Introduction to Cloud COMPUTING

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"**Introduction to the course"**

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Outline

Intro to
Computing Concepts

Cluster
Computing

What is a computer?

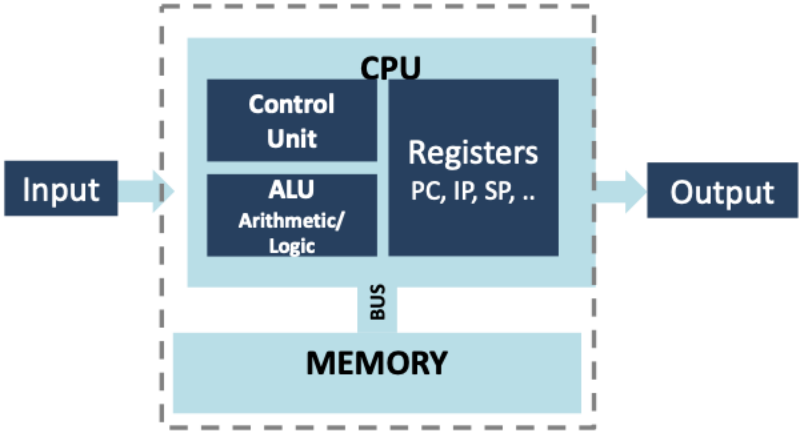
"A computer is a machine that can be **programmed** to automatically carry out sequences of arithmetic or logical operations (**computation**). Modern digital electronic computers can perform generic sets of operations known as programs. These programs enable computers to perform a wide range of tasks. The term computer system may refer to a nominally complete computer that includes the **hardware, operating system, software, and peripheral equipment** needed and used for full operation;"

A Computer **cluster** is a group of computers that are linked and function together"

https://en.wikipedia.org/wiki/Computer

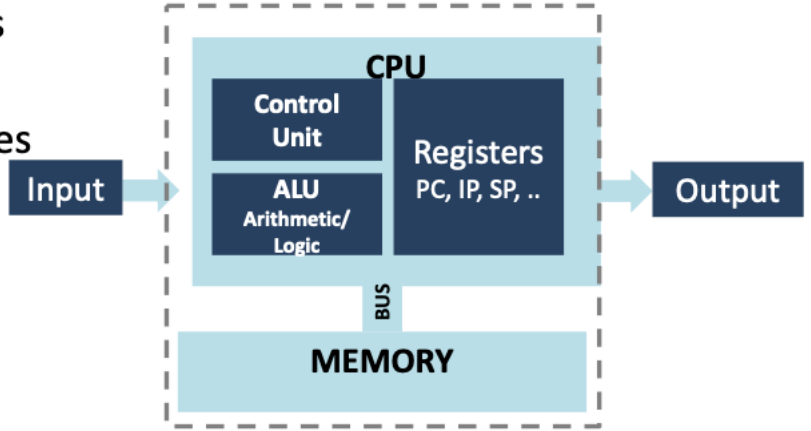
What is a serial computer ?

- Von Neumann architecture (the fundamental model)



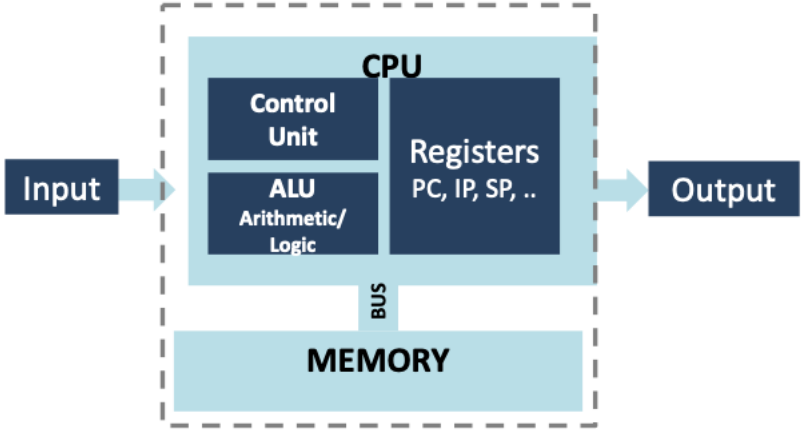
Von Neumann architecture

- There is only one process unit (CPU)
  - Control Unit: processes instructions
  - ALU: math and logic operations
  - Register: store data



Von Neumann architecture

- 1 instructions is executed at a time
- memory is “flat”:
  - access on any location has always the same cost
  - access to memory has the same cost than op execution

