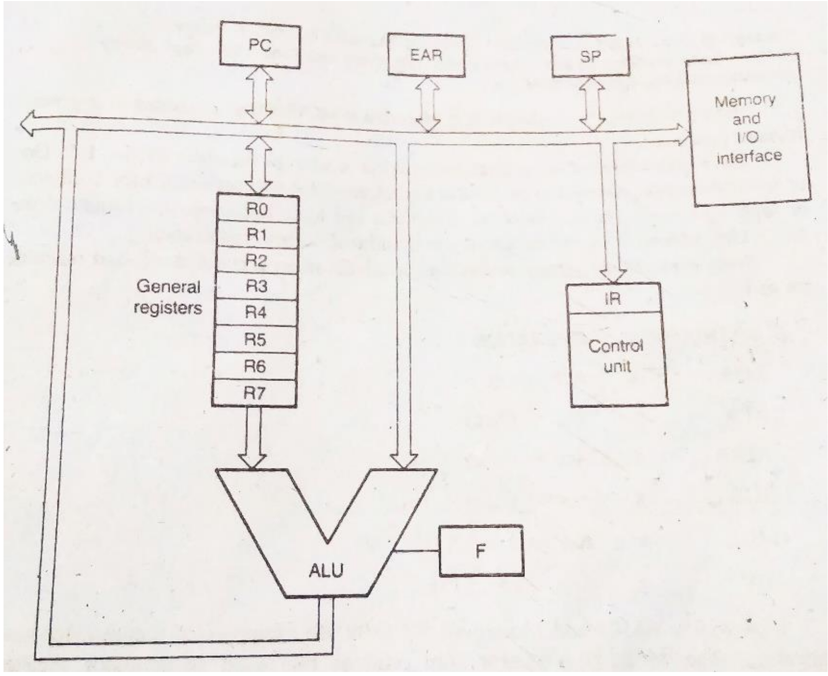
Computer Structures:

Can be classified into three groups

- General Register Machines
- Accumulator Based Machines
- Stack Machines

General Register Machines:

- Eight general registers (R0 to R7)
- Register may hold address, data or result of arithmetic or logical operation.
- **F Register:** Hold status flag like Z- flag and the carry flag. Update after arithmetic or logical operation.
- Z-flag is set to 1 means the last instruction produces a result 0.
- *General Register processor support three and two address instructions*



Two address instructions:

• ADD X,Y,Z	Z←(X) + (Y)
• SUB Y,X,Z	Z←(X) - (Y)
• MUL X,Y,Z	Z←(X) * (Y)
• DIV Y,X,Z	Z←(X) / (Y)

Three address instructions:

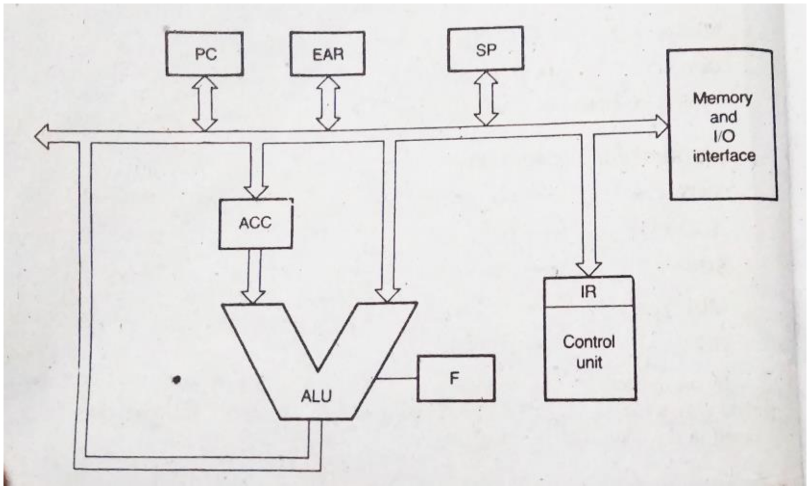
• MOV X, Y	Y←(X)
• ADD X,Y	Y←(X) + (Y)
• SUB Y, X	X←(X) - (Y)
• MUL X,Y	X←(X) * (Y)
• DIV Y,X	X←(X) / (Y)

