

Department of Computer Science

Understanding Parallel Computers - Paradigms and Programming Models

Sofien GANNOUNI

Computer Science

E-mail: gnnosf@ksu.edu.sa ; gansof@yahoo.com



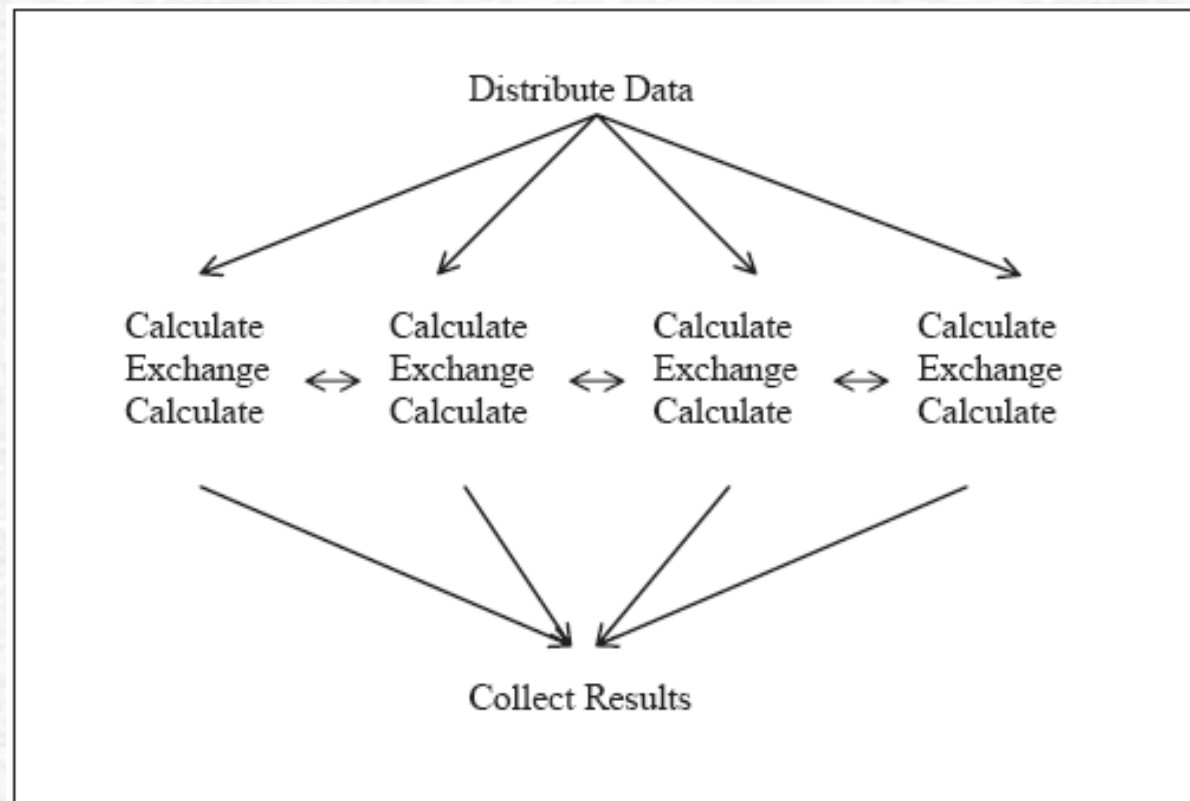
Parallel Programming Models

- **SPMD**
- **Task Farming**
- **Divide and Conquer**
- **Dataflow**

Single Program Multiple Data (SPMD)

- SPMD model is the dominant pattern to structure parallel programs.
- A single program is loaded into each node of a parallel system.
- Nodes are executing the code independently but act on multiple data sets including "private" and "shared" data.
- Nodes cooperating in the execution of the program are assigned unique IDs, allowed to self-schedule themselves, and dynamically get assigned to the required tasks under this cooperative execution.

SPMD: The Concept



Basic structure of SPMD program

Task Farming Model

☞ **Task farming (or Master-Worker or Master-Slave or Manager-Worker) consists of two entities:**

- the master
- and many workers.