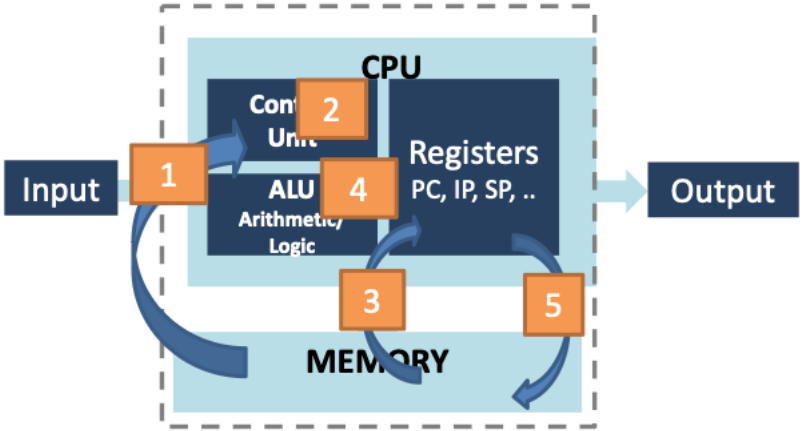


Von Neumann architecture

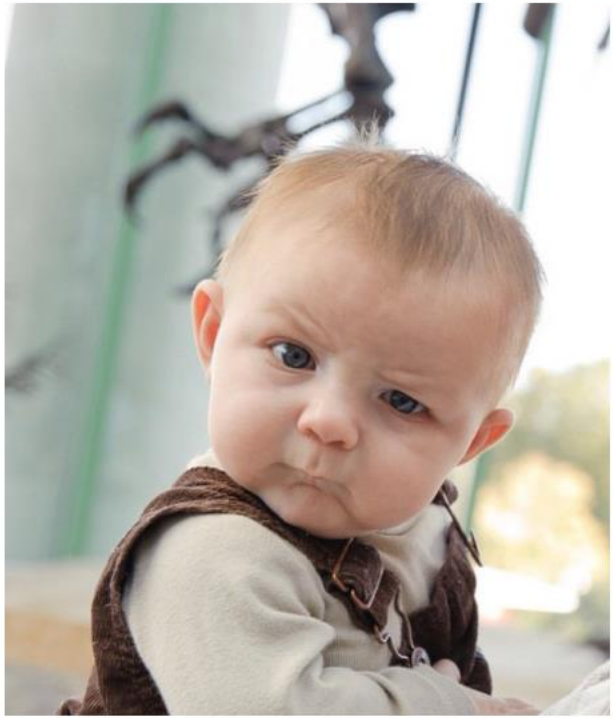
5 step WORKFLOW:

1. instruction fetch
2. Instruction decode: determine operation and operands
3. Memory fetch: Get operands from memory
4. Perform operation
5. Write results back

