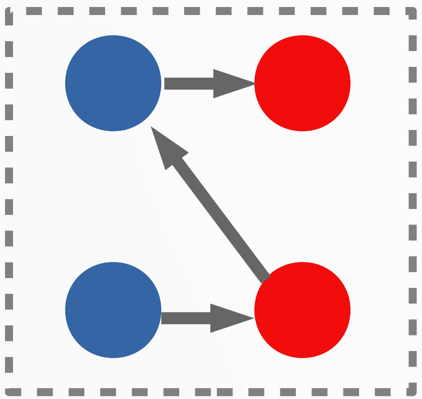
MPI Introduction

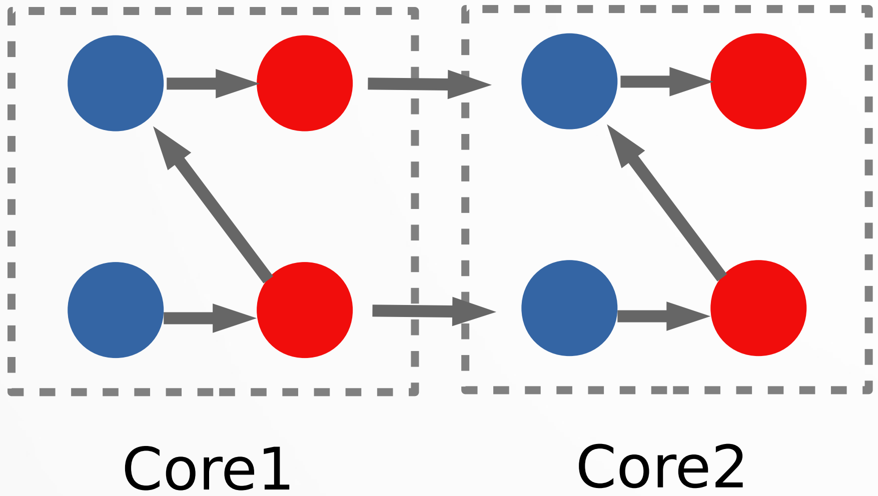
Programming Models for Emerging Platforms

