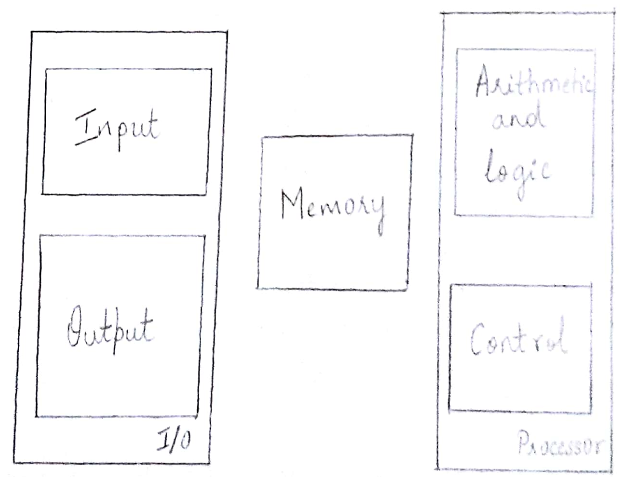
Functional Units:

A computer consists of 5 functionally independent main parts: input, memory, arithmetic and logic, output and control units.

The input unit accepts coded information from human operators, from electromechanical devices such as keyboards, or from other computers over digital communication lines. The information recieved is either stored in the computer's memory for later reference or immediatly used by the arithmetic and logic circuitry to perform the desired operations. The processing steps are determined by a program stored in the memory. Finally, the results are sent back to the outside world through the output unit. All of these actions are coordinated by the control unit.



3. ... and Logic Unit: ... executed in

1. Input Unit

Computers accept coded information through input units, which read the data. The most well-known input device is the keyboard. Whenever a key is pressed the corresponding letter or digit is automatically translated into its corresponding binary code and transmitted over a cable to either the memory or the processor.

Many other kinds of input devices are available including joysticks, trackballs and mouses.

2. Memory unit:

The function of the memory unit is to store programs and data. There are two classes of storage, called primary and secondary.

Primary storage is a fast memory that operates at electronic speeds. Programs must be stored in the memory while they are being executed. Instructions and data can be written ~~or~~ into the memory or read out under the control of the processor. Memory in which any location can be reached in a short and fixed amount of time after specifying its address is called random-access memory (RAM). The time required to access one word is called the memory access time.

Although primary storage is essential, it tends to be expensive. Thus additional cheaper, secondary storage is used when large amounts of data and many programs have to be stored. Examples for secondary storage: CD-ROM's, Pendrive, etc.

3. Arithmetic and Logic Unit:

Most computer's operations are executed in the arithmetic and logic unit (ALU) of the processor.

Any arithmetic or logic operation, like division, multiplication or comparison of numbers, is initiated by bringing the required operands into the processor, where the operation is performed by the ALU. When operands are brought into the processor, they are stored in high-speed storage elements called registers. The control and the arithmetic and logic units are many times faster than other devices connected to a computer system. This enables a single processor to control a number of external devices

4. Output Unit:

Its function is to send processed results to the outside world. Printer is the most familiar example of such a device. Most computer data output that is meant for humans is in the form of audio or video.
Ex: monitors, speaker, projectors, etc.

To perform a given task, an appropriate program consisting of

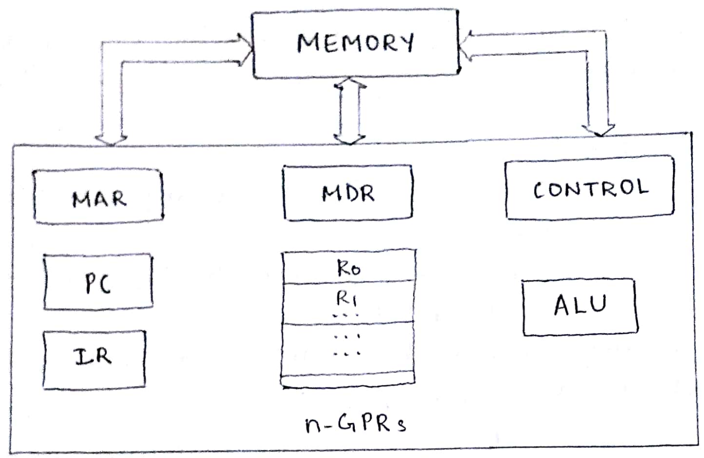
5. Control Unit:

The memory, arithmetic and logic, and input and output units store and process information and perform input and output operations. The operation of these units must be coordinated in some way. This is the task of the control unit. The control unit is effectively the nerve center that sends control signals to other units and senses their states.

