ADVANCED COMPUTER ARCHITECTURE

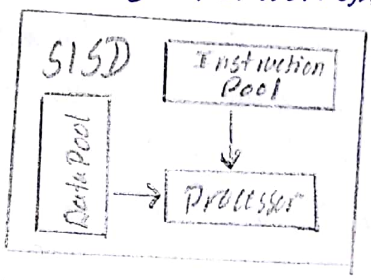
① Flynn's Classification of Computer Architecture

→ In 1966, Michael Flynn proposed a classification for computer architectures based on the number of instruction steams and data streams (Flynn's Taxonomy).
→ Flynn uses the stream concept for describing a machine's structure.
→ A stream simply means a sequence of items (data or instructions).
→ The classification of computer architectures based on the number of instruction steams and data streams (Flynn's Taxonomy).

Flynn's Taxonomy

1. Single-instruction, single-data (SISD) systems –

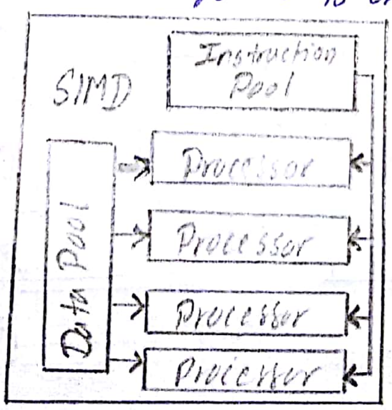
An SISD computing system is a uniprocessor machine which is capable of executing a single instruction, operating on single data stream. In SISD, machine instructions are processed in sequential manner and computers adopting this model are popularly called sequential computers. Most conventional computers have SISD architecture. All the instructions and data to be processed have to be stored in primary memory. The speed of the processing element in the SISD model is limited (dependent) by the rate at which the computer can transfer information internally. Dominant representative SISD systems are IBM PC, workstations.



2. Single-instruction, multiple-data (SIMD) systems –

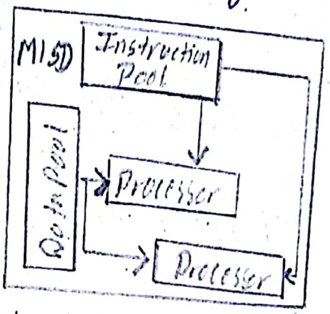
An SIMD system is a multiprocessor machine capable of executing the same instruction on all the CPUs but operating on different data streams. Machines based on an SIMD model are well suited to scientific computing since they involve lots of vector and matrix operations. So that the information can be passed to all the processing elements (PEs) organised data elements of vectors can be divided into multiple sets (N-sets for N PE systems) and each PE can process on data set.

Dominant representative SIMD systems is Cray's vector processing machine.



3. Multiple-instruction, single data (MISD) Systems-

An MISD computing system is a multiprocessor machine capable of executing different instructions on different PEs but all of them operating on same dataset.
The system performs different operations on the same data set. Machines built using the MISD model are not useful in most of the application, a few machines are built, but none of them are available commercially.

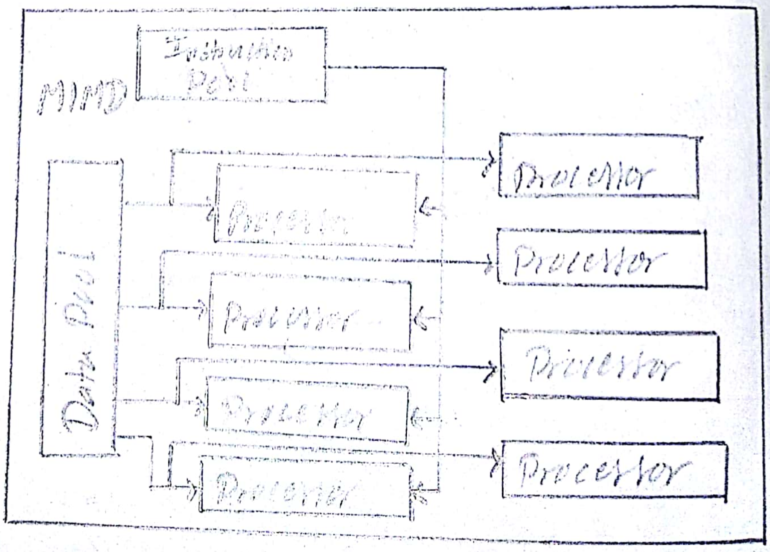


4. Multiple-instruction, multiple-data (MIMD) Systems

An MIMD system is a multiprocessor machine which is capable of executing multiple instructions on multiple data sets. Each PE in the MIMD model has separate instruction and data streams; therefore machines built using this model are capable to any kind of application. Unlike SIMD and MISD machines, PEs in MIMD machines work asynchronous.
MIMD machines are broadly categorised into shared-memory MIMD and distributed memory MIMD based on the way PEs are coupled to the main memory.