Shared Memory Model



CPU1

Shared Memory Model



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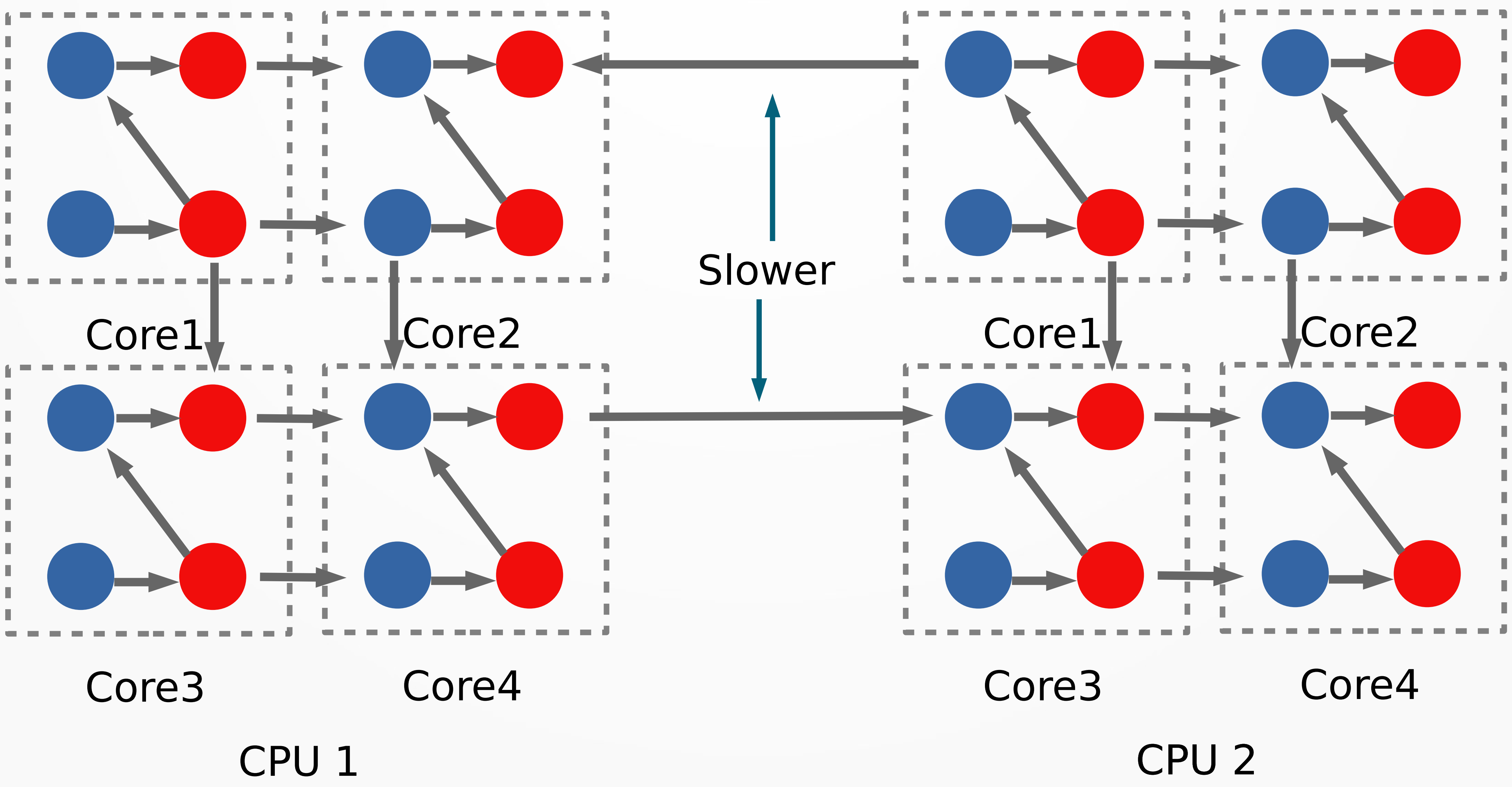