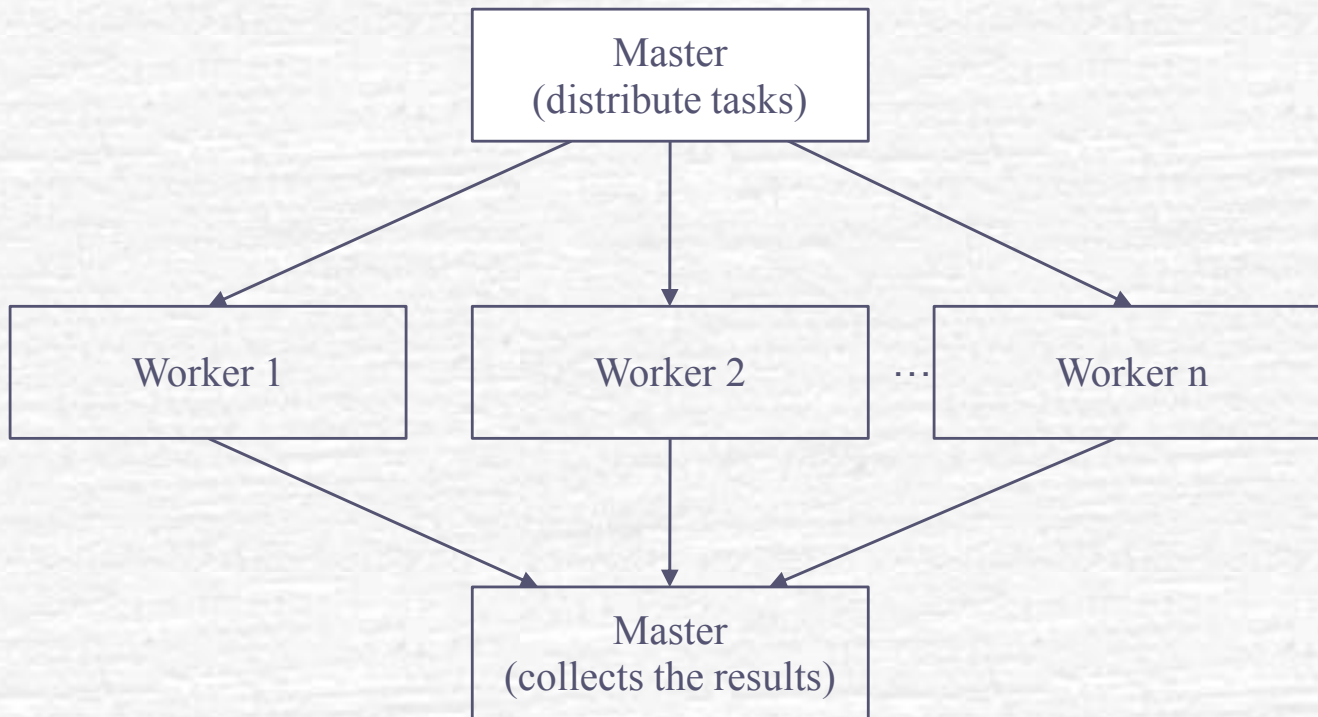
☞ **The master:**

- decomposes the problem into small tasks,
- then distributes/farms these tasks among a farm of workers
- and finally collects the partial results to produce the final result of the computation.

☞ **The worker:**

- receives a task, process it and send the result back to the master.