Accumulator Based Processor:

- One of the operand is assumed to be stored in Accumulator Register.
- *Following are the one address instructions used in accumulator based processor.*

One address instructions:

LDA X	Acc←(X)
STA X	X←(Acc)
ADD X	Acc←(Acc) + (X)
SUB X	Acc←(Acc) - (X)
MUL X	Acc←(Acc) * (X)
DIV X	Acc←(Acc) / (X)



Expression Using Three Addresses, Two Addresses and One Address:

D: = A + B * C

By using three Addresses:

- MUL B,C,D ; D ← (B) * (C)
- ADD A,D,D ; D ← (A) + (D)

By using two Addresses:

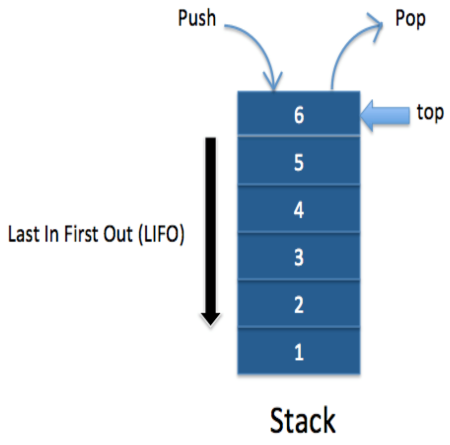
- MOV B,D ; D ← (B)
- MUL C,D ; D ← (C) * (D)
- ADD A,D ; D ← (A) + (D)

By using one Address:

- LDA B ; Acc ← (B)
- MUL C ; Acc ← (Acc) * (C)
- ADD A ; Acc ← (Acc) +(A)
- STA D ; D ← (Acc)

Stack Based Machines/Processor:

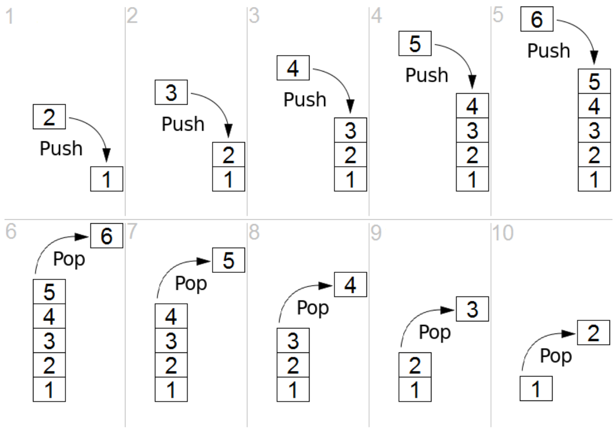
- A stack machine is a computer system in which the primary element of the CPU is a stack.
- Follow LIFO(Last In Last Out) property
- Data is inserted and removed from the same end.



Why Stack is used?

- To implement subroutine calls and returns and to pass parameters from a main program to a subroutine.
- To handle interrupts.
- It may be implemented in hardware or software.
- A hardware stack with a storage capacity of P words can be obtained using P shift registers.
- Stack Manipulation is faster in hardware.

Stack Operation:



PUSH Operation:

PUSH(Writing into the stack)