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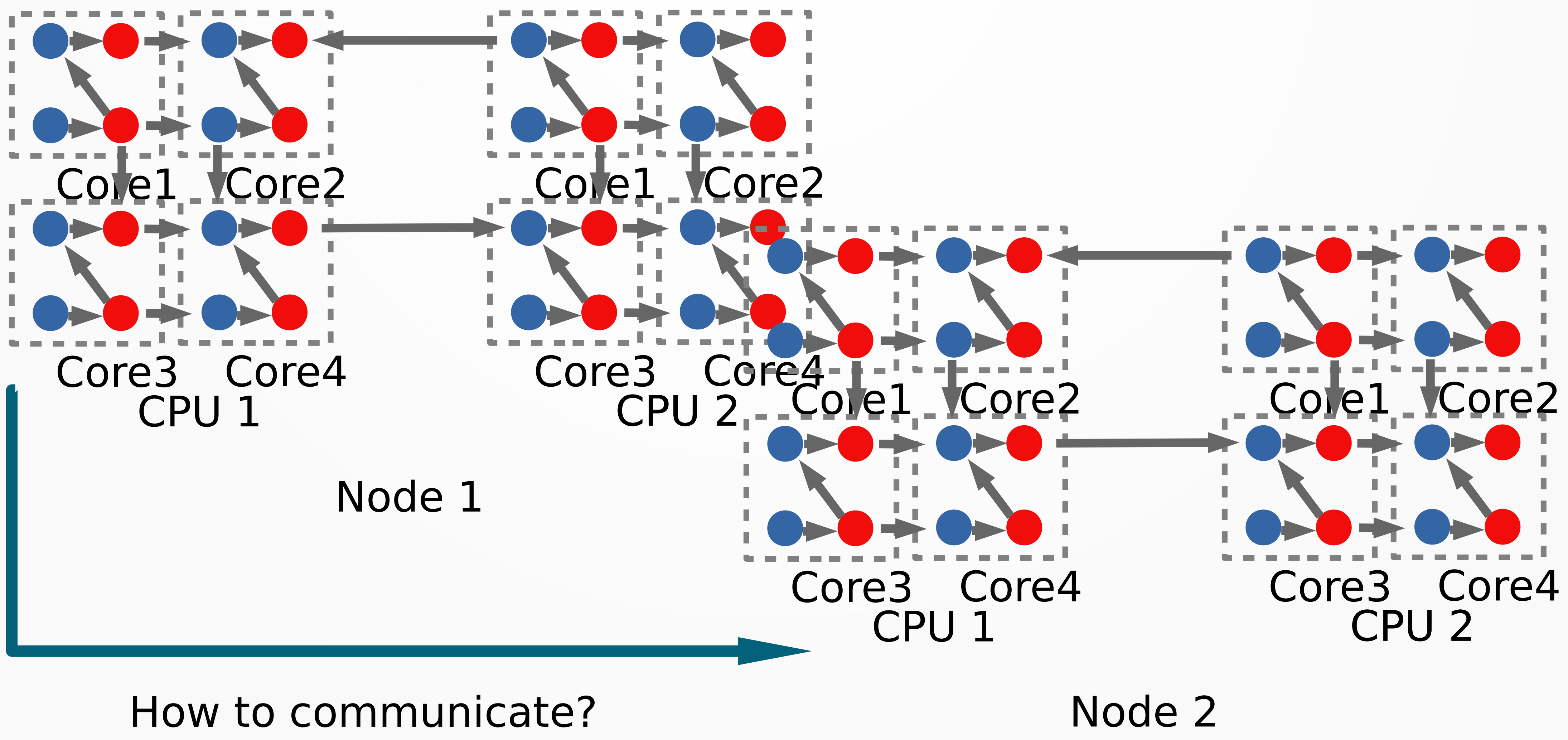

