# SNS COLLEGE OF TECHNOLOGY


**Coimbatore-35.**

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## COURSE NAME : 19CSB201 – OPERATING SYSTEMS

## II YEAR/ IV SEMESTER

## UNIT – II Process Scheduling And Synchronization

## Topic: Deadlock: System Model & Characterization


Mr.N.Selvakumar

Assistant Professor

Department of Computer Science and Engineering

# Deadlocks

- System Model
- Deadlock Characterization
- Methods for Handling Deadlocks
- Deadlock Prevention
- Deadlock Avoidance
- Deadlock Detection
- Recovery from Deadlock

# Deadlock

A process requests resources; if the resources are not available at that time, the process enters a waiting state.

Sometimes, a waiting process is never again able to change state, because the **resources it has requested are held by other waiting processes**. This situation is called a deadlock.

# System Model

- System consists of resources
- Resource types $R_1, R_2, \ldots, R_m$

  *CPU cycles, memory space, I/O devices*
- Each resource type $R_i$ has $W_i$ instances.
- Each process **utilizes a resource** as follows:
  - **request**
  - **use**
  - **release**

- A process must **request** a resource before using it and must **release** the resource after using it.
- A process **may request as many resources** as it requires to carry out its designated task.
- Obviously, the number of resources requested may **not exceed the total number of resources available** in the system. In other words, a process cannot request three printers if the system has only two.

# Deadlock Characterization

## Necessary Conditions

Deadlock can arise if four conditions hold simultaneously.

- **Mutual exclusion**: only one process at a time can use a resource
- **Hold and wait**: a process holding at least one resource is waiting to acquire additional resources held by other processes
- **No preemption**: a resource can be released only voluntarily by the process holding it, after that process has completed its task
- **Circular wait**: there exists a set $\{P_0, P_1, \ldots, P_n\}$ of waiting processes such that $P_0$ is waiting for a resource that is held by $P_1$, $P_1$ is waiting for a resource that is held by $P_2$, …, $P_{n-1}$ is waiting for a resource that is held by $P_n$, and $P_n$ is waiting for a resource that is held by $P_0$.

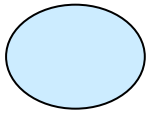
# Resource-Allocation Graph

A set of vertices $V$ and a set of edges $E$.

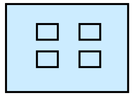
- V is partitioned into two types:
  - $P = \{P_1, P_2, \ldots, P_n\}$, the set consisting of all the **active processes** in the system
  - $R = \{R_1, R_2, \ldots, R_m\}$, the set consisting of all **resource** types in the system
- **request edge** – directed edge $P_i \rightarrow R_j$
- **assignment edge** – directed edge $R_j \rightarrow P_i$