Basic Task Farming Structure



Simple Task Farming Algorithm

Initialization

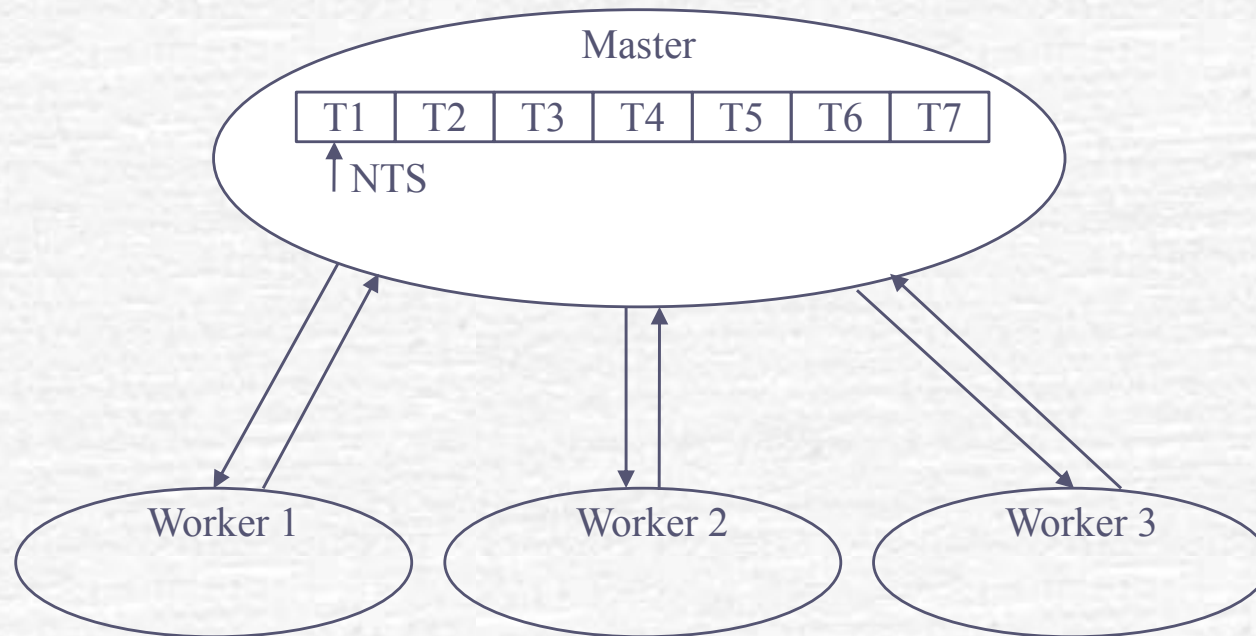
For task = 1 to N

PartialResult = + Function (task) ← Worker Tasks