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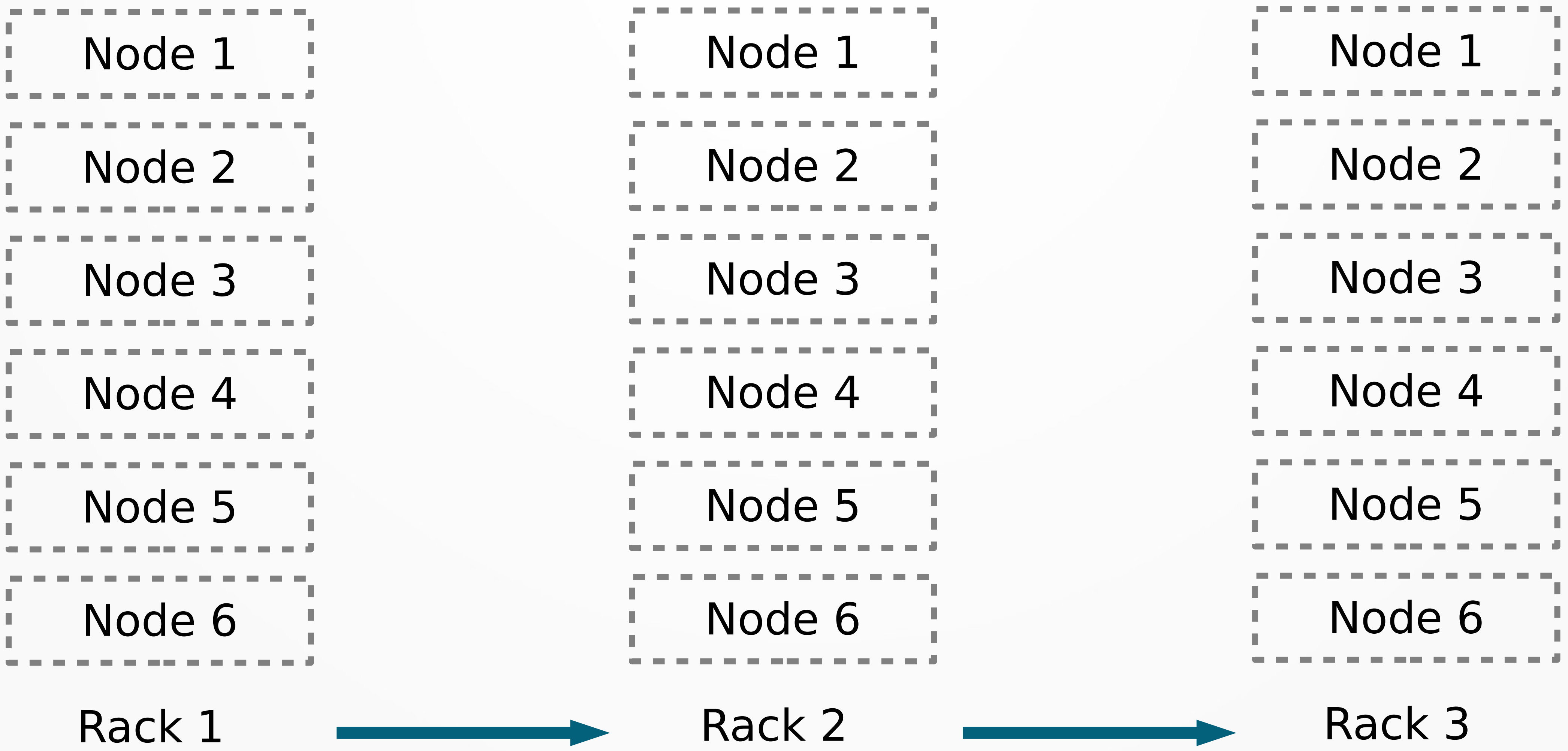

Shared vs Non-Shared

- Shared
- Non-Shared

Shared vs Non-Shared

- Shared
  - Immediate Updates
  - Lower programming effort (requires fewer loc / abstractions)
  - Higher mental effort (consider ALL program execution pathways)
  - Local Synchronization and Deadlock
- Non-Shared

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  - Immediate Updates
  - Lower programming effort (requires fewer loc / abstractions)
  - Higher mental effort (consider ALL program execution pathways)
  - Local Synchronization and Deadlock
- Non-Shared
  - Must communicate updates
  - Higher programming effort (need to send/gather data)
  - Lower mental effort (consider each process execution pathway in isolation)
  - Global synchronization and deadlock

Shared vs Non-Shared

- From a PL model perspective
  - Trade-offs associated with both (although Non-Shared most certainly provides a better abstraction)
  - We will revisit

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- From a implementation perspective
  - Two models are complementary (shared for *intra*process, non-shared for *inter*process)

High Performance Computing

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- 112,896 Cores
- 9,408 Nodes
- 147 TB Memory

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How do we program this machine?

Message Passing Interface (MPI)

- *Standard* interface for programming large-scale parallel platforms
  - Specific implementations exist, such as mpich, openmpi
  - Easily the most widely used parallel programming interface

