# 6 Load Balancing and Termination Detection

[Weightage(12%): Approx. 8-9 Marks out of 70 Marks]

- Load Balancing

- Dynamic Load Balancing

- Distributed Termination Detection Algorithms

- Program Example

6.1 Load Balancing

- **Load balancing** is used to distribute computations fairly across processors in order to obtain the highest-possible execution speed.
- A related issue is detecting when a computation is completed: **termination detection**.
- So far, a problem is divided into a fixed number of processes that are to be executed in parallel. The distribution of processes among available processors was done simply without looking at the features/speed of processors. Due to such uneven distribution, some fast processors would become idle after performing the tasks assigned to them.
- Ideally, we want all the processors to run continuously without letting anyone idle which would lead to improvement in execution time.
- This is achieved through load balancing where the tasks are spreaded evenly across the processors.

6.1 Load Balancing
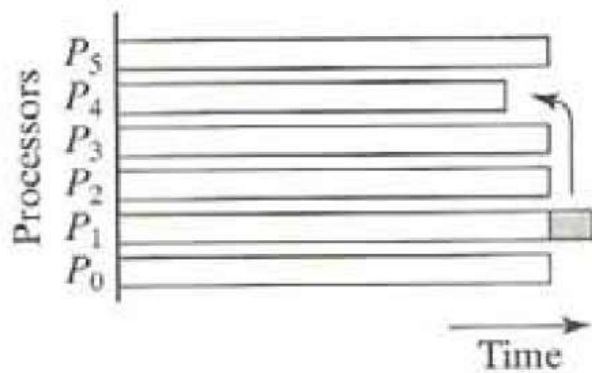
(a) Imperfect load balancing leading to increased execution time
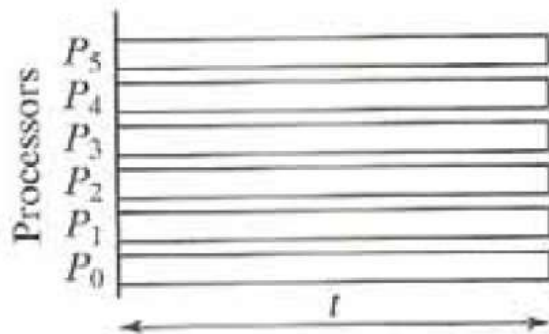
(b) Perfect load balancing

This figure is also viewed as a form of bin packing (i.e. placing objects into boxes to reduce the total number of boxes)
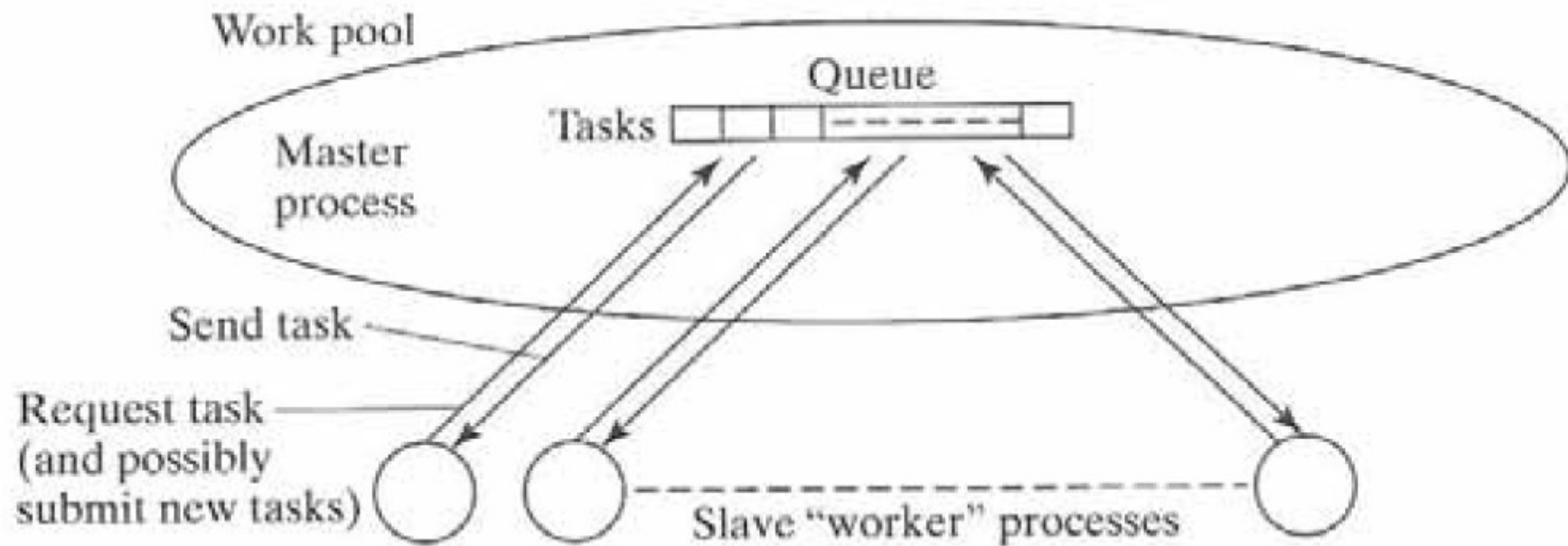
Load Balancing:
- **Static**: Before execution of any process
- Also known as mapping problem or scheduling problem
- Round Robin Algorithm
- Randomized Algorithm
- Recursive Bisection
- Simulated Annealing
- Genetic Algorithm
- **Dynamic**: During execution of any process
- Flaws of static load balancing are taken into consideration
- Centralized
- Decentralized