PUSH <Memory Address>

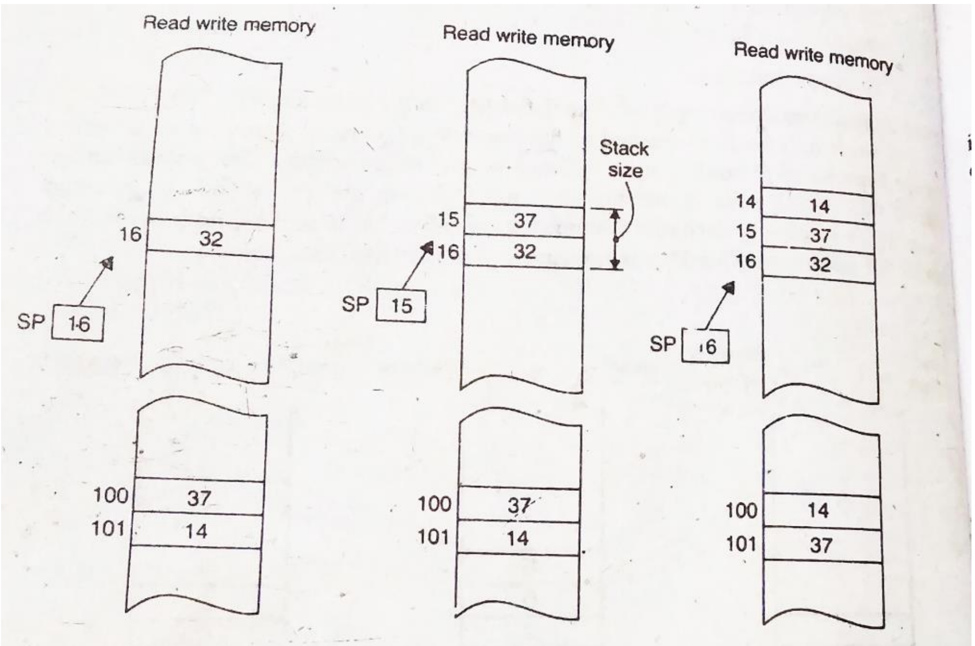
- SP ← SP - 1 (Decrement the SP by 1)
- SP← <Memory Address> (Copy the content of the specified memory address into the location whose address is the current contents of the SP).

POP Operation:

POP(Reading from the stack)

POP <Memory Address>

- <Mem Adr> ← (SP) (Copy the contents of the memory location point to by the SP into the specified memory address)
- SP ← SP + 1



a. Initial Configuration

b. Configuration that Results after Executing the Instruction PUSH 100

c. Configuration that Results after Executing the Sequenc of Instructions PUSH 100
PUSH 101
POP 100
POP 101

Question: SWAP the content (1004 and 1003) of memory using PUSH POP operation of stack.

SP=18	983
SP=19	351
SP=20	40
	Stack

109	1001
404	1002
983	1003
351	1004
Memory	

SOL:

- SP ← SP-1 (SP will be 19)

  PUSH<1004>

- SP ← SP-1 (SP will be 18)

  PUSH<1003>

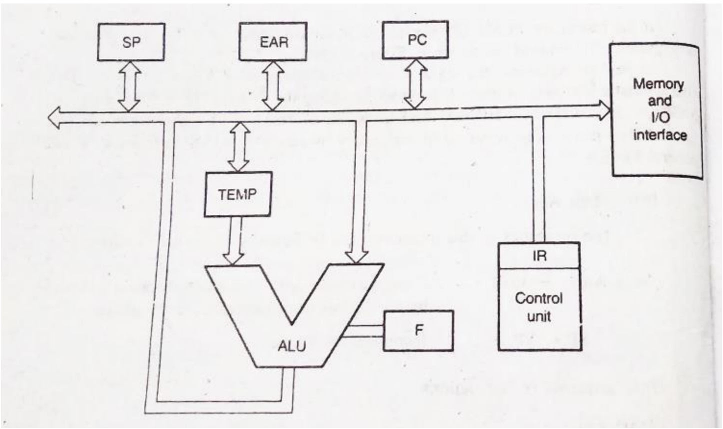
- POP<1004>

  SP ← SP+1 (SP will be 19)

- POP<1003>

  SP ← SP+1 (SP will be 20)

Organization of Stack Machine



D : = A + B * C

- PUSH A
- PUSH B
- PUSH C
- MUL: Calculate B*C
- ADD: Add A to B*C
- POP D: Save Results