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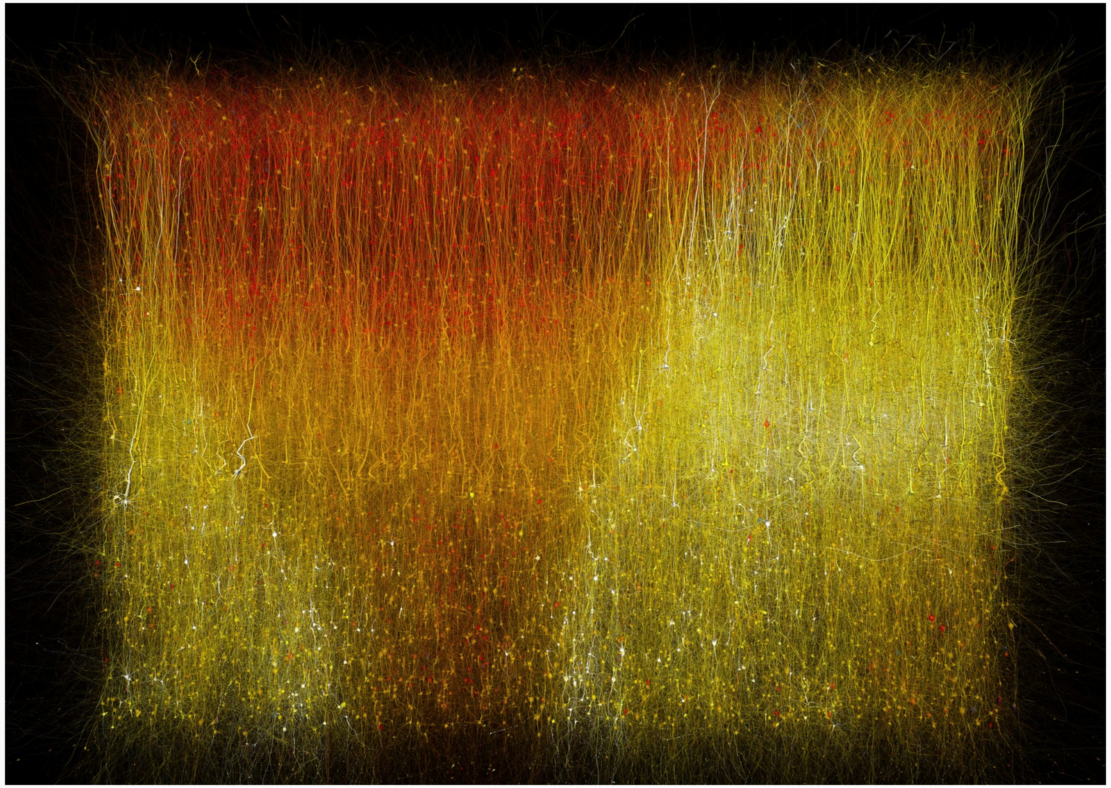
- *Standard* interface for programming large-scale parallel platforms
  - Specific implementations exist, such as mpich, openmpi
  - Easily the most widely used parallel programming interface
- Essentially, processes send and recv messages with MPI_Send, MPI_Recv
  - Lots of features to ease the “parallel process” part

A Word of Caution

Table 2 Shortest path computation times comparing a GPGPU with a parallel implementation of the $O(n^2)$ Bellman-Ford algorithm, and a serial CPU using either Bellman-Ford or the $O(n \log n)$ Dijkstra algorithm.

	CPU Bellman-Ford	GPGPU Bellman-Ford	CPU Dijkstra
Bunny (35k vertices)	2.9s	0.06s	0.08s
Buddha (544k vertices)	62.5s	3s	1.6s

Blue Brain Project



- Digital reconstruction of brain
- Mathematical models for individual neurons and synapses
- 100 billion neurons, 100 trillion synapses