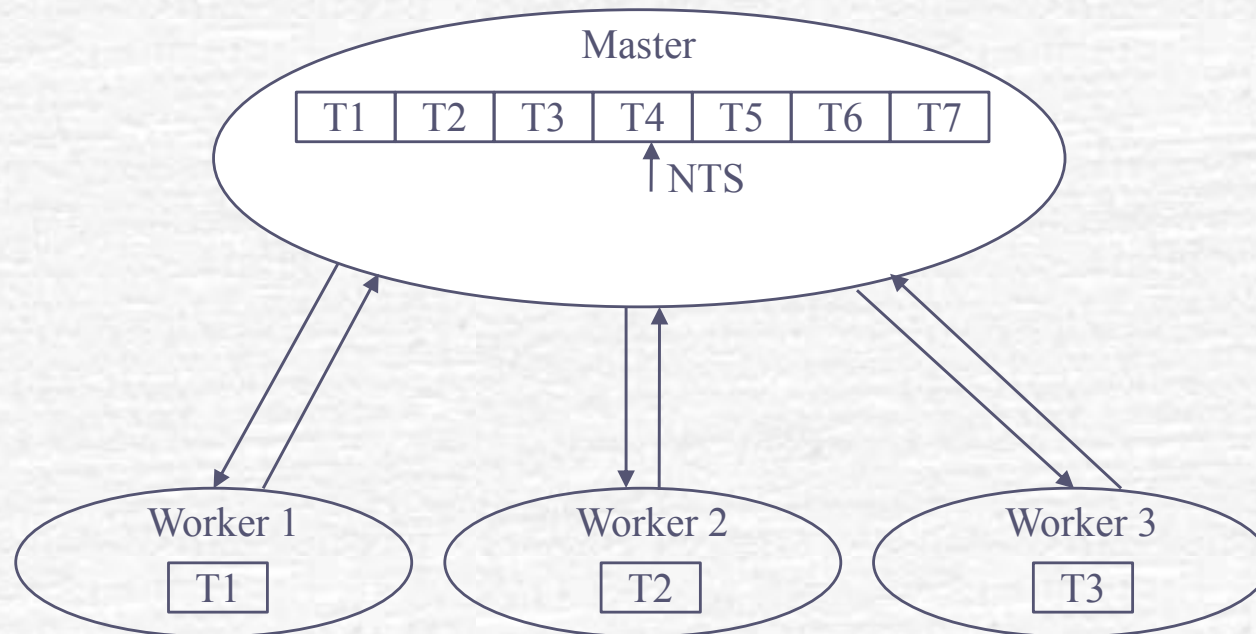
End

act_on_tasks_complete() ← Master Tasks

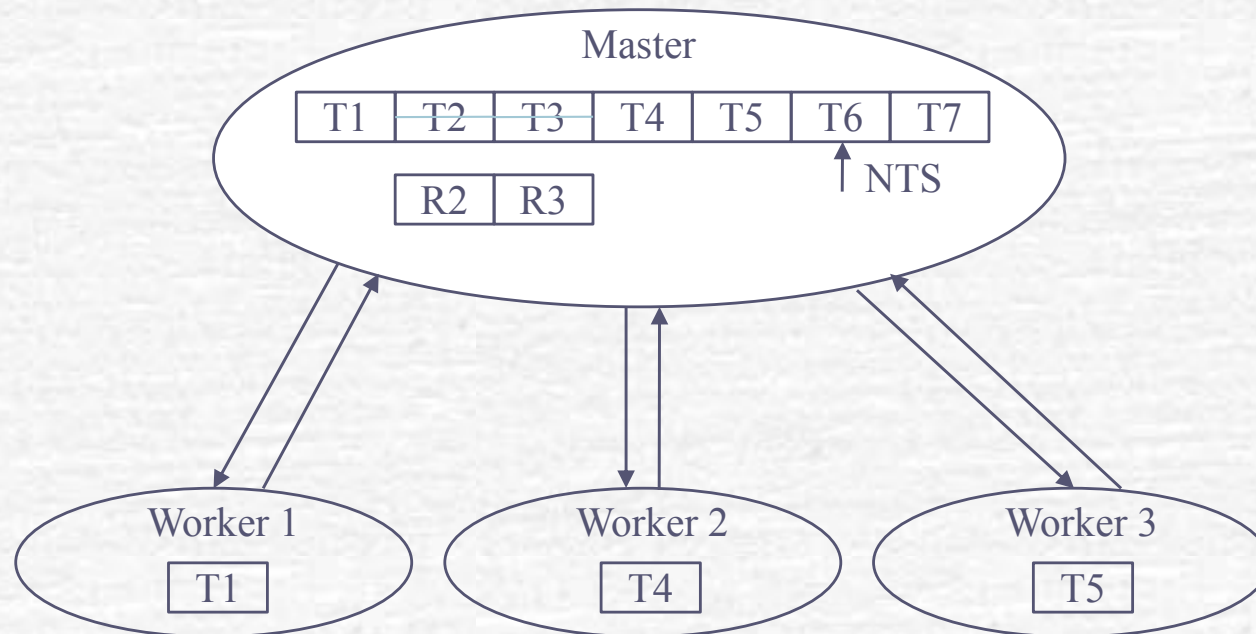
Simple Task Farming Example (a)