Continue with next instruction

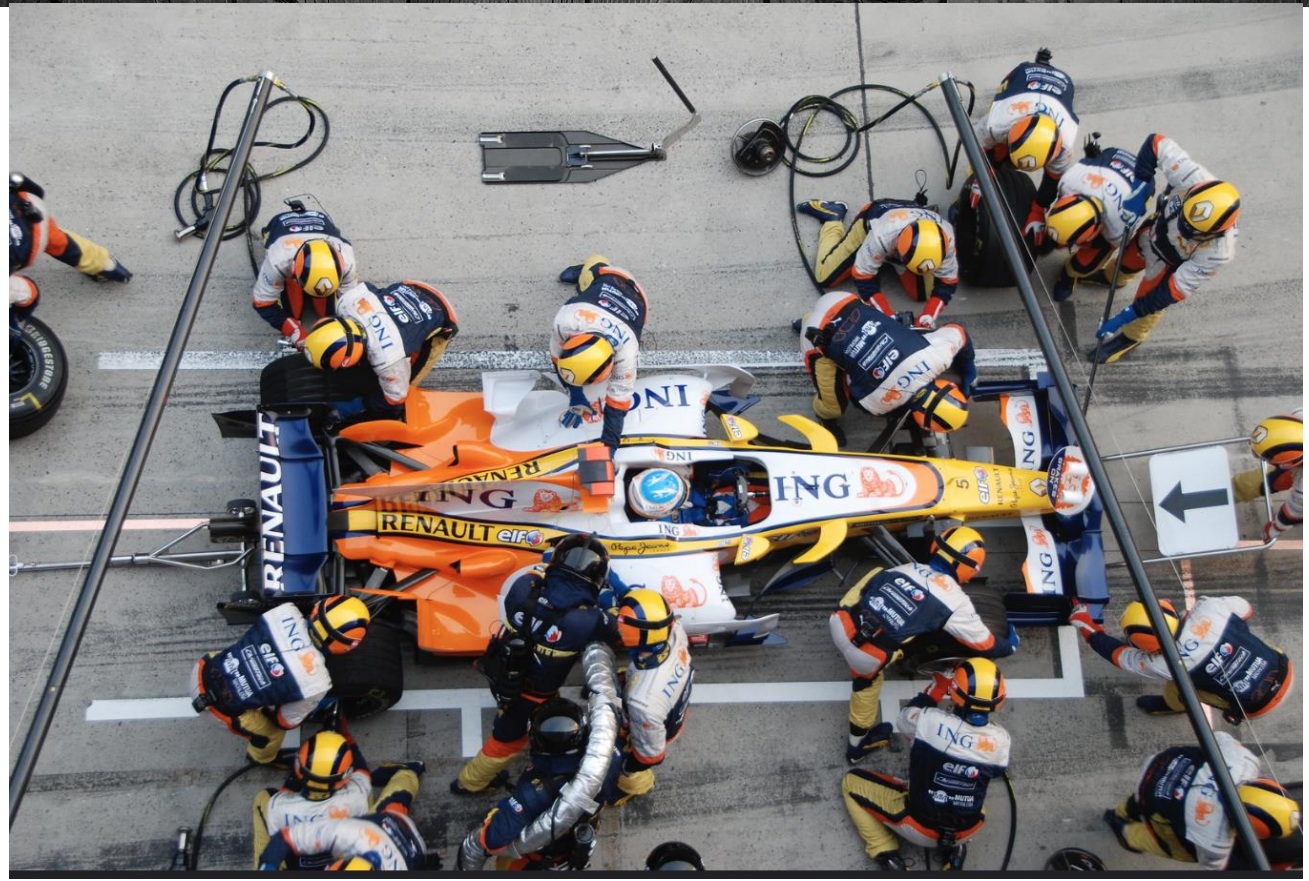


Does still serial computer exist?

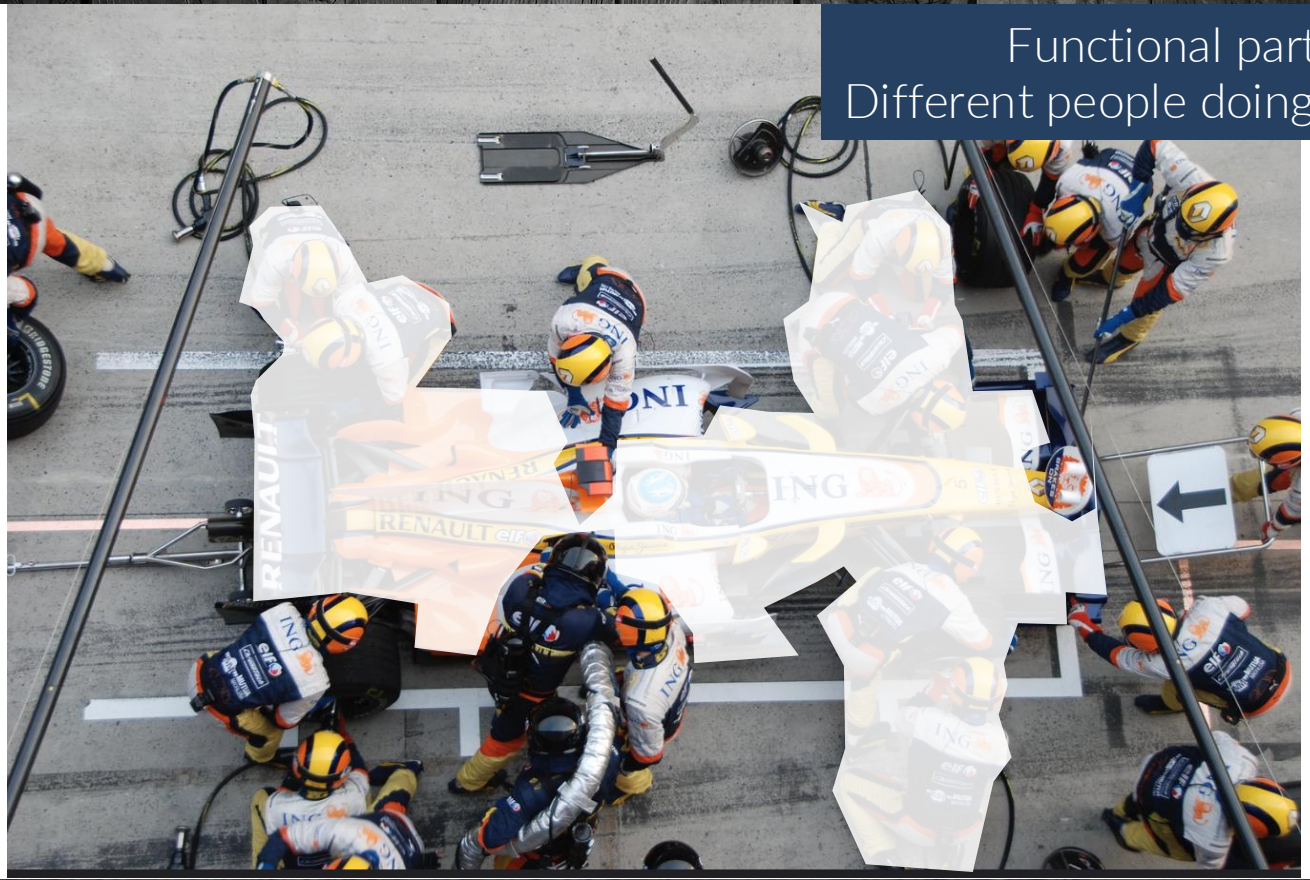


PARALLELISM IS EVERYHERE even in your laptop..