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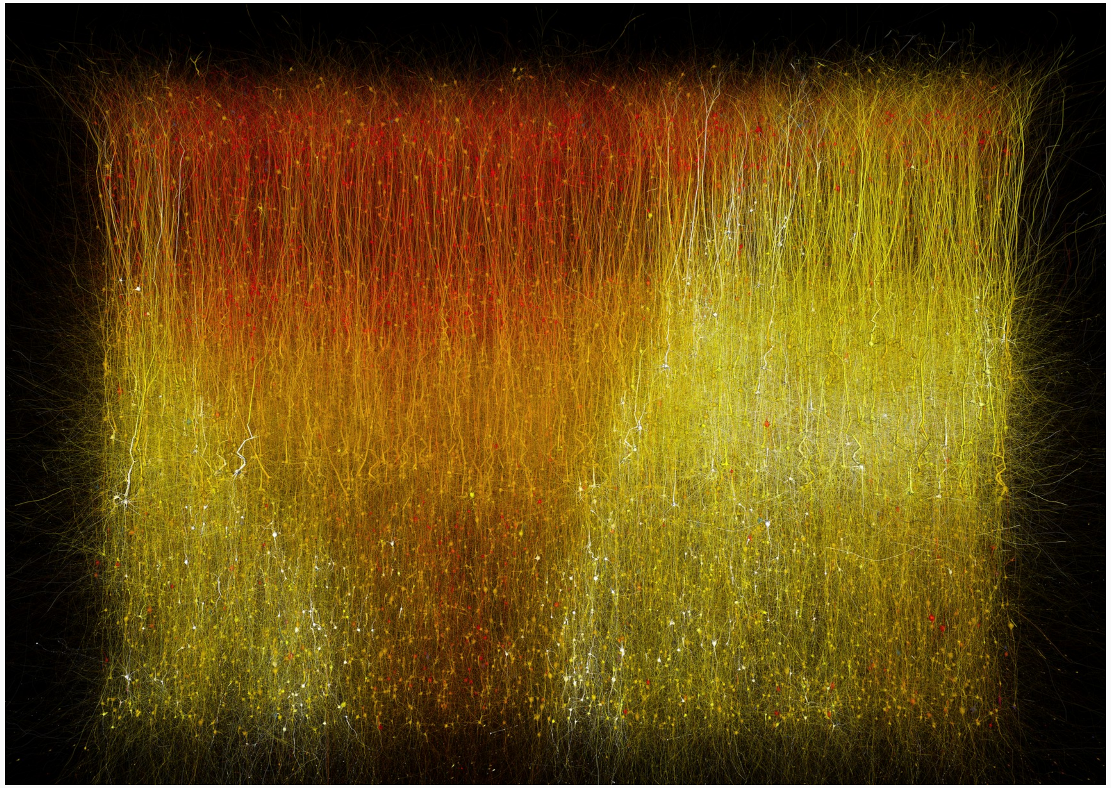

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Simulation fits parallel programming!