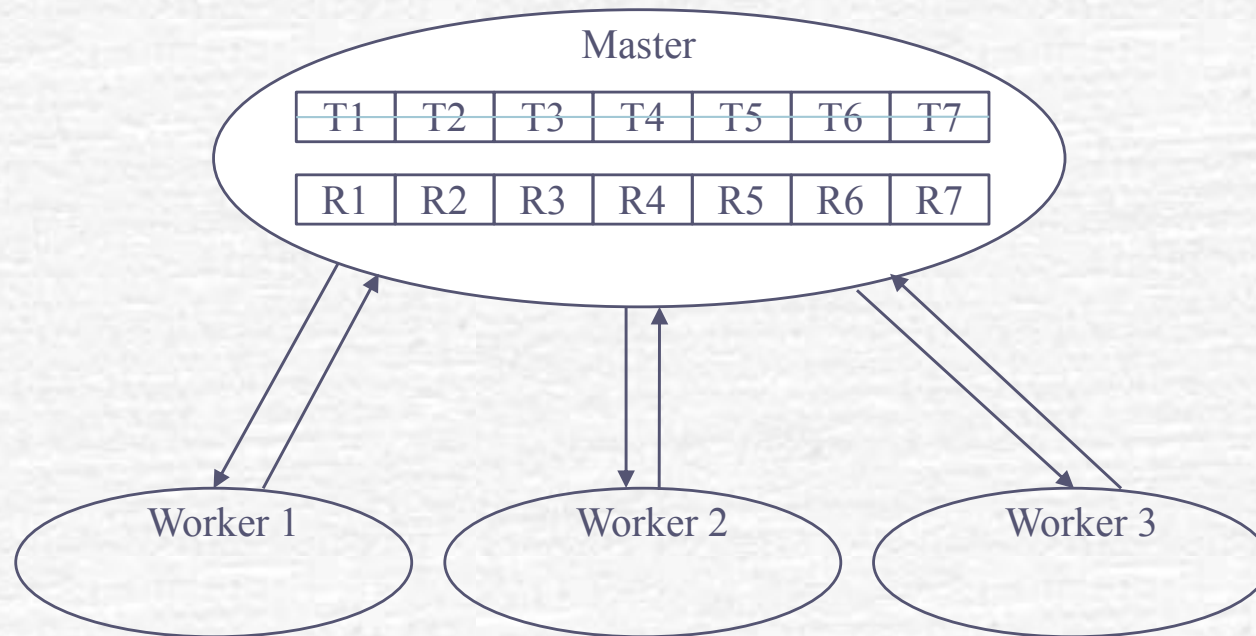
Simple Task Farming Example (b)



Simple Task Farming Example (c)



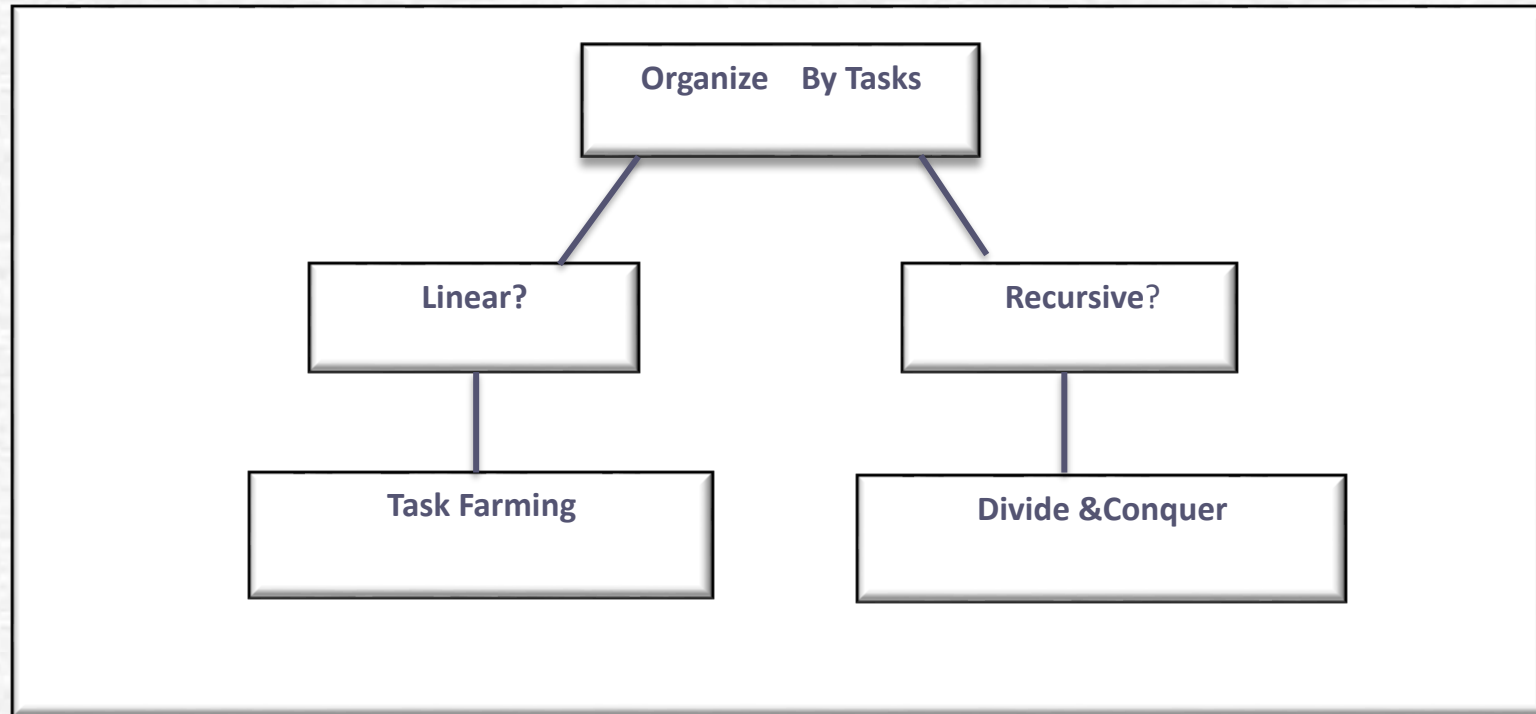
Simple Task Farming Example (d)