Parallel solution



Analysis of a Parallel solution



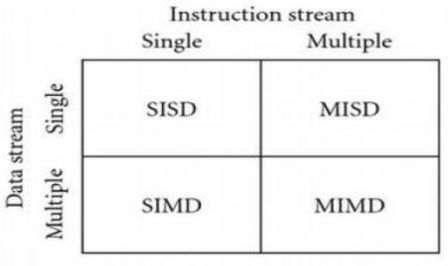
Functional partitioning:
Different people doing different things

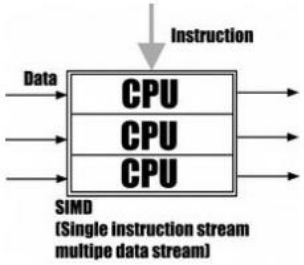
Analysis of a Parallel solution

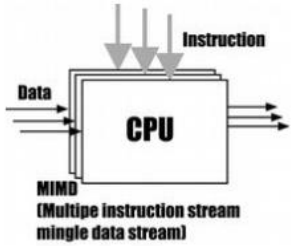
Domain decomposition:
Different people are solving the same global task but on smaller subset

Parallel Computers

Flynn's taxonomy is a classification of computer architectures, proposed by Michael J. Flynn in 1966, based upon the number of concurrent instruction (or control) streams and data streams available in the architecture







Flynn taxonomy does not help too much nowadays with modern HPC infrastructure

However, SIMD and MIMD concepts are still used HPC hardware

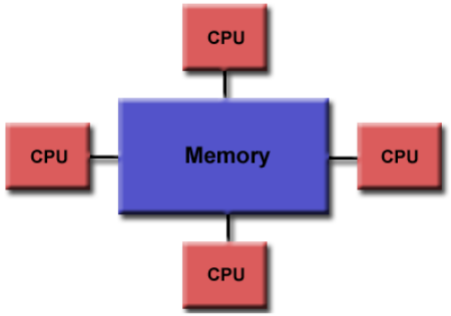
Parallel computers: memory

In the old time the simplest and most useful way to classify modern parallel computers was by their memory model:

– SHARED MEMORY

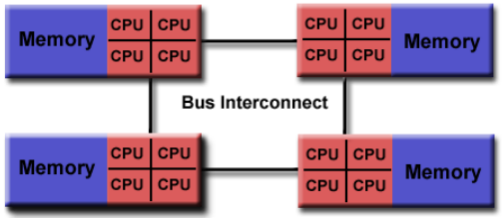
– DISTRIBUTED MEMORY

Shared memory



Uniform memory access (UMA): Each processor has uniform access to memory. Also known as symmetric multiprocessors (SMP)

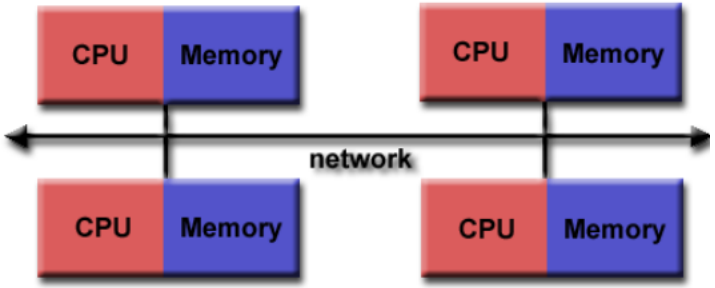
Non-uniform memory access (NUMA): Time for memory access depends on location of data. Local access is faster than non-local access.



Distributed memory

Distributed memory

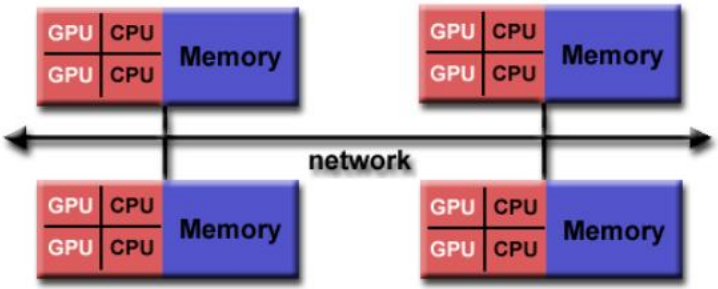
– each processor has its own local memory. Must do message passing to exchange data between processors



ARE THESE MACHINES STILL AVAILABLE ?

