SP-2

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# BASIC STRUCTURE OF COMPUTERS

COMPUTER TYPES

○ Computer:

Computer is a fast electronic calculating machine that accepts digitized input information, process it according to a list of internally stored instructions and produce the resulting output information.

○ Based on features (by use) computers are classified into these types:

  ○ Personal Computer
  ○ Notebook Computer
  ○ Workstation
  ○ Enterprise Computer, Servers, Super Computer

FUNCTIONAL UNITS

o Five functionally independent main parts:

Input		Memory	Arithmetic & Logic
output			Control
	I/O		Processor
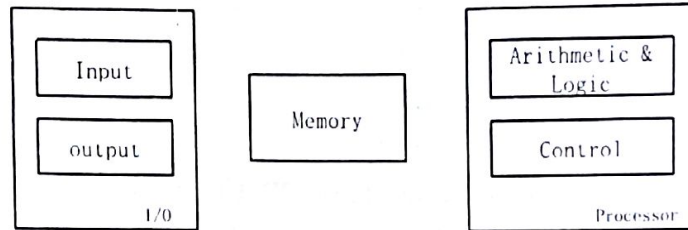
FUNCTIONAL UNITS

o Storage memory are two types:
  o Primary memory
  o Secondary memory

o Primary memory – fast memory, program must be stored while being executed.

o RAM – memory in which any location can be reached in a short and fixed amount of time after specifying its address is called RAM.
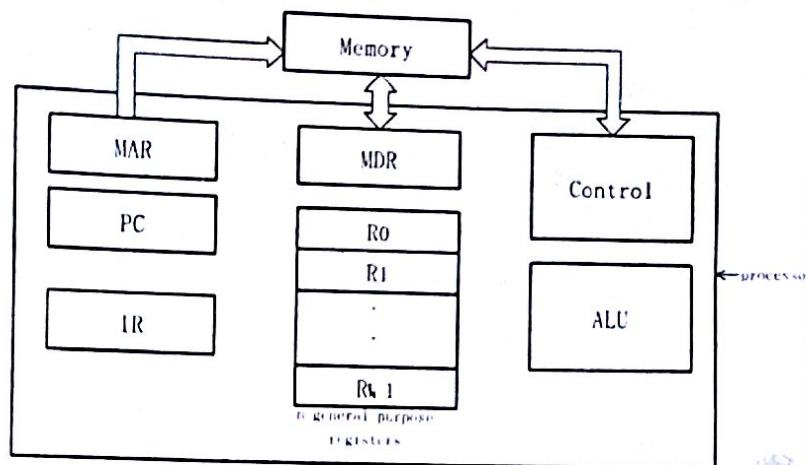
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BASIC OPERATIONAL CONCEPT

```
                    ┌──────────┐
              ┌────▶│  Memory  │◀────┐
              │     └──────────┘     │
              │          ▲▼          │
    ┌─────────┼──────────────────────┼─────────┐
    │   ┌───────────┐  ┌───────────┐  ┌───────────┐ │
    │   │   MAR     │  │   MDR     │  │           │ │
    │   └───────────┘  └───────────┘  │  Control  │ │
    │   ┌───────────┐  ┌───────────┐  └───────────┘ │
    │   │    PC     │  │    R0     │                │
    │   └───────────┘  ├───────────┤  ┌───────────┐ │ ◀── processor
    │                  │    R1     │  │           │ │
    │   ┌───────────┐  │     ·     │  │    ALU    │ │
    │   │    IR     │  │     ·     │  │           │ │
    │   └───────────┘  ├───────────┤  └───────────┘ │
    │                  │   Rn-1    │                │
    │                  └───────────┘                │
    │               n general purpose               │
    │                   registers                   │
    └───────────────────────────────────────────────┘
```

Fig: connection between processor and memory

BASIC OPERATIONAL CONCEPT

- **IR (Instruction Register)** – instructions that are currently being executed are stored here.

- **PC (Program Counter)** – contains the memory address of the next instruction to be fetched and executed.

- **MAR (Memory Address Register)** – holds the address of the location to be accessed.

- **MDR (Memory Data Register)** – contains the data to be written into or read out of the addressed location.

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Basic Operational Concept

o Steps of a basic operation:
1. Program resides in the memory.
2. PC is set to the first instruction.
3. The contents of PC are transferred to MAR.
4. A Read Control signal is sent to the memory.
5. The addressed instruction is read out of the memory and loaded into MDR.
6. Then the contents of MDR is transferred to the IR.
7. If the instruction involves an operation, it is performed by ALU.
8. To load an operand sent its address to MAR.
9. Initiate a read cycle and load operand into MDR.
10. Then the operand is transferred from MDR to ALU.
11. Result is sent to MDR and the address where result should be stored is sent to MAR.
12. A write cycle is initiated and result is stored.

(please read the full concept from book for better understanding)

Bus Structure

o Bus- a group of lines/wires that serves as a connecting path for several devices is called bus. It carries the data. Bits of word are transferred simultaneously.

o Single Bus - only one transfer at a time.