Divide and Conquer Model

- This model solves a complex problem by splitting it into smaller easier sub-problems.
- The sub-problems have the same nature as the original one and could be solved by recursively applying the same algorithm.
- The recursion stops at the base case in which the sub-problem is solved directly.
- The results of all sub-problems are then joined to produce the final overall solution.
- The sub-problems are usually solved independently and concurrently

Task Organization



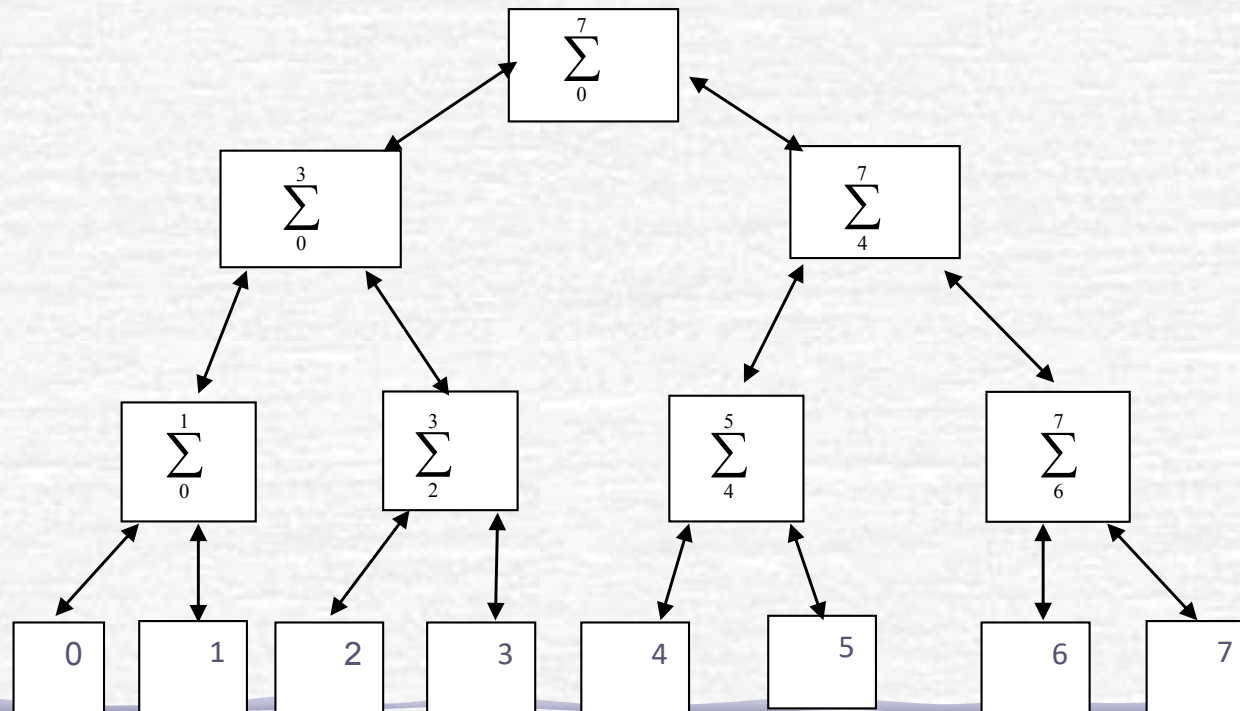
- ☛ The key point in Divide and Conquer is that the same task is recursively performed on different data.