Cluster infrastructures

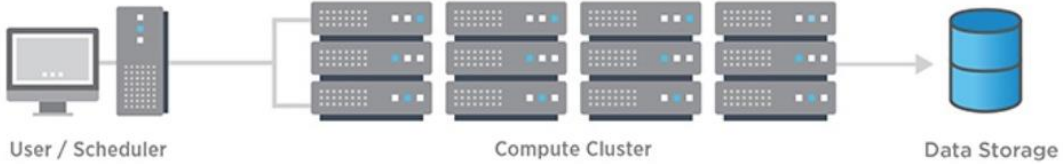
- Cluster of nodes (shared memory)



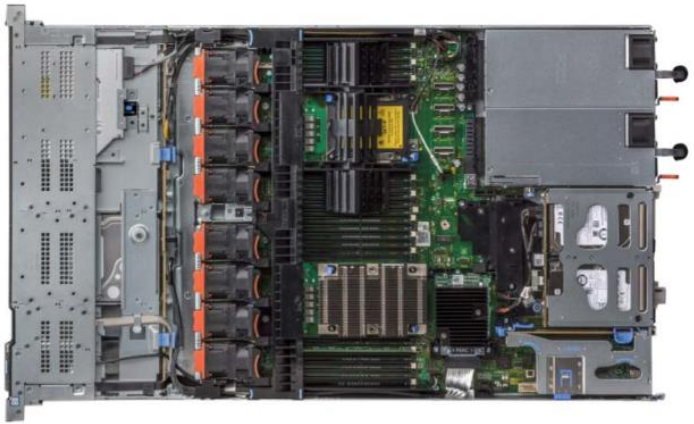
- Hybrid distributed/shared approach from memory point of view

Essential cluster components

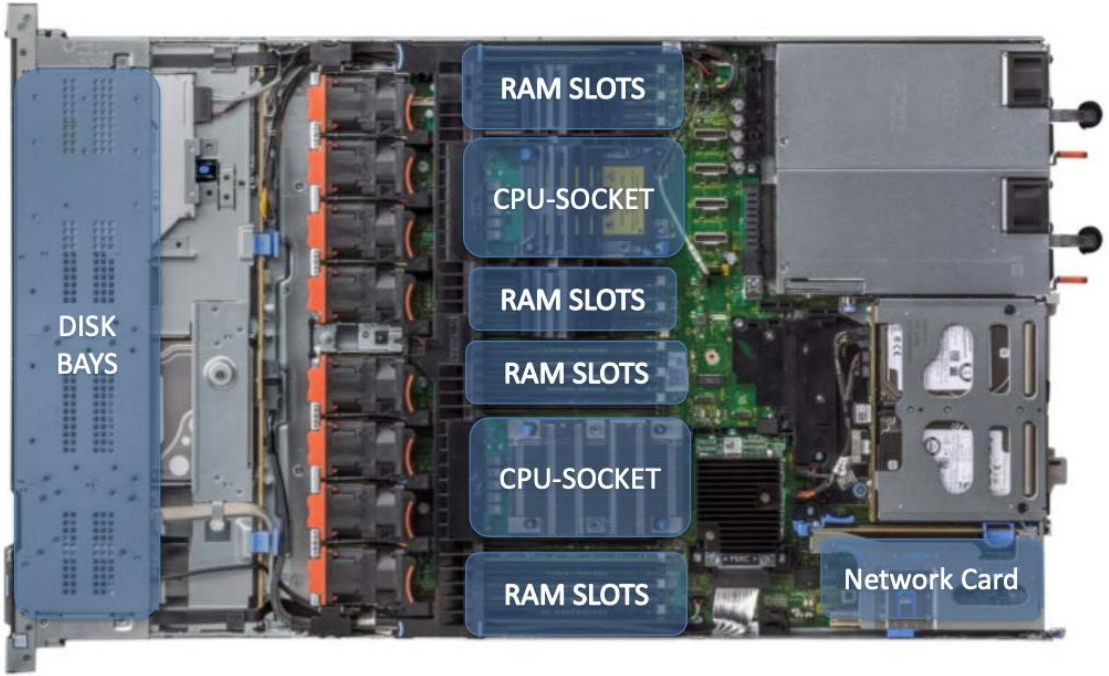
- Several computers (nodes)
  - often in special cases (1U) for easy mounting in a rack
- One or more networks (interconnects) to hook the nodes together
- Some kind of storage
- A login/access node..



Modern 1U server

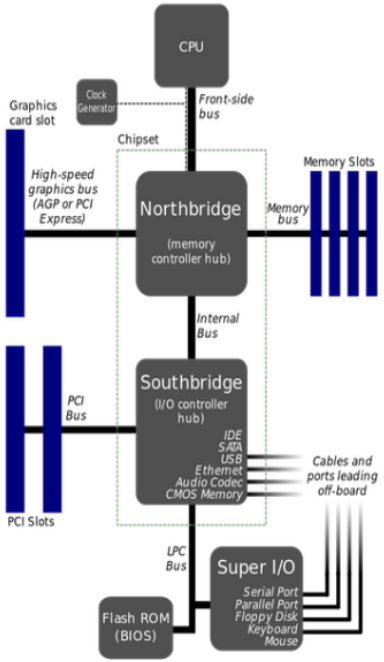


What does one node contain exactly ?