- **Flaws in Static Load Balancing**:
- Flaws in static load balancing:
- It is difficult to estimate accurately the execution times of various parts of a program without actually executing the parts, which results into inaccuracy.
- Some system may have communication delays which depends on various circumstances.
- Some problems have an indeterminate number of steps to reach their solution.

6.2 Dynamic Load Balancing

Centralized Dynamic Load Balancing

6.2 Dynamic Load Balancing
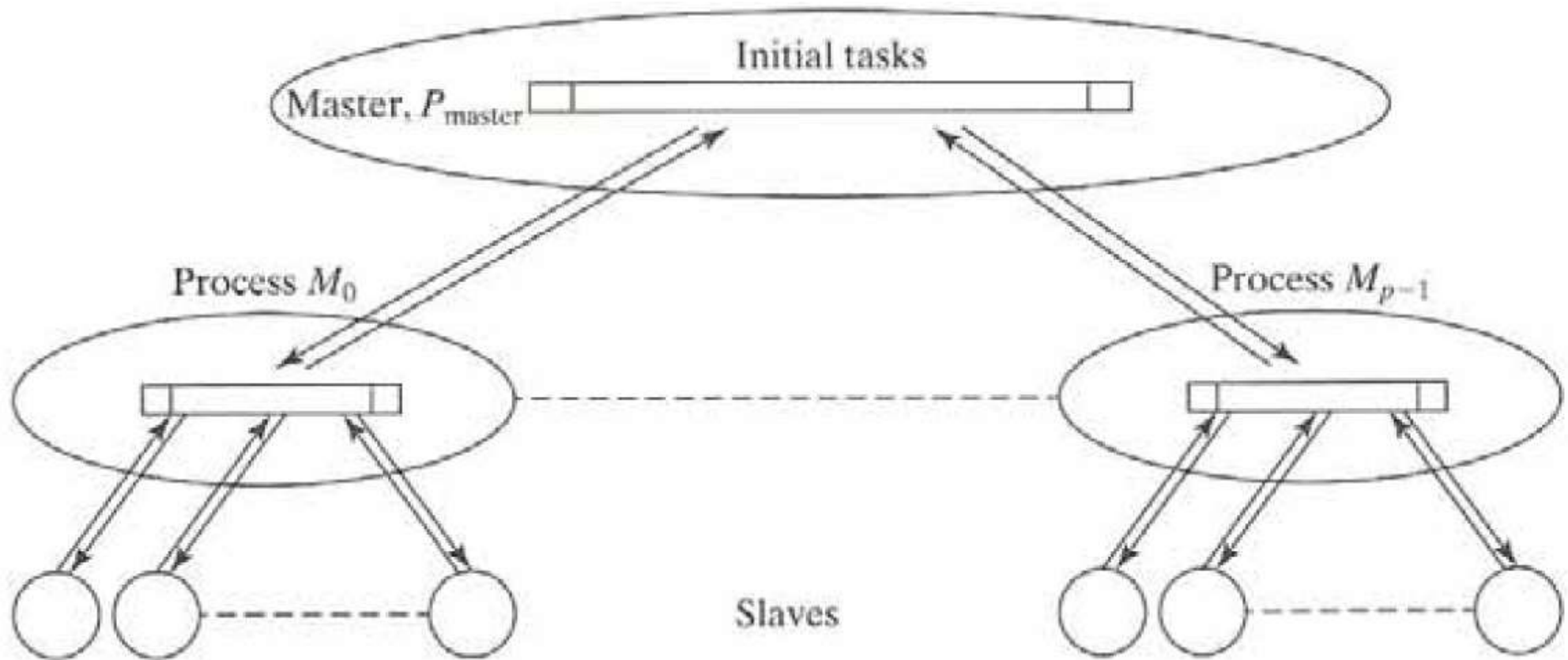

Decentralized Dynamic Load Balancing

6.3 Distributed Termination Detection Algorithms

- It is important to look at hot to terminate the distributed tasks. Before that, let us first understand the **termination conditions**.