Data transfers between the processor and the memory are also controlled by the control unit through timing signals. The actual timing signals that govern the transfers are generated by the control circuits. Timing signals are signals that determine when a given action is to take place.

BASIC OPERATIONAL CONCEPTS OF A COMPUTER

To perform a given task, an appropriate program consisting of a list of instructions is stored in the memory. Individual instructions are brought from the memory into the processor, which executes the specified operations. Data to be stored are also stored in the memory.



CONNECTIONS BETWEEN PROCESSOR & THE MEMORY

The figure shows how memory and the processor can be connected. In addition to the ALU and the control circuitry, the processor contains a number of registers used for several different purposes.

THE INSTRUCTION REGISTER (IR):

Holds the instructions that is currently being executed. Its output is available for the control circuits which generate the timing signals that control the various processing elements in one execution of instruction.

THE PROGRAM COUNTER (PC):

This specialized register keeps track of execution of a program. It contains the memory address of the next instruction to be fetched and executed.

Besides IR and PC, there are n-general purpose registers R_0 through R_{n-1}.

The other two registers which facilitate communication with the memory are:

- MAR (MEMORY ADDRESS REGISTER):
  It holds the address of the location to be accessed.
- MDR (MEMORY DATA REGISTER):
  It contains the data to be written into or read out of the address location.

The operating steps are:

- Programs reside in the memory and usually get these through the I/p unit.
- Execution of the program starts when the PC is set to point at the first instruction of the program.
- Contents of PC are transferred to MAR and a Read control signal is sent to the memory.
- After the time required to access the memory elapses, the address word is read out of the memory and loaded into the MDR.
- Now contents of MDR are transferred to the IR and now the instruction is ready to be decoded and executed.
- If the instruction involves an operation by the ALU, it is necessary to obtain the required operands.
- An operand in the memory is fetched by sending its address to MAR and initiating a read cycle.
- When the operand has been read from the memory to the MDR it is transferred from MDR to the ALU.
- After one or two such repeated cycles, the ALU can perform the desired operation.
- If the result of this operation is to be stored in the memory, the result is sent to MDR.
  Address of location where the result is stored is sent to MAR and a write cycle is initiated.

- The contents of PC are incremented so that PC points to the next instruction that is to be executed.

Normal execution of a program may be temporarily interrupted if some devices require urgent servicing, to do this, one device raises an Interrupt signal.

An interrupt is a request signal from an I/O device for service by the processor. The processor provides the requested service by executing an appropriate interrupt service routine.

The diversion may change the internal stage of the processor. Its state must be saved in the memory location before interruption. When the interrupt - routine service is completed, the state of the processor is restored so that the interrupted program may continue.

BUS STRUCTURES

A Group of lines that serves as a connecting path for several devices is called a bus.

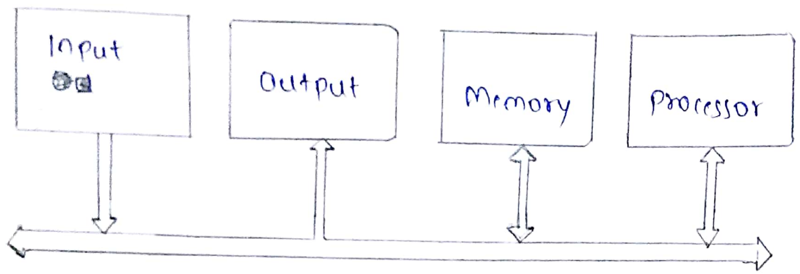


fig: Single-bus structure

The simple way to interconnect functional units is to use a single bus, as shown in fig. All units are connected to this bus. Because the bus can be used for only one transfer at a time, only two units can actively use the bus at any given time. Bus control lines are used to arbitrate multiple requests for use of the bus. The main virtue of the single bus structure is its low cost and its flexibility for attaching peripheral devices. Systems that contain multiple buses achieve more concurrency in operations by allowing two or more transfers carried out at the same time.