Parallel Divide and Conquer Example

Problem : Summing N numbers .

Solution : Divide into two subproblems each of size N/2

Using the feature $\sum_{i=0}^{2^n-1} = \sum_{i=0}^{2^{n-1}-1} + \sum_{i=2^{n-1}}^{2^n-1}$



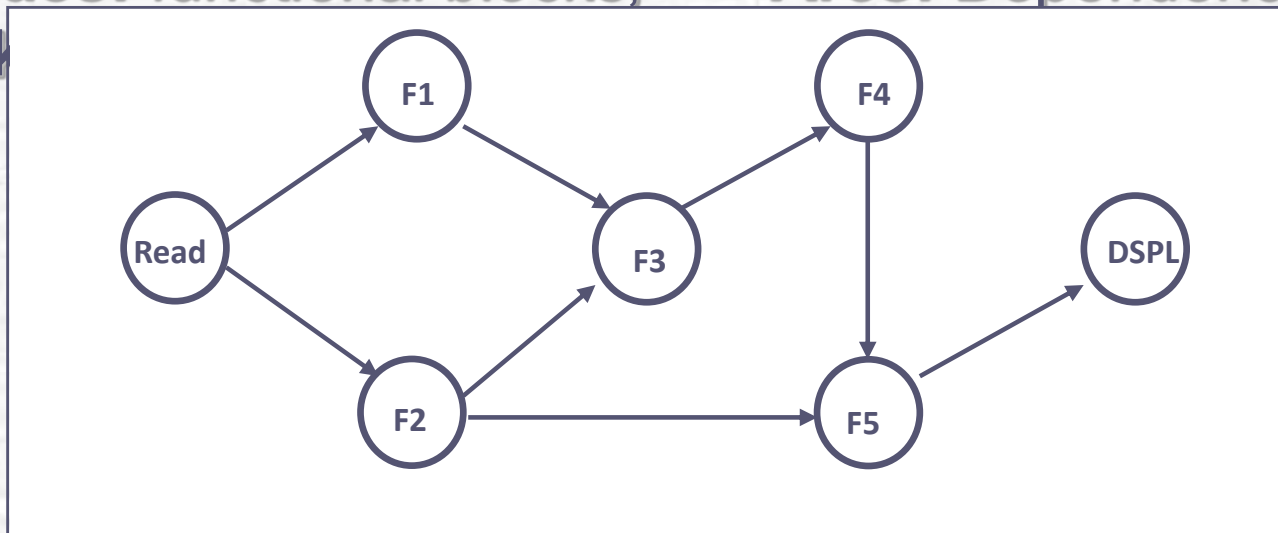
Dataflow

- The main concept of dataflow programming is to divide the computation problem into multiple disjoint functional blocks.
- Each block solves part of the problem.
- Blocks are connected to each other to :
 - show the dependency between them.
 - *express the logical execution flow*, and they can be used to easily express parallelism.
- Data-pipelining is a specialized case of dataflow model.

Principles of Dataflow Model

In dataflow model, computation is modeled as a directed graph.

- Nodes: functional blocks, Tokens
Arcs: Dependency,



There may be many nodes that are ready to fire (execute) at a given time.