Termination conditions

- When a computation is distributed, recognizing that the computation has come to an end may be difficult.
- In general, distributed termination at time t requires the following conditions to be satisfied:

(a) Application specific local terminating conditions exist throughout the collection of processes, at time t.

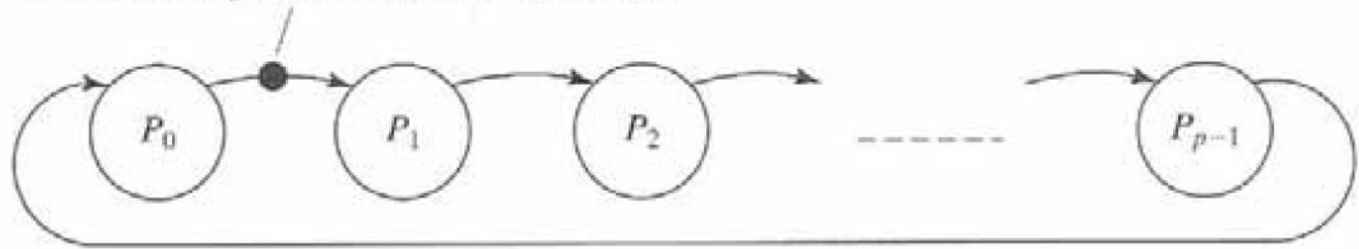(b) There are no messages in transit between processes at time t.
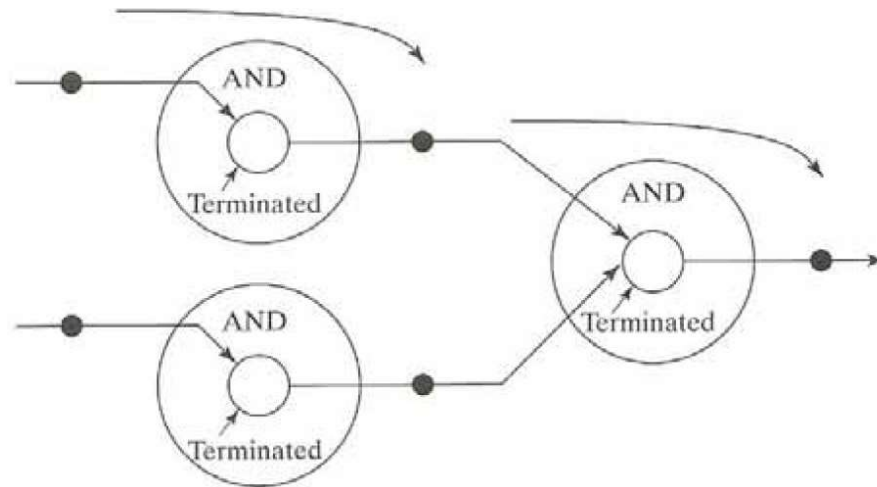
Using Acknowledgement Messages
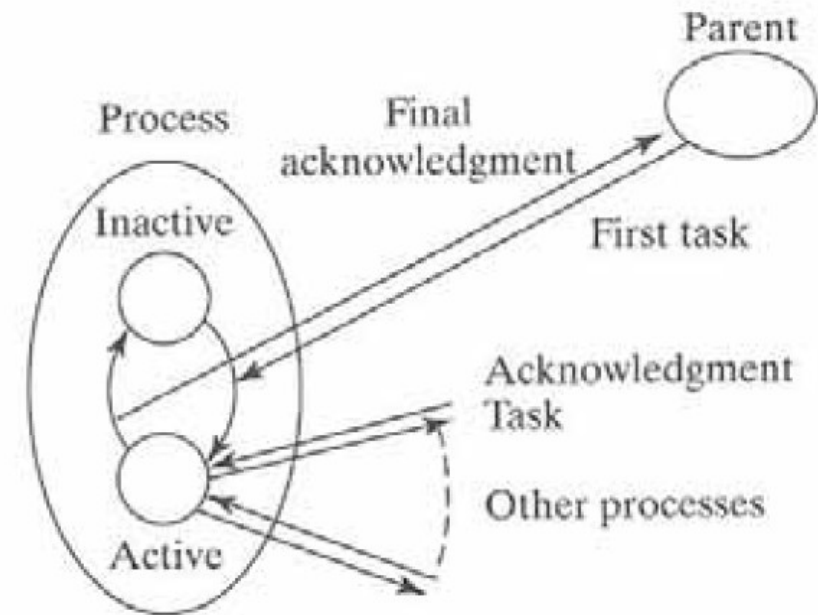
6.3 Distributed Termination Detection Algorithms

