PARALLEL PROCESSING

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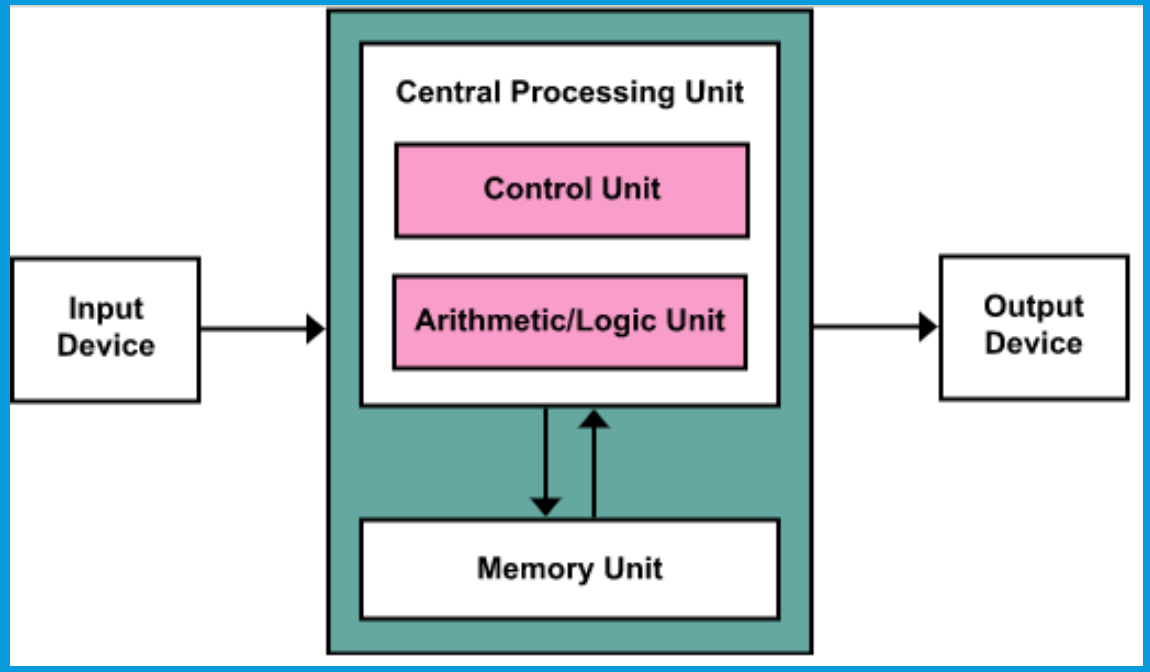
TYPES OF PARALLELISM

- Parallel computers can be divided into two main categories.
  - **Control flow** based on sequential machine architecture(von Neumann Machine).
  - **Data flow** not based on sequential machine. No pointer to next instruction the control is distributed. The instruction triggered when the data is available.

John von Neumann

TYPES OF PARALLELISM



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TYPES OF PARALLELISM

- In 1966, Flynn proposed a four-way classification of computer systems based on instruction streams and data streams. Namely SISD,SIMD,MISD, MIMD.

	Single Data Stream	Multi Data Stream
Single Instruction Stream	**SISD**	**SIMD**
Multi Instruction Stream	**MISD**	**MIMD**

TYPES OF PARALLELISM

- SISD : represents ordinary "uniprocessor" machines.
- SIMD : several processors directed by instructions issued from a central control unit, with array of data "array or vector processors."
- MISD : Not widely used.
- MIMD : includes a wide class of computers: shared memory, distributed memory, message passing, etc.

TYPES OF PARALLELISM

- Johnson 1988, proposed a further classification of MIMD machines based memory structure.