Input	Output	Memory	Processor
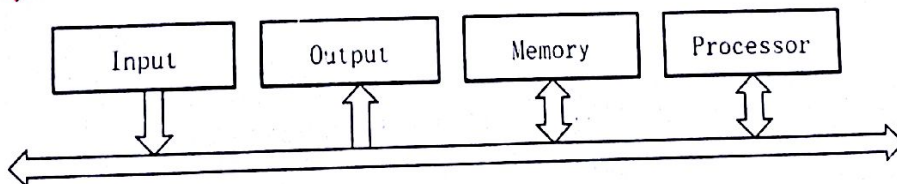
○ System Software- is a collection of programs that are executed as needed to perform functions for user to enter and run application program.

Functions of system software:

- Receiving and interpreting user command.
- Entering and editing application program and storing them in secondary storage.
- Managing the storage and retrieval of files.
- Running standard application programs.
- Controlling I/O units.
- Translating programs from source to machine instruction.
- Linking and running user written program.

⊗ Processor clock: processor circuits are controlled by a timing signal called clock. The clock defines regular time interval called clock cycle.

system software is a type of computer program that is design to run a computer hardware and application program,

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MACHINE INSTRUCTIONS AND PROGRAMS

- Binary number- a number system where base is two.
- Bit- Binary Digit

Consider an n-bit vector

$$B = b_{n-1} \dots b_1 b_0$$

where $b_i = 0$ or 1 for $0 \le i \le n - 1$. This vector can represent unsigned integer values V in the range 0 to $2^n - 1$, where

$$V(B) = b_{n-1} \times 2^{n-1} + \dots + b_1 \times 2^1 + b_0 \times 2^0$$

- There are three methods of representing signed number-
  - Sign and magnitude
  - 1's complement
  - 2's complement

- Subtracting by 1's complement

  M = 84D = 1010100
  N = 68D = 1000100

  M - N:

  ```
      1 0 1 0 1 0 0
    - 0 1 1 1 0 1 1
    1 0 0 0 1 1 1 1
    carry         + 1      (if carry remains add the carry)
    1 0 0 1 0 0 0 0        (carry/overflow ignored)
            16
  ```

  N - M:

  ```
      1 0 0 0 1 0 0
    + 0 1 0 1 0 1 1
      1 1 0 1 1 1 1
  ```

                (no carry.)

  result is negative. So it is converted from 1's complement as - (0010000) = -16

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Subtracting by 2's complement

M = 84D = 1010100

N = 68D = 1000100   2's complement = 0111100

M – N:

```
    1 0 1 0 1 0 0
  + 0 1 1 1 1 0 0
  ─────────────────
  1 0 0 1 0 0 0 0   (carry/overflow ignored)
carry      16
```

N – M:

```
    1 0 0 0 1 0 0
  + 0 1 0 1 1 0 0
  ─────────────────
    1 1 1 0 0 0 0
```
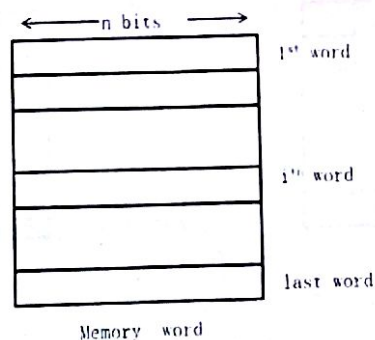
(no carry.)

result is negative. So it is converted from 2's complement as –(001000) = –16

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o Memory Location and Address:

o <mark>Word– a group of storage cell which act a unit.</mark>

  • <mark>In a 32-bit computer a sign word can store 32bit 2's complement or 4 ASCII characters.</mark>

Memory word

Byte Addressability:

It is impractical to assign distinct addresses to individual bit location in the memory. The most practical assignment is to have successive addresses refer to successive byte location in the memory. This is known as byte addressable memory.

There are two ways that byte addresses can be assigned across words.

- **Big Endian assignment:** - when lower byte addresses are fixed for the more significant bytes.
- **Little Endian assignment:** - when lower byte addresses are fixed for the less significant bytes.

Word Address	Byte address			
0	0	1	2	3
1	4	5	6	7
2^k-4	2^k-4	2^k-3	2^k-2	2^k-1

Big endian assignment

Word Address	Byte address			
0	3	2	1	0
1	7	6	5	4
2^k-4	2^k-1	2^k-2	2^k-3	2^k-4

Little endian assignment

When processor is in arm mode then instruction are word aligned and it is in thumb mode instruction are half word aligned.

○ **Word Alignment:**

• Words are said to be aligned in memory if they begin at a byte address. i.e multiple of the number of byte in a word. Otherwise it is called unaligned addresses.

  ○ For a 32-bit computer word addresses are 0, 4, 8 . . .

Memory Operation:

• Two basic memory operation—

  • Load (read/fetch) – the load operation transfers a copy of the contents of specific memory location to the processor. The memory contents remain unchanged. → Returns value without changing the value stored at that address

  • Store (write) – the store operation transfers an item → Writes new value into the cell at given address. of information from the processor to a specific memory location, destroying the former contents of that location.

Instructions and instruction sequence:

4 types of instruction:

  • Data transfer between the memory and processor register.
  ○ Arithmetic and logic operation on data.
  ○ Program sequencing and control.
  ○ I/O transfer.

Register Transfer Notation (RTN):

• Most of the time we identify a location by a symbolic name.

  ○ Example of memory address   LOC, PLACE, A, VAR2
  ○ Processor register names R0, R5
  ○ I/O register names DATAIN, OUTSTATUS

R1 <- [LOC]
R3 <- [R1] + [R2]