# Parallel Computing

**Submitted by:**

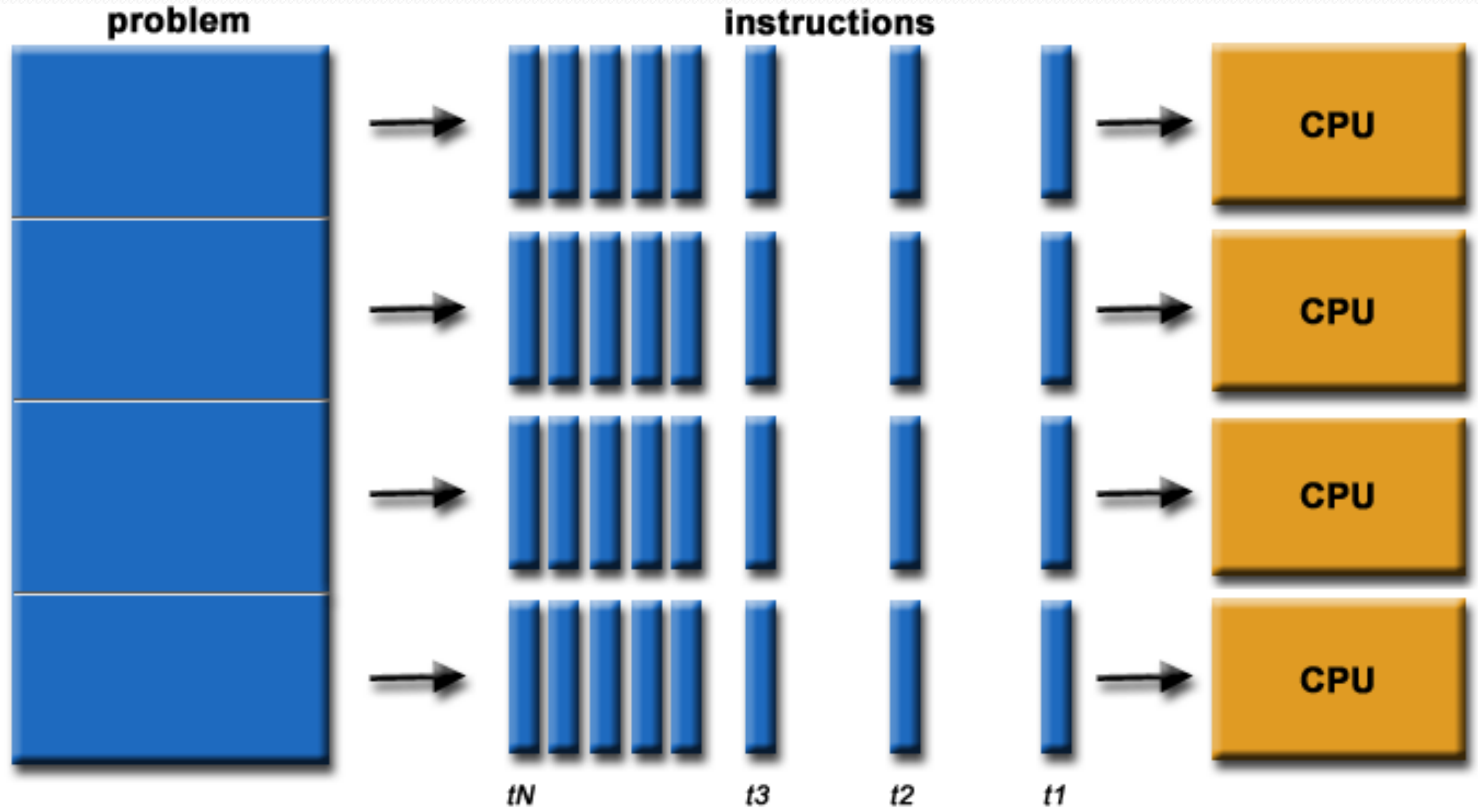
- **Virendra Singh Yadav**

# Overview

- What is Parallel Computing
- Why Use Parallel Computing
- Concepts and Terminology
- Parallel Computer Memory Architectures
- Parallel Programming Models
- Examples
- Conclusion