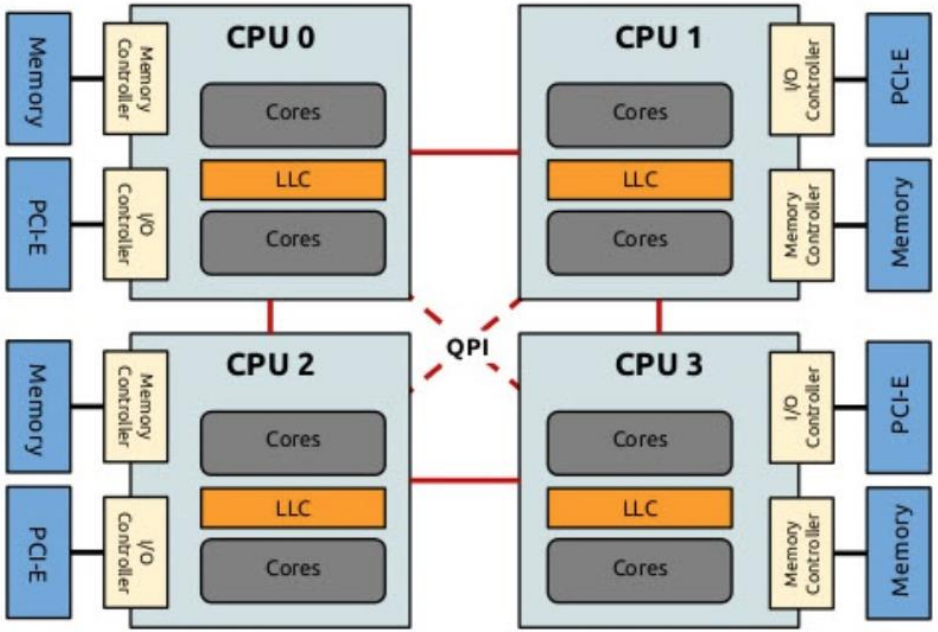
standard modern architecture

- All data communication from one CPU to another must travel over the same bus used to communicate with the Northbridge.
- All communication with RAM must pass through the Northbridge.
- Communication between a CPU and a device attached to the Southbridge is routed through the Northbridge.



NUMA architecture

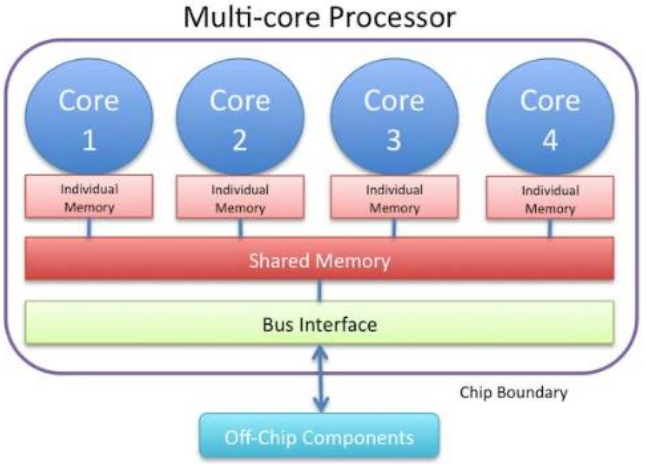
CPU architecture (Intel Sandy Bridge)



CPU are multicore processor

Because of power, heat dissipation, etc increasing tendency to actually lower clock frequency but pack more computing cores onto a chip.

These cores will share some resources, e.g. memory, network, disk, etc but are still capable of independent calculations



What is a CORE?

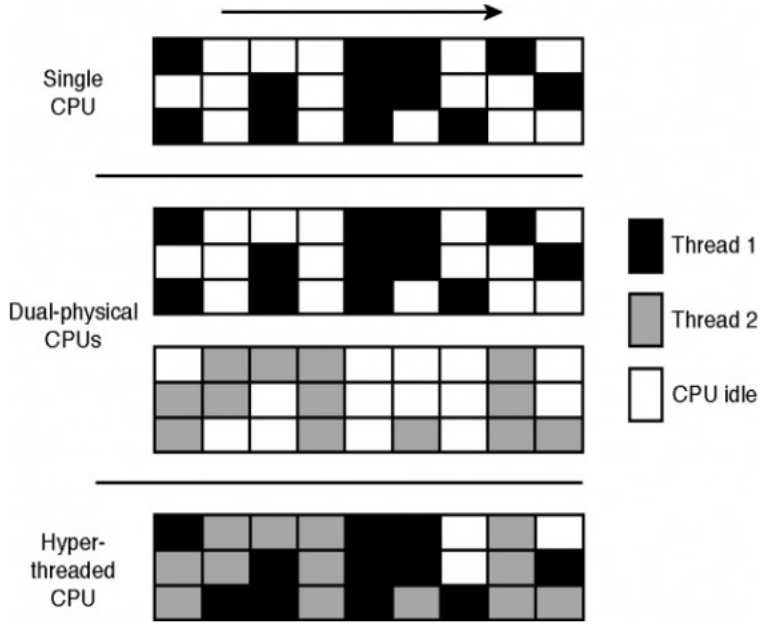
A core is the smallest unit of computing, having one or more (hardware/software) threads and is responsible for executing instructions.