	Shared Variables	Message Passing
Global Memory	**GMSV**	**GMMP**
Distributed Memory	**DMSV**	**DMMP**

TYPES OF PARALLELISM

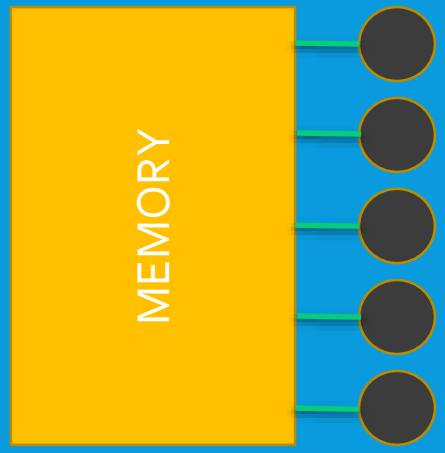
- **Visit the Top 500 website :**

  https://www.top500.org/

- What the term GFlop/s or TFlop/s mean?

TYPES OF PARALLELISM

- **GMSV : Shared Memory Multiprocessor.**

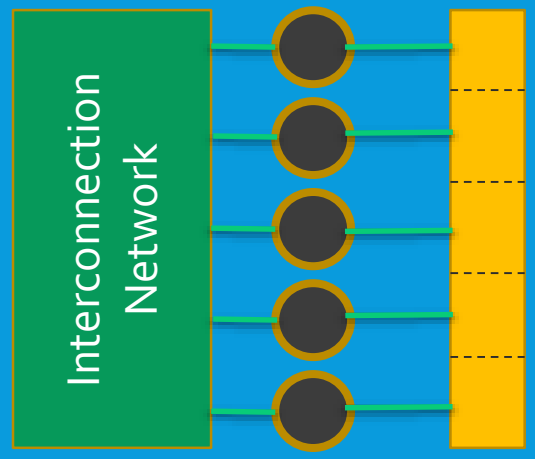


TYPES OF PARALLELISM

- **GMMP : ?**

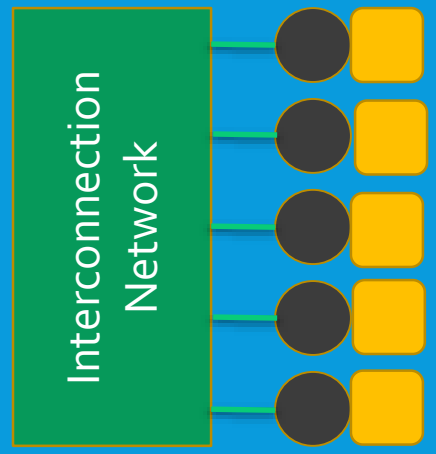
TYPES OF PARALLELISM

- **DMSV : Distributed Shared Memory (single address space).**



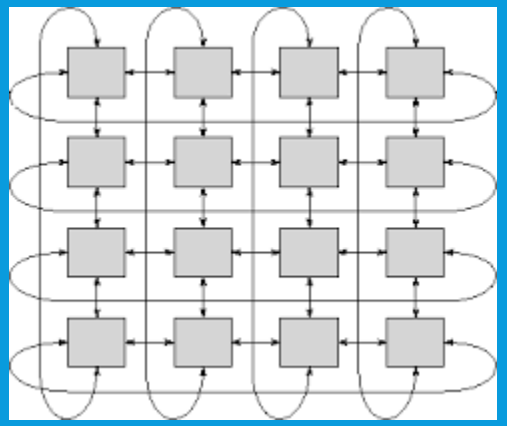
TYPES OF PARALLELISM

- **DMMP : Distributed Memory Multicomputer.**

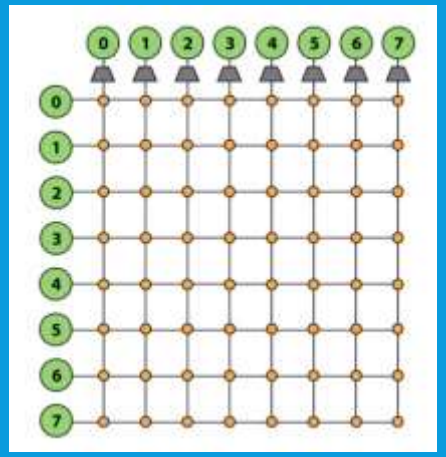


TYPES OF PARALLELISM

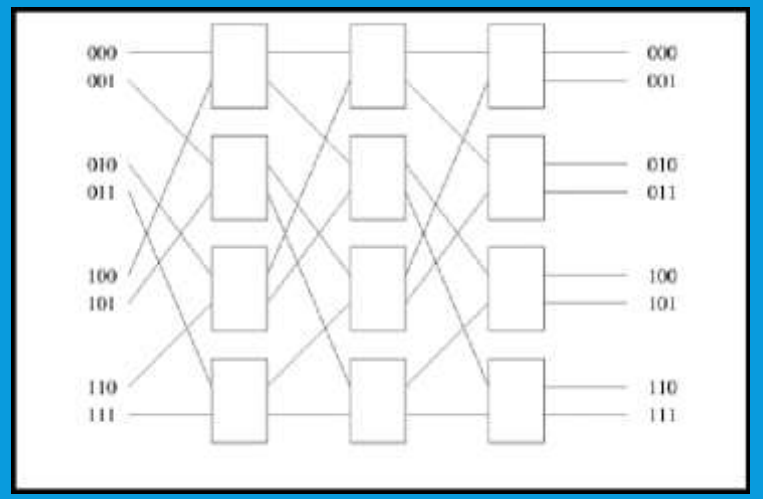
- **Interconnection Networks Example:**



2D Mesh



Crossbar



Multistage

TYPES OF PARALLELISM

- **PRAM : Parallel Random Access Machine.**
  - **Shared memory abstract machine.**
  - **Used to model parallel algorithmic performance.**
    - **EREW**
    - **ERCW**
    - **CREW**
    - **CRCW**

TYPES OF PARALLELISM

- **NUMA : Non-Uniform Memory Access Machine.**
  - **A design of a distributed memory machine.**

    The access time to memory depends on the location of the memory.
- **UMA: Uniform Memory Access Machine. (cross bar, multistage switching)**

PARALLEL PROCESSING MEASURES

- How to measure the benefit of parallel computing?
- It is measured by the time it takes to complete a task on a single processor versus the time it takes to complete the same task on *P* parallel processors.

PARALLEL PROCESSING MEASURES

جامعة الملك سعود
King Saud University

- **Speedup:**

  T1: Serial time (time to complete the task on single processor).