# What is Parallel Computing?

- Parallel computing is the simultaneous use of multiple compute resources to solve a computational problem.


problem
instructions
CPU
CPU
CPU
CPU
tN
t3
t2
t1

# Why Use Parallel Computing?

- Saves time
- Solve larger problems
- Cost savings
- Provide concurrency

# Concepts and Terminology: Types Of Parallelism

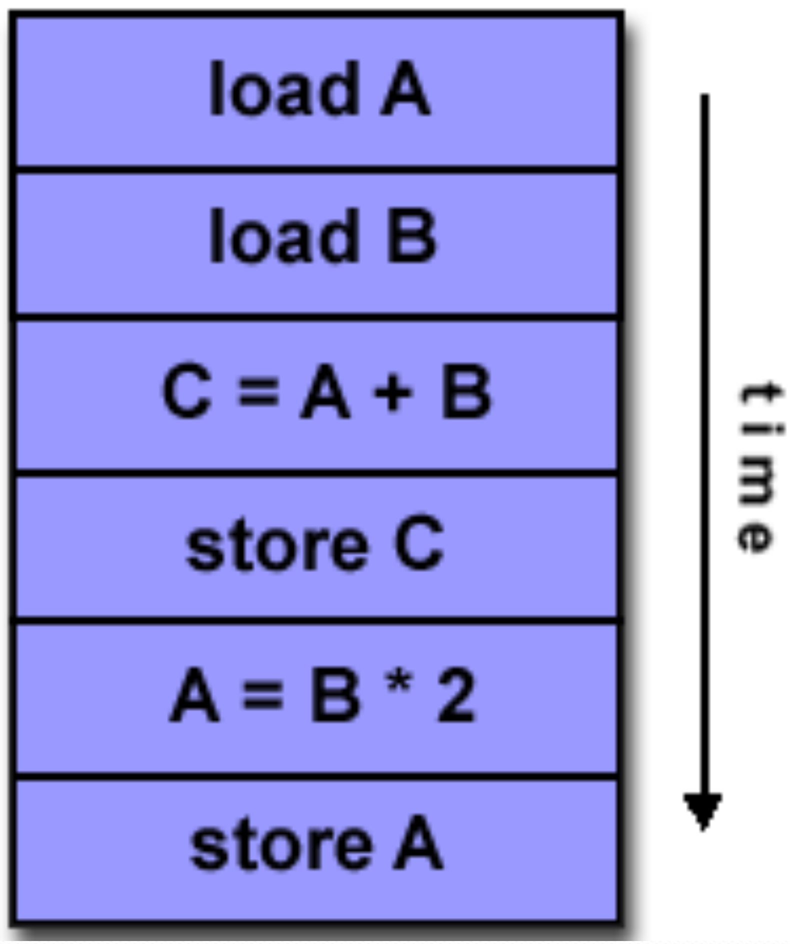
- Data Parallelism
- Task Parallelism

# Concepts and Terminology: Flynn's Classical Taxonomy

Distinguishes multi-processor architecture by instruction and data