→ In the shared memory MIMD model (tightly coupled multiprocessor systems), all the PEs are connected to a single global memory and they all have access to it. The communication between PEs in this model takes place through the shared memory, modification of the data stored in the global memory by one PE is visible to all other PEs. Dominant representative shared memory MIMD systems are Silicon Graphic machines.

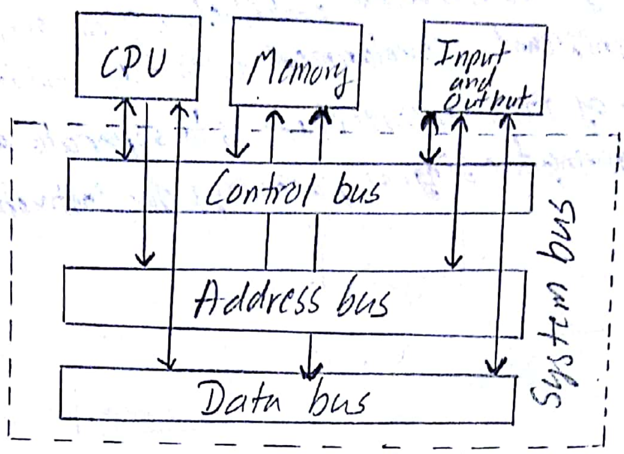
→ In Distributed Memory MIMD machines (loosely coupled multiprocessor systems) all PEs have a local memory. The communication network connecting PEs can be configured to tree, mesh or in accordance to requirement. It is easier to program but is less tolerant to failures. ~~They~~ Shared MIMD are less likely to scale due to memory contention, but in Distributed MIMD each PE has its own memory; it comes out to be superior model.



② Von Neuman & Harvord Architecture

VON NEUMAN ARCHITECTURE

A Von Neuman Architecture is an art about how an electronic computer can be stored. It was first published in 1945.



Von Neuman Architecture

Application and Features of the Von Neuman Architecture

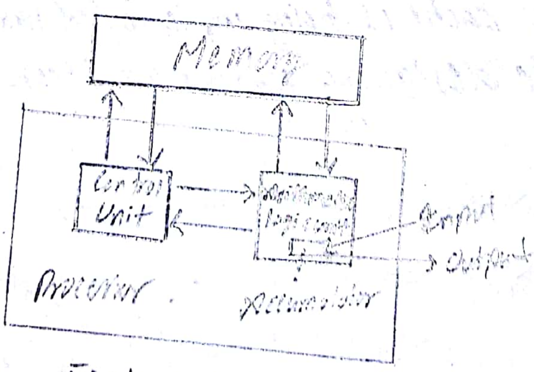
The von neuman architecture has got extensive application in everyday life. following are the elaborated features:

Memory: This is responsible for both holding and storing of data & programming data. In modern days this has been replaced by RAM.

Control Unit: All the data stored in the memory and during the processing of data the control unit plays the role and it manages the data flow. It follows the principle of 'One at a time' and accordingly it processes all the data.

Input-Output: This provides the basic functionality of communicating with the device.

ALU: Any sorts of addition, subtraction, multiplication and division of the data is carried out by this unit. It also carries out other kinds of algorithmic functions and activities.

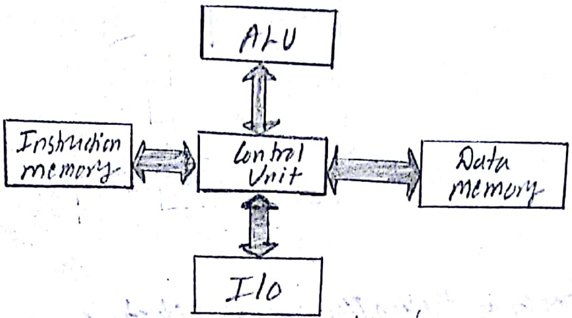


Features of Von Neuman Architecture

Harvard Architecture

When it comes to the physical storage of the data the Harvard architecture is better. The Harvard Mark I relay-based computer is the term from where the concept of the harvard architecture first arises and then onwards there has been a significant development with this architecture.

The main function of this architecture is to separate and physical storage of the data and giving the signal pathways for instruction and data



Harvard Architecture

Application and Features

→ It has got extensive application in the audio and video processing.

Memory Status

→ In the previous architecture we've seen two memories. here there is only one.