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mpirun -n 2 ./a.out arg1 arg2
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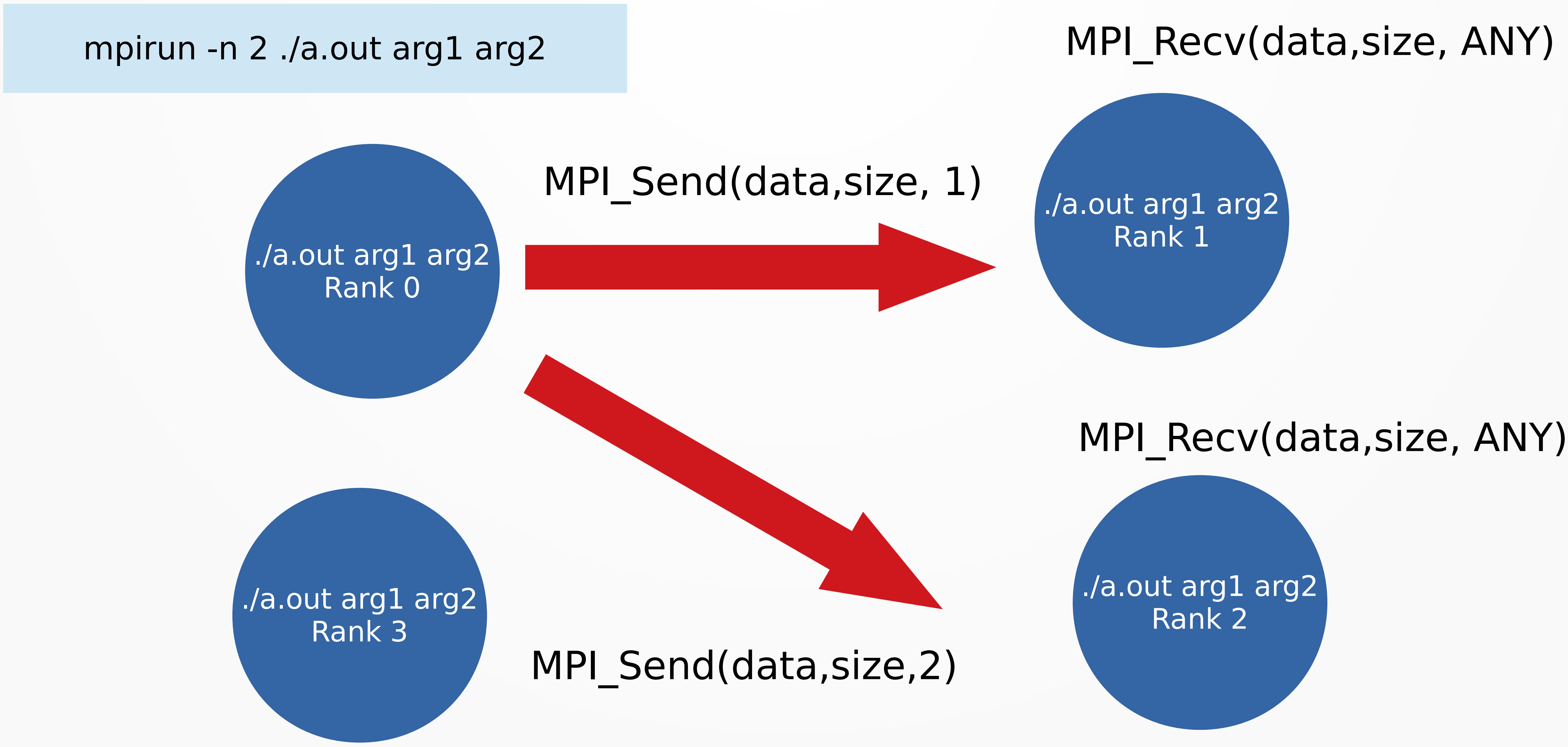

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mpirun -n 2 ./a.out arg1 arg2

MPI_Recv(data,size, ANY)

No sockets
No connecting
Runtime takes care of message communication

a,size, ANY)

Rank 3

MPI_Send(data,size,2)

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rank (id) of process
to send to

a way to “type” messages

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Group of MPI processes

Default MPI_COMM_WORLD

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Group of MPI processes

Default MPI_COMM_WORLD

If MPI_Send succeeds, all data gets sent!

How does MPI work?

int MPI_Recv(**void** *b, **int** count, **MPI_Datatype** type, **int** src, **int** tag, **MPI_Comm** com, MPI_Status *stat)

rank of process to recv
from (can use MPI_ANY_SOURCE)

type of message to recv
(can use MPI_ANY_TAG)

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May receive *up to* **count** items

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get recv information such as:
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But no partial receives (if you can’t recv *at least* count items, error)

Send/Recv

- Example (hello.c, fib.c)

Practice

- circular.c on website
- Convert the circular prime search from Cilk into an MPI program
- Make a master split work, workers perform search and return found primes to master

For Reference / Self Study

- MPI Functions
  - MPI_Init
  - MPI_Comm_rank
  - MPI_Comm_size
  - MPI_Recv
  - MPI_Send
  - MPI_Finalize
- Compiling and linking
  - Compile: mpicc hello.c
  - Run: mpirun -n 4 ./a.out
- MPI Structs
  - MPI_Datatype
  - MPI_Status