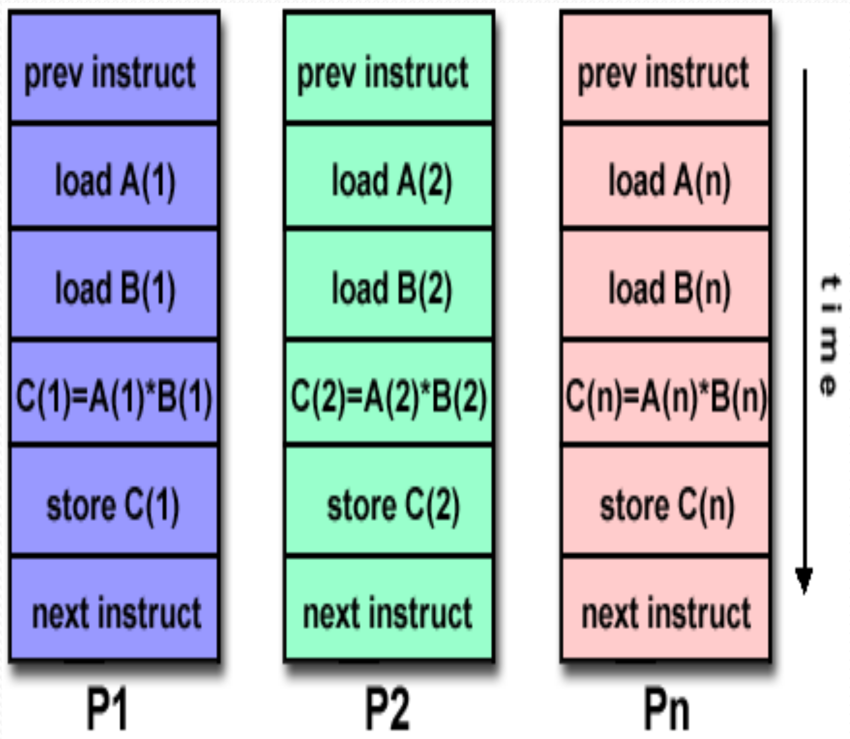
- SISD – Single Instruction, Single Data
- SIMD – Single Instruction, Multiple Data
- MISD – Multiple Instruction, Single Data
- MIMD – Multiple Instruction, Multiple Data

# Flynn's Classical Taxonomy: SISD




- Serial
- Only one instruction and data stream is acted on during any one clock cycle

# Flynn's Classical Taxonomy: SIMD

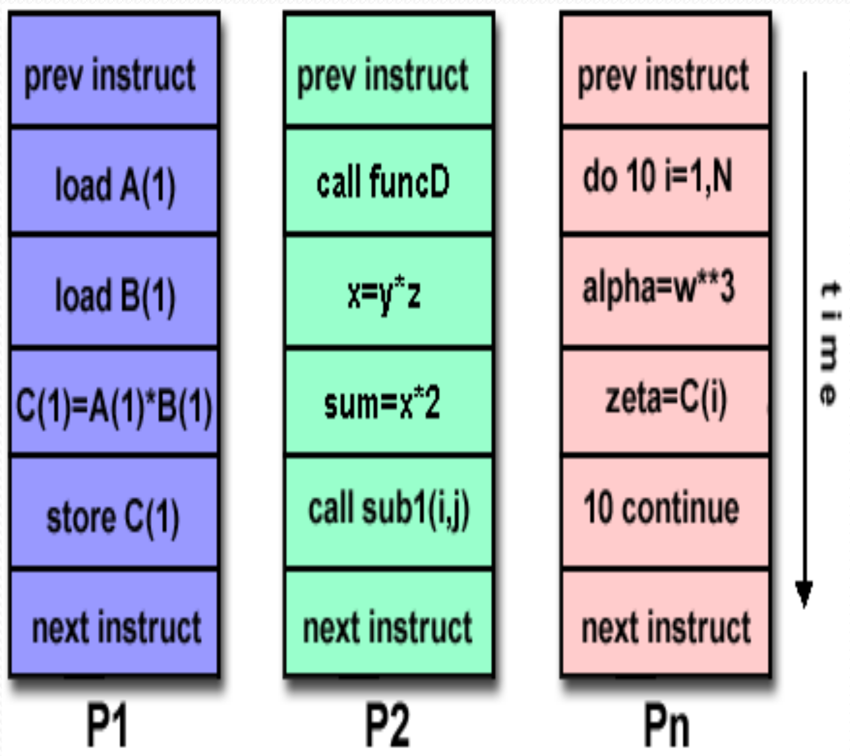



- All processing units execute the same instruction at any given clock cycle.
- Each processing unit operates on a different data element.