Hyper threading (HT)

Intel® Hyper-Threading Technology uses processor resources more efficiently, enabling multiple threads to run on each core.

O.S. “sees” two cores and transparently try to execute two program on two different “cores”

Generally bad for HPC ?



a little bit of jargon..

Multiprocessor = server with more than 1 CPU

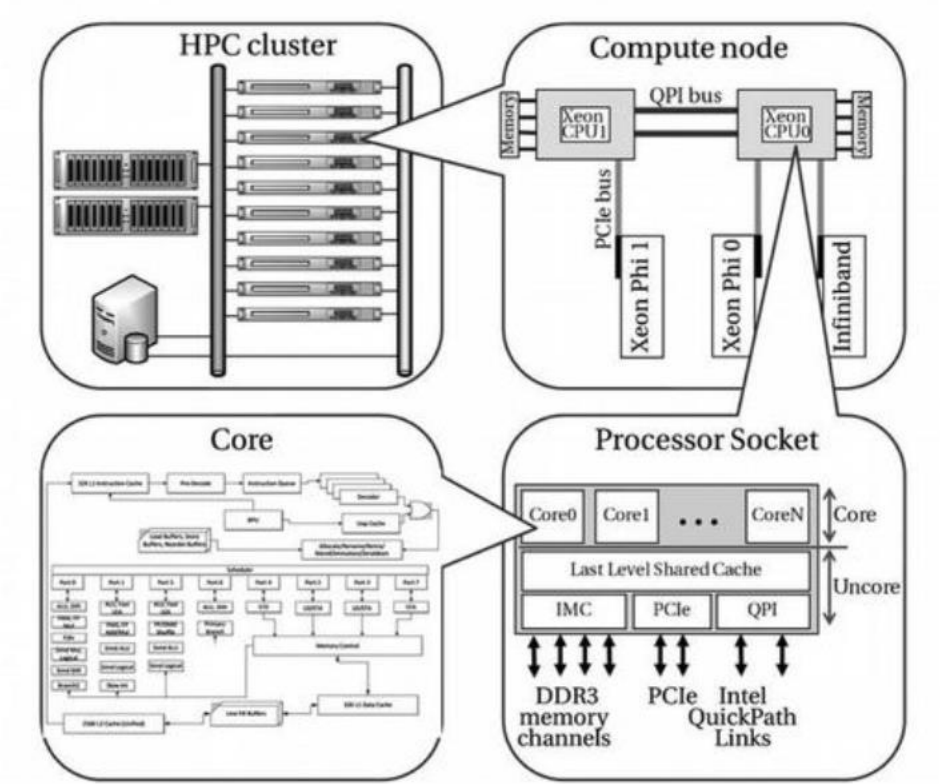
Multicore = a CPU with more than 1 core

Processor = CPU = socket

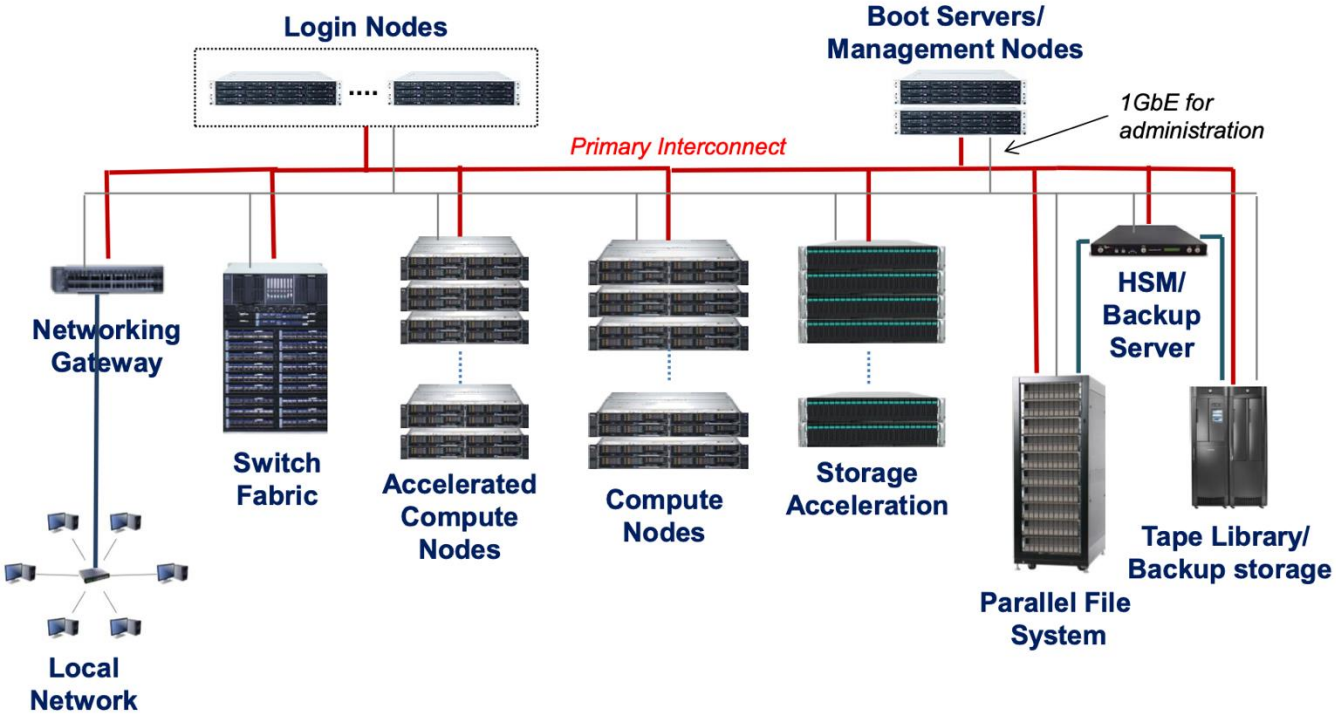
BUT SOMETIME:

Processor = core
a process for each processor (i.e. each core)

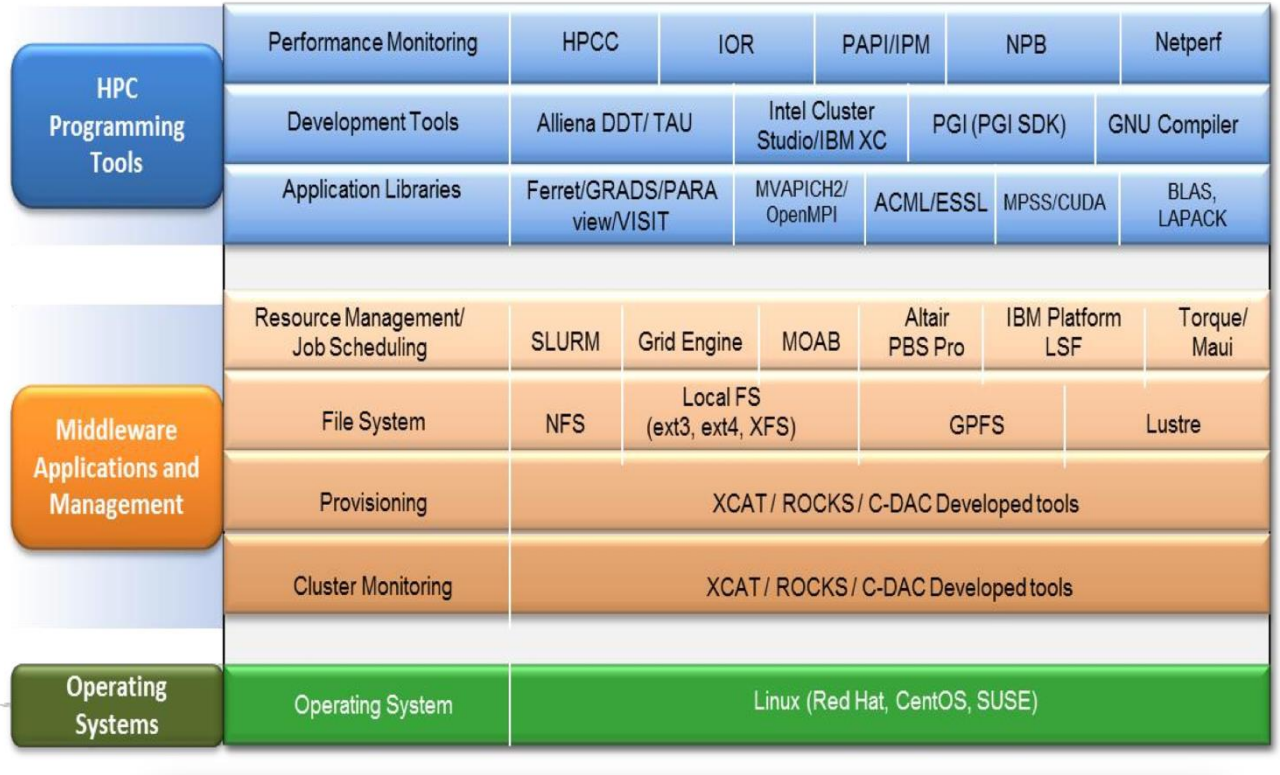
Computing Cluster



HPC computing cluster



Software stack



Using a cluster: the scheduler

- It allocates exclusive or non-exclusive access to the resources (compute nodes) to users during a limited amount of time so that they can perform they work

- It provides a framework for starting, executing and monitoring work

- It arbitrates contention for resources by managing a queue of pending work.

- It permits to schedule jobs for users on the cluster resource

Using a cluster: the scheduler

- A user job is characterized by:
  - the number of nodes
  - the number of CPU cores
  - the memory requested
  - the walltime
  - the launcher script, which will initiate your tasks

- Partition: group of compute nodes, with specific usage characteristics (time limits and maximum number of nodes per job

Using a Cluster: Slurm

that’s all, have fun