Classifications of Parallel Computers

Introduction

In this course we'll be using **MPI** which falls under a specific type of parallel computing

But there are also other APIs that use other architectures to achieve parallelism

Including, but not limited to:

- pthreads
- OpenMP
- CUDA

The two ways of classifying these APIs is through

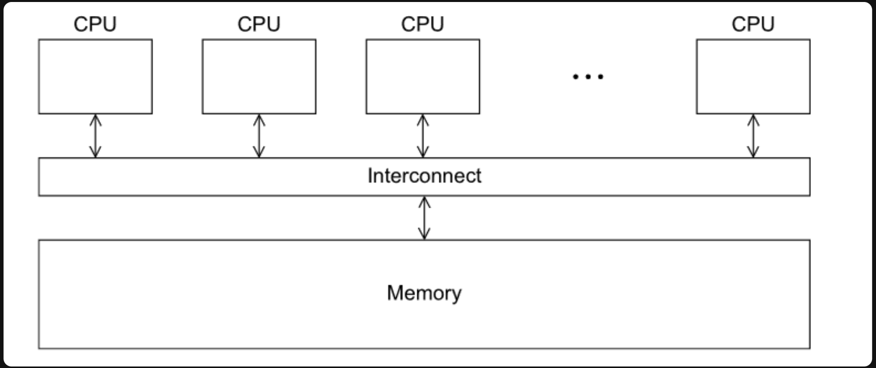
1. each core's **access** to memory (classification through memory)
2. if each core can operate **independently** (classification through instructions)

Memory Classifications

Shared memory systems

Where each core can **share** access to the computer's memory

- each core can read and write each memory location

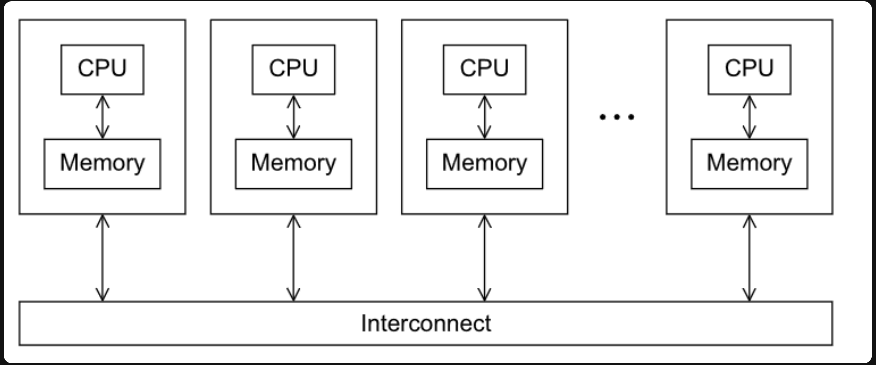


Each core is coordinated by reading and updating to memory locations

Distributed memory systems

Where each core has its own **private** memory

- each core can only read and write to its **own** memory
- but has explicit methods to communicate with other cores



Each core is coordinated by *sending messages* to each other

Instruction Classifications

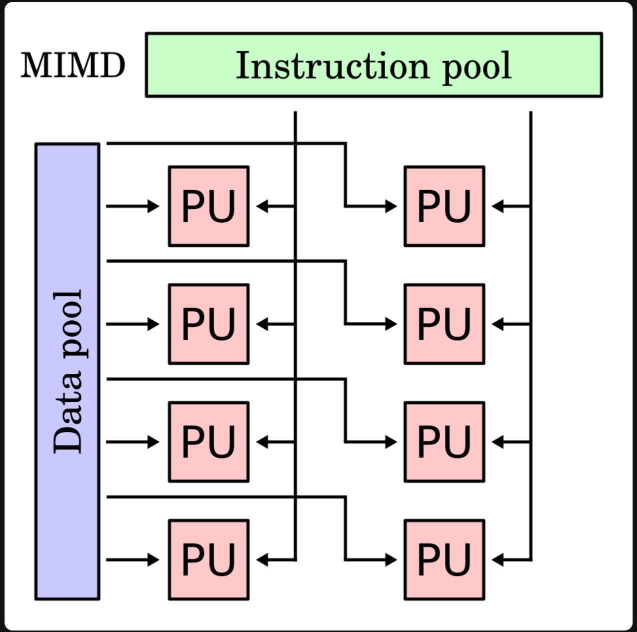
Multiple instruction multiple data

Where each core is considered a normal processor,

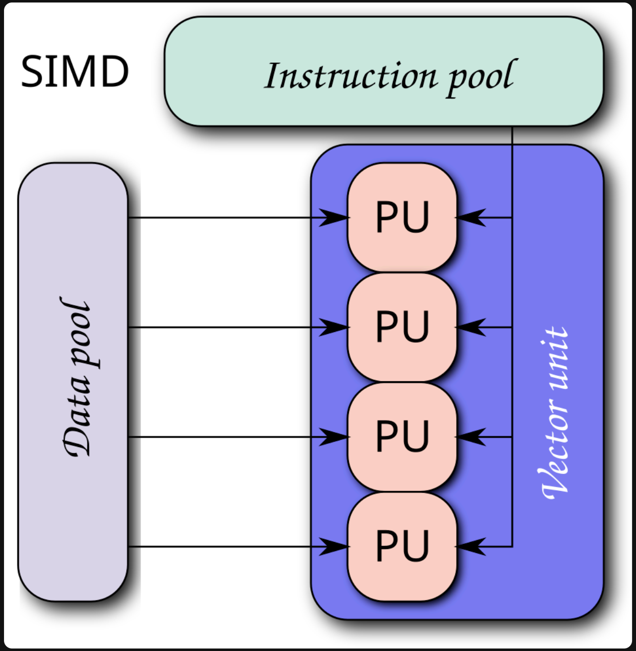
- with their own control units,
- ALUs,
- and can operate **independently**

This is called a *Multiple-Instruction Multiple-Data* (**MIMD**) system

You can do addition **and** multiplication on different sets of data at the same time



Single instruction multiple data



Where each core is **does not** have its own control unit

- Each core share a single control unit
- but they can access their own memory

This is called a Single-Instruction Multiple-Data (SIMD) system

you must do addition **or** multiplication on different sets of data

MIMD vs SIMD Example

MIMDs are more natural to think about and program, but some problems can be solved much easier with SIMD

For example

- Assume have three arrays with `n` elements
- we want to add the first two arrays
- then store it in the third array

```c
int x[n], y[n], z[n];

for (i = 0; i < n; i++) {
    z[i] = x[i] + y[i];
}
```

With SIMD

If we have `n` SIMD cores, and each core is assigned one element from each of the arrays

- core `i` is assigned elements `x[i], y[i], z[i]`

Then we can simply

```
i = what_is_my_subscript();
z[i] = x[i] + y[i];
```

Concurrent, parallel, and distributed

These terms are usually used informally and interchangeably

But for our purposes, and agreeing to overall consensus

- Concurrent means multiple tasks can be *in progress* at the same time
- Parallel means a program has multiple tasks **executing** at the same time
- Distributed means a program needs to cooperate with **other programs** to accomplish a task

Parallel and distributed programs **are concurrent**

But an operating system, is **also concurrent** even if it’s only running one core

Note that terms are made up and will change depending on context