The devices which is connected to bus ~~like~~ such as keyboards and printers are relatively slow in operation, others like magnetic or optical disks are considerably fast. Memory and processors units operate at electronic speeds, making them the fastest parts of a computer, therefore an efficient

PERFORMANCE: ... of a computer s

transfering is not happen among processors, memories and external devices. To solve this buffer registers helps to hold the information. The let us take ex than processor sends the character over the bus to the printer buffer, once buffer loaded it starts printing. The bus and processor are no longer needed and can be released for other activity.

PERFORMANCE:

The most important measure of performance of a computer is how quickly it can execute programs. The speed with which a computer execute programs is affected by the design of its hardware and its machine language instructions.

For best performance, it is necessary to design the compiler, the machine instruction set, and the hardware in a coordinated way.

1. PROCESSOR CLOCK:-

Processor circuits are controlled by a timing signal called a clock. The clock defines regular time intervals, called clock cycles.

To execute a machine instruction, the processor divides the action to be performed into a sequence of basic steps, such that each step can be completed in one clock steps.

2. BASIC PERFORMANCE EQUATION:-

Basic performance equation is given by,

$$T = \frac{N \times S}{R}$$

Where $T \rightarrow$ Processor time required to execute a program.

$N \rightarrow$ Actual number of instructions to be executed.

$S \rightarrow$ Average number of basic steps needed to execute

$R \rightarrow$ Clock rate.

Performance can be increased by decreasing the value of T. which can be done by reducing N and S and by increasing the value of R.

CISC - Complex Instruction Set Regs Computer

3. PIPELINING AND SUPERSCALAR OPERATION:

A substantial improvement in performance can be achieved by overlapping the execution of successive instructions, using a technique called pipelining.

A higher degree of concurrancy can be achieved if multiple instruction pipelines are implemented in the processor. This means that multiple functional units are used creating parallel paths through which different instructions can be executed in parallel. With such an arrangement, it becomes possible to start the execution of several instructions in every clock cycle. This mode of operation is called superscalar execution.

4. CLOCK RATE:

Clock Rate is number of cycles per second.

There are two possibilities for increasing the clock rate,

* By improving the integrated-circuit technology makes logic circuits faster, which reduces the time needed to complete a basic step. This allows clock period to increase and clock rate to decrease.
* Reducing the amount of processing done in one basic step also makes it possible to reduce the clock period

5. INSTRUCTION SET : CISC , RISC:-

RISC - Reduced Instruction Set Computers.

It is a central processiong unit design strategy based on the vision that basic instruction set gives a great performance when combined with a microprocessor which has the capacity to perform the instructions by using some microprocessor cycles per instruction.

CISC - Complex Instruction Set ~~Reg~~ Computer

It has the capacity to perform multistep operations or addressing modes within one instruction set.
It is the CPU design where one instructions works several low level acts like memory storage, loading from memory, arithmetic operation.

6. COMPILER:-

A compiler translates a high-level language program into a sequence of machine instructions.

The number of cycles is dependent not only on the choice of instructions. The compiler may rearrange program instructions to achieve better performance. But such changes must not affect the result of the computation.

7. PERFORMANCE MEASUREMENT:-

Performance measurement is given by SPEC rating.
[SPEC - System Performance Evaluation Corporation].

$$\text{SPEC Rating} = \frac{\text{Running time on the reference computer}}{\text{Running time on the computer under test}}$$

$$\text{SPEC rating} = \left(\prod_{i=1}^{n} \text{SPEC}_i\right)^{1/n}$$

where $n \rightarrow$ Number of programs in the suite.

SPEC rating is a measure of the compined effect of all factors affecting performance, including the compiler, the operating system, the processor, and the memory of the computer being tested.