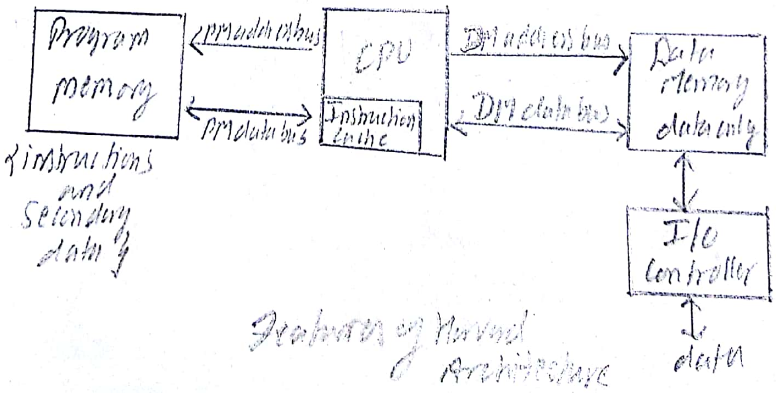
→ The existing memory will be able to perform all the functions.

→ There will be only Read-Only memory and this memory will be used for the purpose of reading, coding and decoding and storing of data.

Speed Aspect

→ It is able to process data at much higher speed

→ The concept of CPU cache is being implemented nowadays is also being implemented while designing Harvard architecture.



Evolution of Harvard Architecture

③ Parallel and Grid Computing

Parallel computing

Parallel computing is the concurrent use of multiple processors (CPUs) to do computational work.

In traditional (serial) programming, a single processor executes program instructions in a step-by-step manner.

Some operations, however have multiple steps that do not have time dependencies and therefore can be seperated into multiple tasks to be executed simultaneously.

For example: adding a number to all the elements of a matrix does not require that the result obtained from summing one element be acquired before summing the next element. Elements in the matrix can be made available to several processors, and the sums performed simultaneously, with the results available faster than if all operations had been performed serially.

Parallel computations can be performed on shared-memory systems with multiple CPUs, distributed-memory clusters made up of smaller shared-memory systems, or single-CPU systems. Coordinating the concurrent work of the multiple processors and synchronizing the results and handled by program calls to parallel libraries; these tasks usually require parallel programming expertise.

→ In the simplest sense, parallel computing is the simultaneous use of multiple compute resources to solve a computational problem:

- A problem is broken into discrete parts that can be solved concurrently.
- Each part is further broken down to a series of instructions.
- Instructions from each part execute simultaneously on different processors
- An overall control/coordination mechanism is employed

Grid Computing

The term "grid computing" denotes the connection of distributed computing, visualization, and storage resources to solve large-scale computing problems that otherwise could not be solved within the limited memory, computing power, or I/O capacity of a system or cluster at a single location. Much as an electrical grid provides power to distributed sites on demand, a computing grid can supply the infrastructure needed for applications requiring very large computing and I/O capacity.

The creation of a functional grid requires a high-speed network and grid middleware that lets the distributed resources work together in a relatively transparent manner. For example, whereas sharing resources on a single large system may require a batch scheduler, scheduling and dispatching jobs that run concurrently across multiple systems in a grid requires a metascheduler that interacts with each of the local schedulers. Additionally, a grid authorization system may be required to map user identities to different accountants and authenthicate users on the various systems.

Unlike with parallel computing, grid computing projects typically have no time dependency associated with them. They use computers which are part of the grid only when idle and operators can perform tasks unrelated to the grid at anytime. Security must be considered when using computer grids as controls on member nodes are usually very loose. Redundancy should also be built in as many computers may disconnect or fail during processing.

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④ Generation of Computers

★ First Generation (1940-1956): - Vacuum Tubes

- These early computers used vacuum tubes as circuitry and magnetic drums for memory.
  As a result, they were enormous, literally taking up entire rooms and costing a fortune to run.
- → They used to generate lots of heat, consume huge amount of electricity
- → They relied on "machine language".
- → Could solve one problem at a time.
- → Input was based on punched cards and paper tape. Output came out on print-outs.
  eg: UNIVAC. ENIAC.

★ Second Generation (1956-1963) :- Transistors

- → They made computers smaller, faster, cheaper and less heavy on electricity use.
- → They still relied on punched card for input / printouts.
- → They were the first computers to store instruction into their memory.

★ Third Generation (1964-1971) :- Integrated Circuits

- → The transistors were miniaturised & put on silicon chips. this led to a massive increase in speed and efficiency. these machines
- → These were the first computers where users interac using keyboard & monitors using OS
- → So became, this new machines could run several applic at once
- → This made m/c cheaper and smaller.

Fourth Generation (1972-2010): Microprocessors

→ The chip makers developed the Intel 4004 chip which positioned all computer components onto a single chip.

→ The size of a computer by now was reduced such that it can now fit in the palm.

→ This advancement lead to further evolution like Internet, GUI etc.

Fifth Generation (2010-): Artificial Intelligence

→ This phase is still under development, but has given so much to the society.

eg: Self Driving Cars, Voice recognisation, robots etc.

→ AI is a reality made possible by using parallel processing and superconductors.

→ The essence of fifth generation will be using these technologies to ultimately create machines which can process and respond to natural language and will have capability to learn and organise themselves.