# Flynn’s Classical Taxonomy: MISD

- Different instructions operated on a single data element.
- Example: Multiple cryptography algorithms attempting to crack a single coded message.

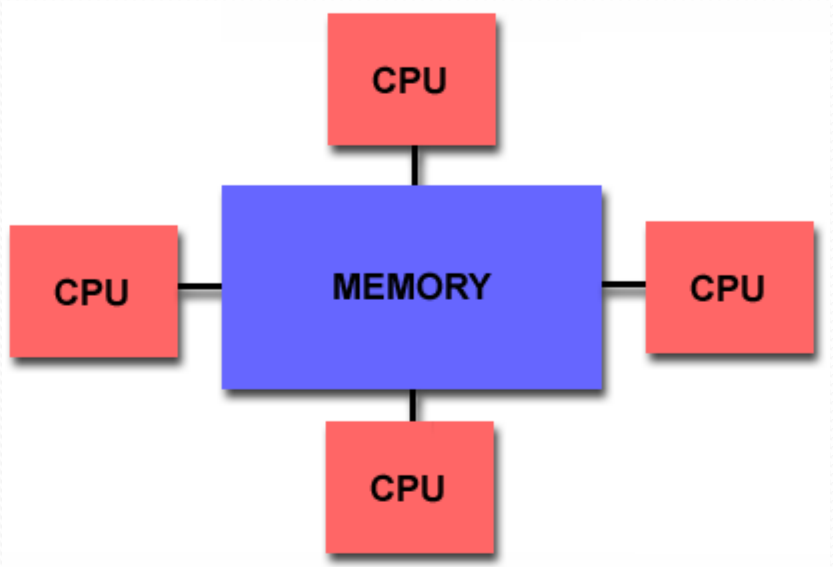
# Flynn's Classical Taxonomy: MIMD




- Can execute different instructions on different data elements.
- Most common type of parallel computer.

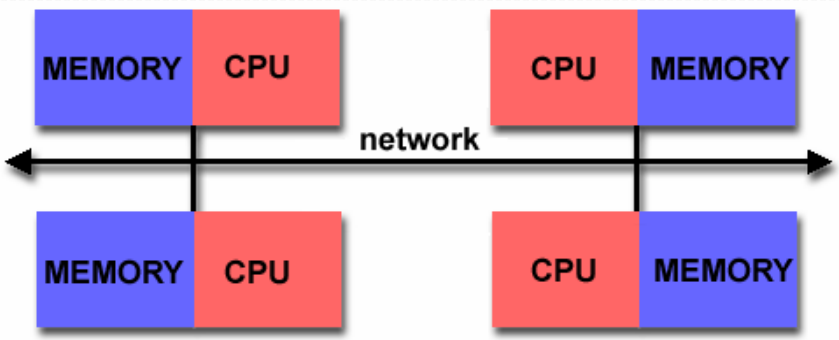
# Parallel Computer Memory Architectures: Shared Memory Architecture

- All processors access all memory as a single global address space.
- Data sharing is fast.
- Lack of scalability between memory and CPUs



# Parallel Computer Memory Architectures: Distributed Memory

- Each processor has its own memory.
- Is scalable, no overhead for cache coherency.
- Programmer is responsible for many details of communication between processors.