# Resource-Allocation Graph (Cont.)

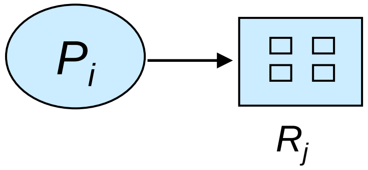
- Process



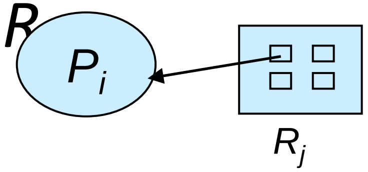
- Resource Type with 4 instances



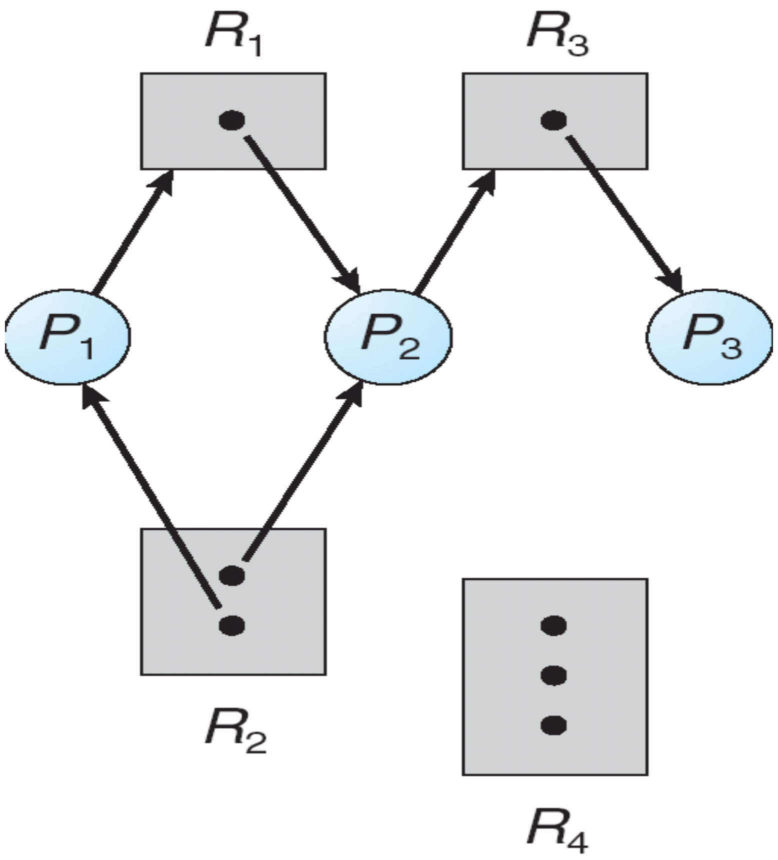
- $P_i$ requests instance of $R_j$




- $P_i$ is holding an instance of $R_j$

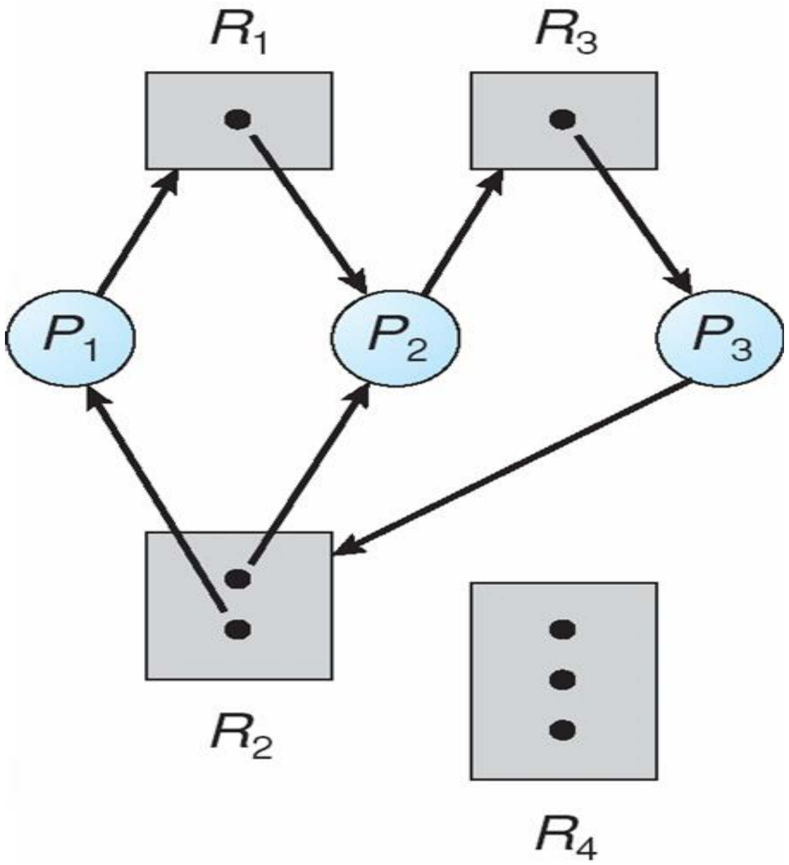


# Example of a Resource Allocation Graph



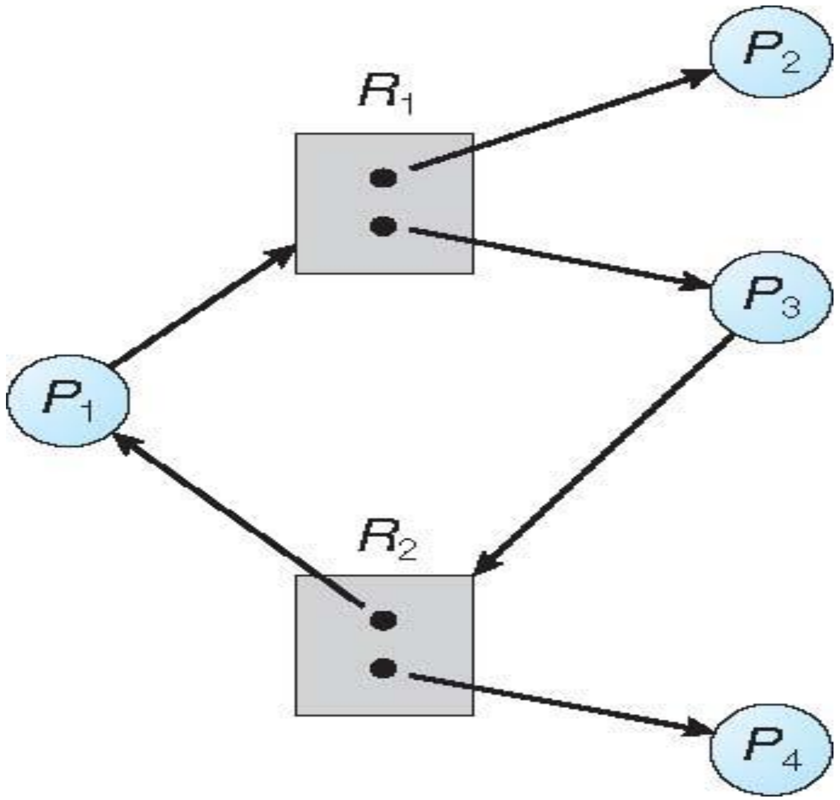

- The sets $P$, $R$, and $E$:
  - $P = \{P_1, P_2, P_3\}$
  - $R = \{R_1, R_2, R_3, R_4\}$
  - $E = \{P_1 \rightarrow R_1, P_2 \rightarrow R_3, R_1 \rightarrow P_2, R_2 \rightarrow P_2, R_2 \rightarrow P_1, R_3 \rightarrow P_3\}$
- Resource instances:
  - One instance of resource type $R_1$
  - Two instances of resource type $R_2$
  - One instance of resource type $R_3$
  - Three instances of resource type $R_4$
- Process states:
  - Process $P_1$ is holding an instance of resource type $R_2$ and is waiting for an instance of resource type $R_1$.
  - Process $P_2$ is holding an instance of $R_1$ and an instance of $R_2$ and is waiting for an instance of $R_3$.
  - Process $P_3$ is holding an instance of $R_3$.

# Resource Allocation Graph **With A Deadlock**




$$P_1 \rightarrow R_1 \rightarrow P_2 \rightarrow R_3 \rightarrow P_3 \rightarrow R_2 \rightarrow P_1$$
$$P_2 \rightarrow R_3 \rightarrow P_3 \rightarrow R_2 \rightarrow P_2$$

# Graph With A Cycle But **No Deadlock**



# Basic Facts

- If graph contains **no cycles** ⇒ **no deadlock**