  Tp: parallel time(time to complete the task on *p* processors).

  n : problem size.

$$Sp = \frac{T1(n)}{Tp(n)}$$

PARALLEL PROCESSING MEASURES

جامعة الملك سعود
King Saud University

- **Efficincey:**

  T1: Serial time.

  Tp: parallel time.

  ***p* : Number of processors.**

$$Ep = \frac{T1(n)}{p\,Tp(n)} \text{ or } Ep = \frac{Sp}{p}$$

PARALLEL PROCESSING MEASURES

Limits of speedup & efficiency:

$$1 \leq Sp \leq p$$

$$0 \leq Ep \leq 1$$

PARALLEL PROCESSING MEASURES

P	T1	Tp	Sp	Ep
2	20	10	2	1
2	20	16	1.25	0.625
4	20	10	2	0.5
8	20	5	4	0.5

PARALLEL PROCESSING MEASURES

What causes communication overhead:

Interconnection network delay. Transmitting data across the interconnection network suffers from bit propagation delay, message/data transmission delay, and queuing delay within the network. These factors depend on the network topology, the size of the data being sent, the speed of operation of the network, etc.

PARALLEL PROCESSING MEASURES

What causes communication overhead:

Memory bandwidth. No matter how large the memory capacity is, access to memory contents is done using a single port that moves one word in or out of the memory at any given memory access cycle.

PARALLEL PROCESSING MEASURES

What causes communication overhead:

Memory collisions , when two or more processors attempt to access the same memory module. Arbitration must be provided to allow one processor to access the memory at any given time.

PARALLEL PROCESSING MEASURES

What causes communication overhead:

Memory wall. The speed of data transfer to and from the memory is much slower than processing speed. This problem is being solved using memory Hierarchy or cache.