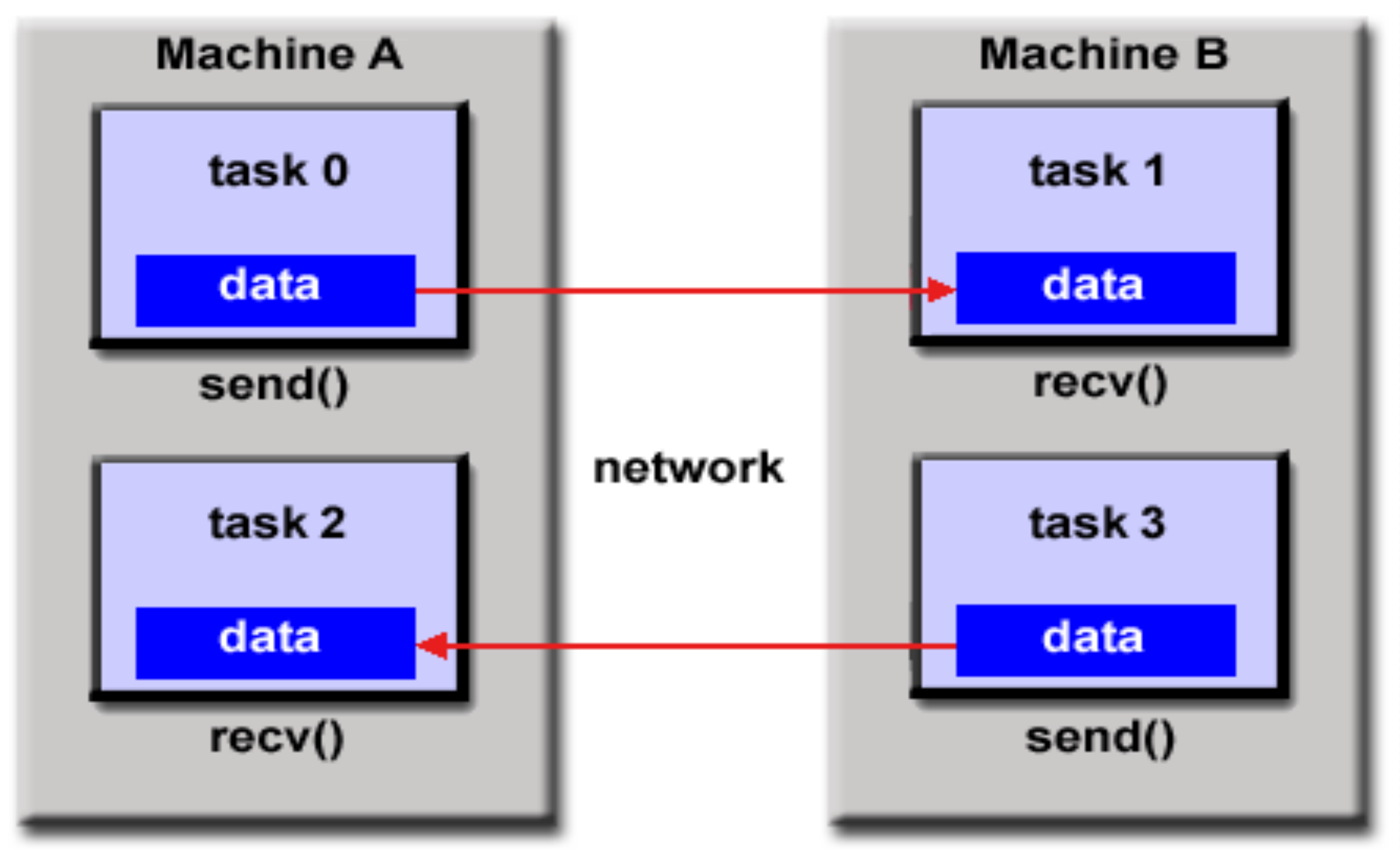
# Parallel Programming Models

- Shared Memory Model
- Messaging Passing Model
- Data Parallel Model

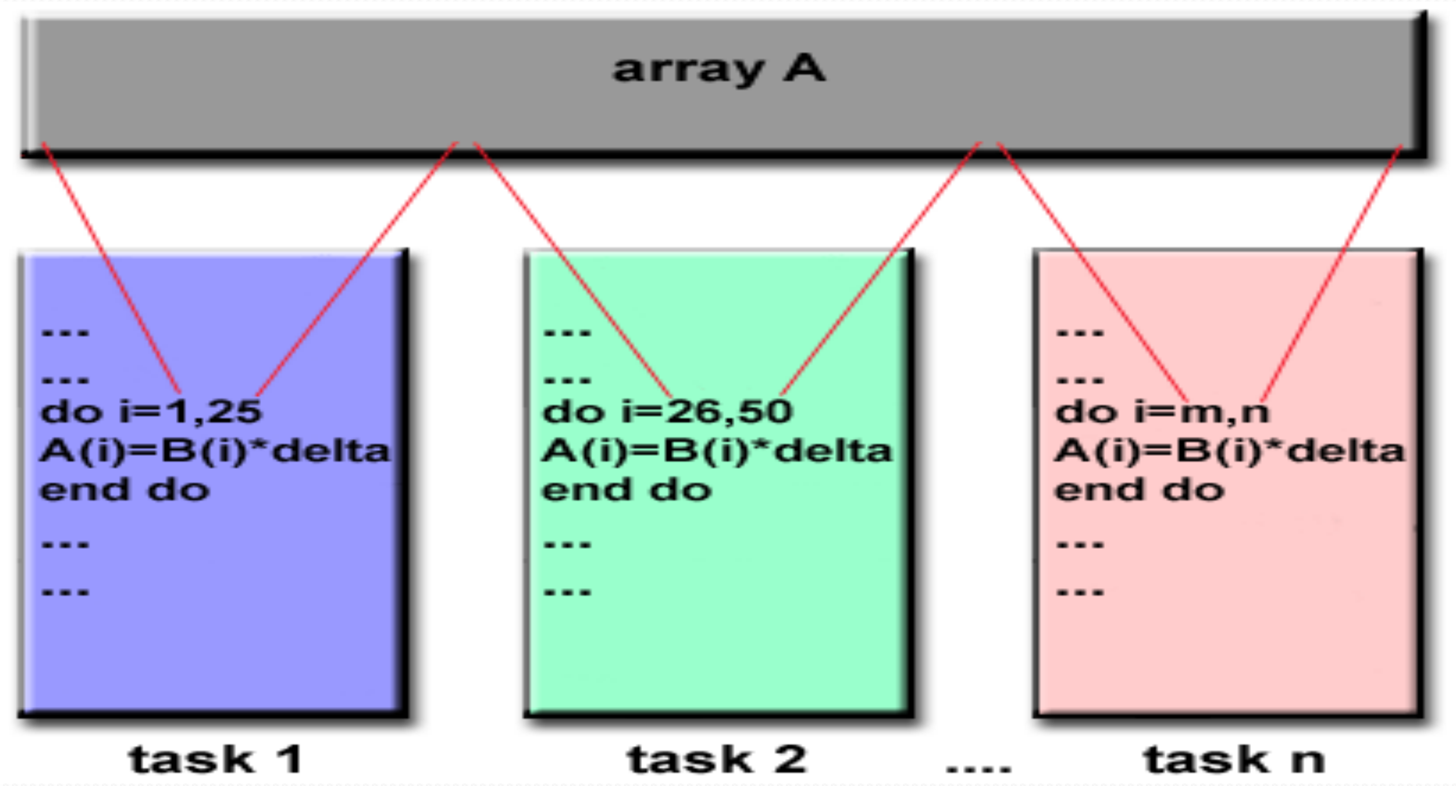
# Parallel Programming Models: **Shared Memory Model**

- In the shared-memory programming model, tasks share a common address space, which they read and write asynchronously.
- Locks may be used to control shared memory access.
- Program development can be simplified since there is no need to explicitly specify communication between tasks.