Ring Termination Algorithms

Token passed to next processor after reaching local termination condition

P_0 P_1 P_2 ------- P_{p-1}

Tree Termination Algorithms

AND
Terminated

AND
Terminated

AND
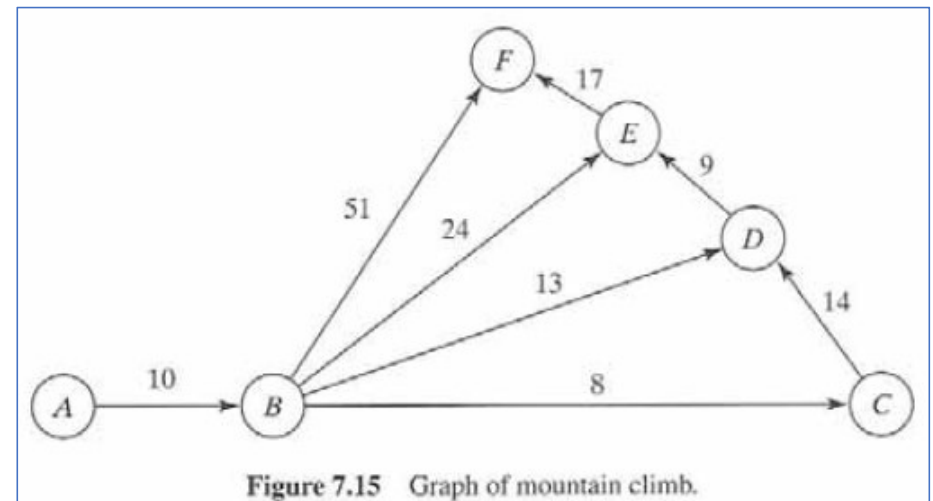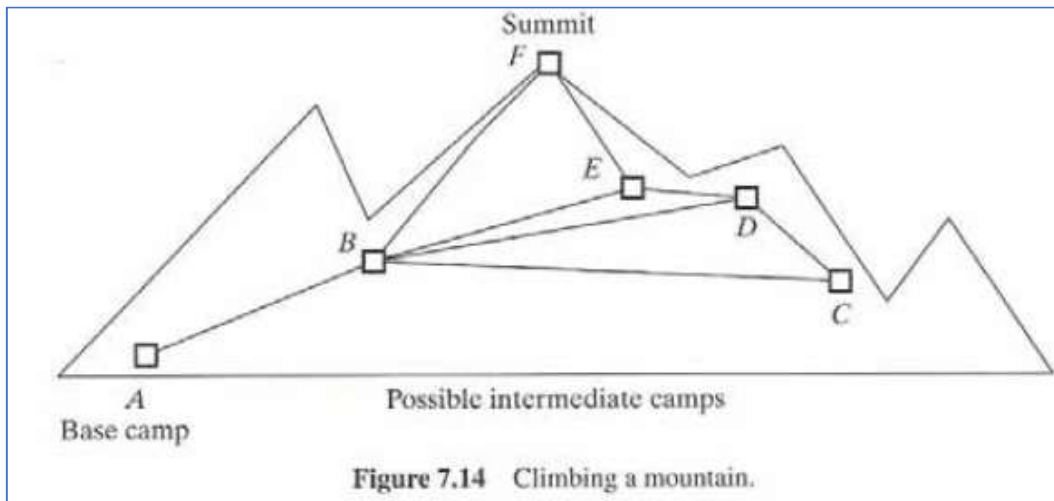Terminated

6.4 Program Example

Now, we'll see how various load-balancing techniques can be applied to a representative problem.
Application areas: Search and Optimization, Image Processing, Ray Tracing, Volume Rendering

Shortest-Path Problem: Shortest distance between two points on a graph. Given a set of interconnected nodes where the links between the nodes are marked with "weights", find a path from one specific node to another that has the smallest accumulated weights.

6.4 Program Example

Shortest-Path Problem:

Figure 7.14   Climbing a mountain.

Figure 7.15   Graph of mountain climb.

6 Load Balancing and Termination Detection

- What is load balancing? What are the issues we face if load balancing is not incorporated?
- List various static load balancing algorithms.
- What are the flaws/limitations of static load balancing?
- Explain Centralized Dynamic Load Balancing with diagram
- Explain Decentralized Dynamic Load Balancing with diagram
- What is termination conditions?
- Explain termination conditions using (a) Using Acknowledgement Messages.
- Explain termination conditions using (b) Ring Termination Algorithms.
- Explain termination conditions using (c) Tree Termination Algorithms.
- Explain "Climbing a mountain" method to find shortest path algorithm