- If graph contains a **cycle** ⇒
  - if only **one instance** per resource type, then **deadlock**
  - if **several instances** per resource type, **possibility of deadlock**

# Methods for Handling Deadlocks

- Ensure that the system will ***never*** enter a deadlock state:
  - Deadlock prevention
  - Deadlock avoidence
- Allow the system to enter a deadlock state and then recover
- Ignore the problem and pretend that deadlocks never occur in the system; used by most operating systems, including UNIX

- we can deal with the deadlock problem in **one of three ways**:
- We can use a protocol to prevent or avoid deadlocks, ensuring that the system will never enter a deadlocked state.
- We can allow the system to enter a deadlocked state, detect it, and recover.
- We can ignore the problem altogether and pretend that deadlocks never occur in the system.

# REFERENCES

**TEXT BOOKS:**

T1 Silberschatz, Galvin, and Gagne, “Operating System Concepts”, Ninth Edition, Wiley India Pvt Ltd, 2009.)

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R1 Gary Nutt, “Operating Systems”, Third Edition, Pearson Education, 2004.

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R3 Abraham Silberschatz, Peter Baer Galvin and Greg Gagne, “Operating System Concepts”, 9th Edition, John Wiley and Sons Inc., 2012.

R4. William Stallings, “Operating Systems – Internals and Design Principles”, 7th Edition, Prentice Hall, 2011


THANK
YOU!