# Parallel Programming Models: **Message Passing Model**



# Parallel Programming Models: Data Parallel Model

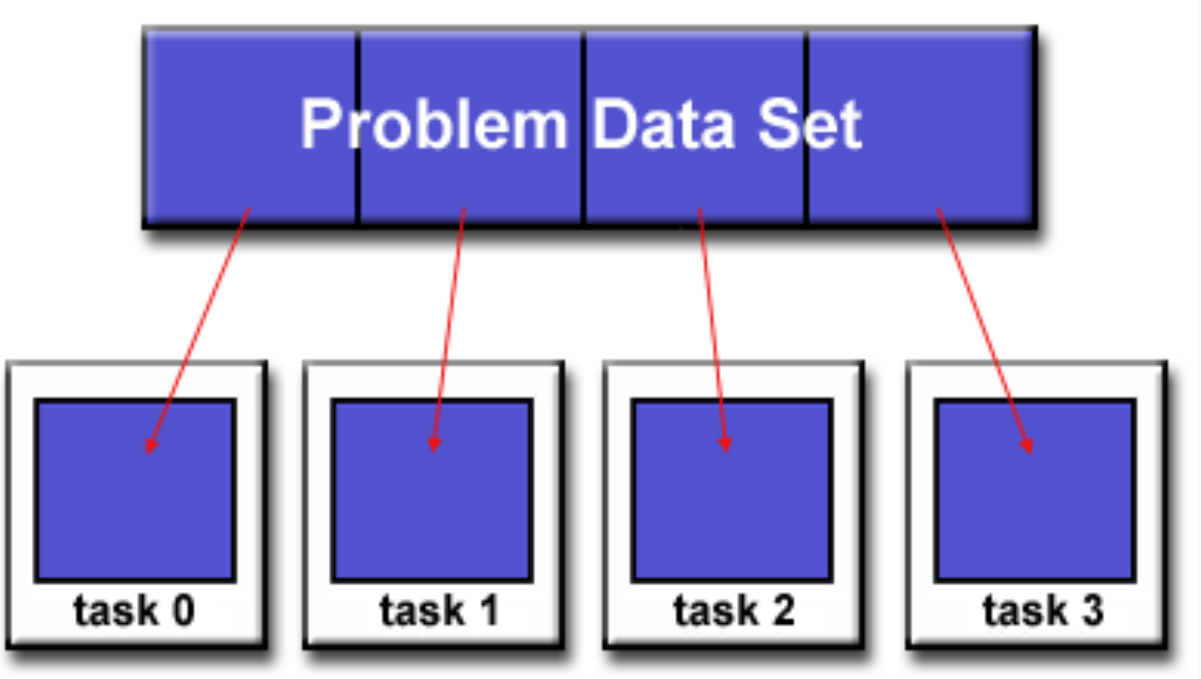


# Designing Parallel Programs

- Patitioning -
  - Domain Decomposition
  - Functional Decomposition
- Communication
- Synchronization

