

A scenic view of the University of Colorado Boulder campus. In the foreground, a large, historic red brick building with a prominent tower and an American flag on top is visible. The building is surrounded by lush green trees with some autumn-colored foliage. In the background, a large, rugged mountain with rocky peaks and green slopes rises under a blue sky with scattered clouds.

Parallel Memory Model

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Memory Models

- There are three common kinds of parallel memory models
 - Shared
 - Distributed
 - Hybrid

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Shared Memory Model

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Shared Memory Model

- All cores share the same pool of memory
- HPC Architecture – we talked about the memory available on one node
- Any memory changes seen by all processors

Shared Memory



Thought Experiment

- Let's go back to our lawn mowing example
- From the serial vs. parallel processing video
- In this example, the lawns are the memory
- The workers are the cores
- When all the workers are working on one lawn, they are sharing the memory
 - Every “core” is impacted by changes to “memory”

Benefits and Drawback

- Benefit:
 - Data sharing is fast
- Drawback:
 - Adding more processors may lead to performance issues when accessing the same shared memory resource (memory contention)

Shared Memory



Distributed Memory Model

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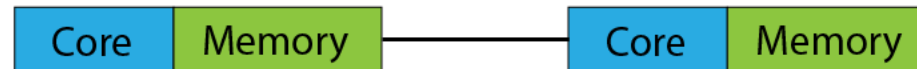


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Distributed Memory Model

- In a distributed memory model, each core has its own memory
- Processors share memory only through a network connection and/or communication protocol (e.g., MPI)
- Changes to local memory associated with processor do not have an impact on other processors
- Remote-memory access must be explicitly managed by the programmer

Distributed Memory



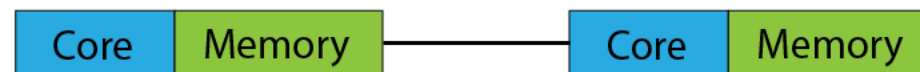
Thought Experiment

- Let's go back to our lawn mowing example
- From the serial vs. parallel processing video
- In this example, the lawns are the memory
- The workers are the cores
- When each worker is working on a different lawn, it is distributed memory

Benefits and Drawbacks

- Biggest benefit is scalability
 - Adding more processors doesn't result in resource contention as far as memory is concerned
- Biggest Drawback
 - Can be tedious to program for distributed memory models
 - All data relocation must be programmed by hand

Distributed Memory



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Hybrid Memory Model

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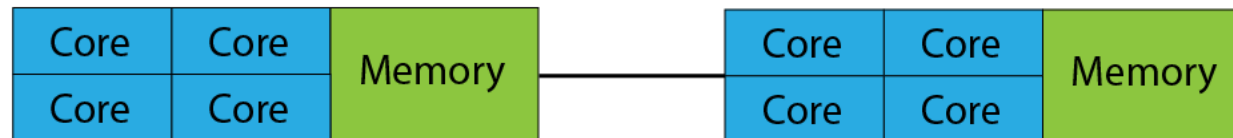


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Hybrid Memory Model

- As the name implies, the hybrid memory model is a combination of the shared and distributed memory models
- Most large and fast clusters today admit a hybrid-memory model
- A certain number of cores share the memory on one node, but are connected to the cores sharing memory on other nodes through a network

Hybrid



Thought Experiment

- Let's go back to our lawn mowing example
- From the serial vs. parallel processing video
- In this example, the lawns are the memory
- The workers are the cores
- The idea that you have several workers working on one lawn
- Or, better, several workers working on sections of a lawn, and have to communicate to make it work
 - Patterns

Benefits and Drawbacks

- Benefit:
 - Scalability
- Drawback
 - Must know how to program communication between nodes (e.g., MPI)

Hybrid