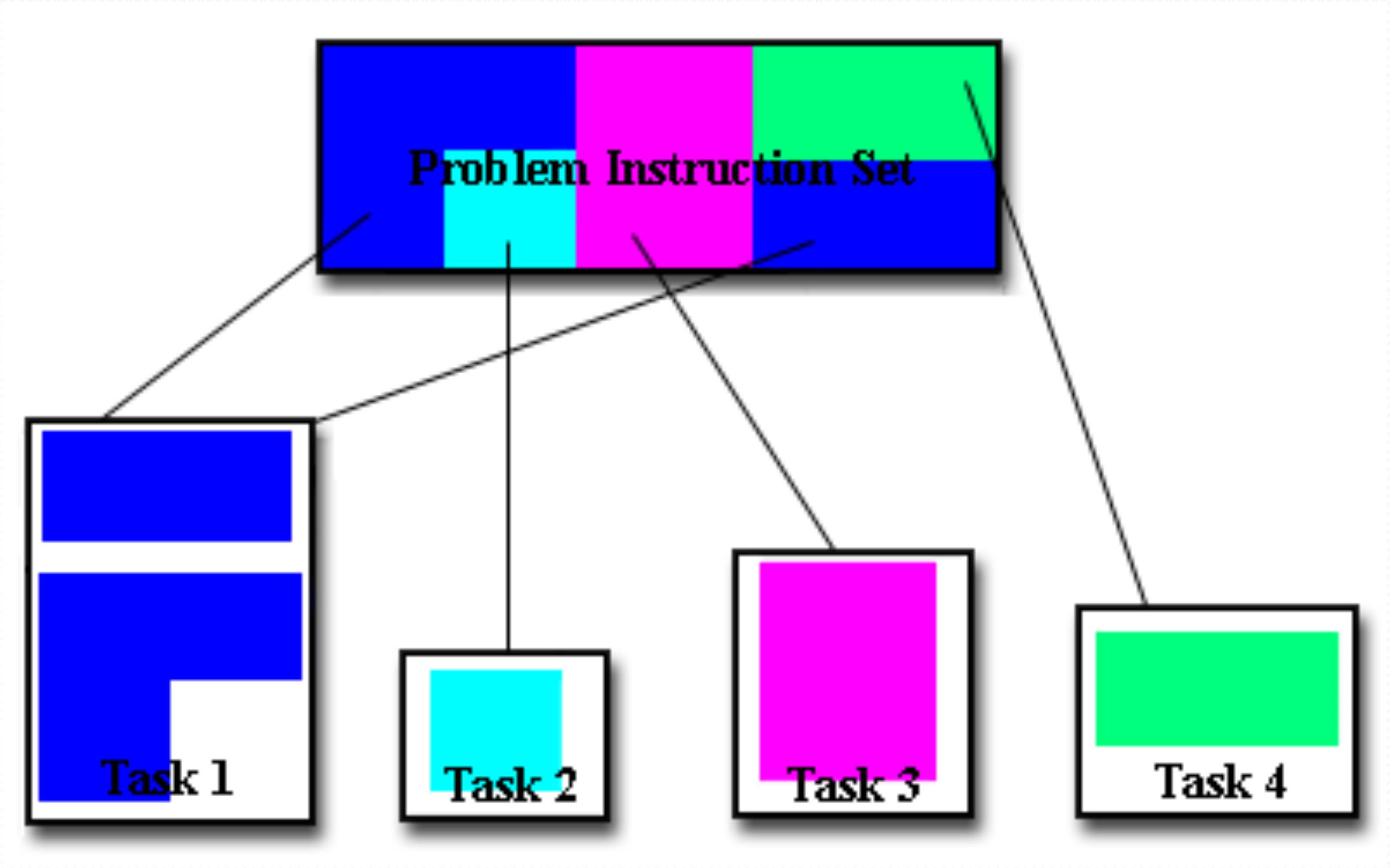
# Partition :
# Domain Decomposition

- Each task handles a portion of the data set.



# Partition
## Functional Decomposition

- Each task performs a function of the overall work



# Designing Parallel Programs
## Communication

- Synchronous communications are often referred to as *blocking communications since other* work must wait until the communications have completed.
- Asynchronous communications allow tasks to transfer data independently from one another.

# Designing Parallel Programs Synchronization

Types of Synchronization:

- Barrier
- Lock / semaphore
- Synchronous communication operations

# Example:

- As a simple example, if we are running code on a 2-processor system (CPUs "a" & "b") in a parallel environment and we wish to do tasks "A" and "B" , it is possible to tell CPU "a" to do task "A" and CPU "b" to do task 'B" simultaneously, thereby reducing the runtime of the execution.

# Example:
# Array Processing

- Serial Solution
  - Perform a function on a 2D array.
  - Single processor iterates through each element in the array
- Possible Parallel Solution
  - Assign each processor a partition of the array.
  - Each process iterates through its own partition.

# Conclusion

- Parallel computing is fast.
- There are many different approaches and models of parallel computing.

# References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# Thank You