L23-A DEADLOCK DETECTION

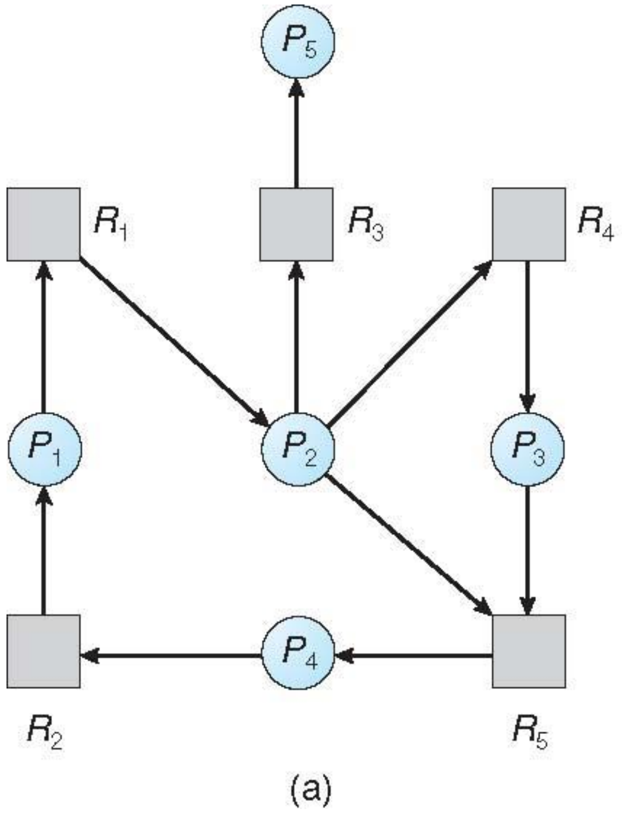
Deadlock Detection

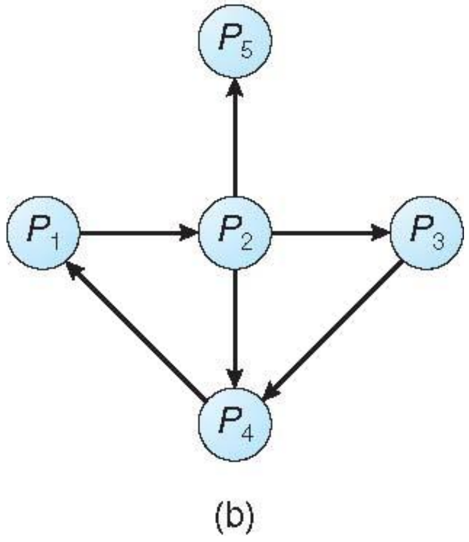
- Allow system to enter deadlock state
- Detection algorithm
- Recovery scheme

Detection in Single Instance Resource Types

- Maintain **wait-for** graph
  - Nodes are processes
  - $\mathbf{P_i} \rightarrow \mathbf{P_j}$ if $\mathbf{P_i}$ is waiting for $\mathbf{P_j}$
- Periodically invoke an algorithm that searches for a cycle in the graph. If there is a cycle, there exists a deadlock
- An algorithm to detect a cycle in a graph requires an order of $\mathbf{n^2}$ operations, where **n** is the number of vertices in the graph

Resource-Allocation Graph and Wait-for Graph





Resource-Allocation Graph Corresponding wait-for graph

Several Instances of a Resource Type

- **Available**: A vector of length **m** indicates the number of available resources of each type

- **Allocation**: An **n x m** matrix defines the number of resources of each type currently allocated to each process

- **Request**: An **n x m** matrix indicates the current request of each process. If **Request [i][j] = k**, then process $\mathbf{P_i}$ is requesting **k** more instances of resource type $\mathbf{R_j}$.

Detection Algorithm

1. Let **Work** and **Finish** be vectors of length **m** and **n**, respectively Initialize:

   (a) **Work = Available**

   (b) For **i = 1,2, …, n**, if **Allocation**$_i \neq$ **0**, then **Finish[i] = false**; otherwise, **Finish[i] = true**

2. Find an index **i** such that both:

   (a) **Finish[i] == false**

   (b) **Request**$_i \leq$ **Work**

   If no such **i** exists, go to step 4

Detection Algorithm contd..

3. **Work = Work + Allocation$_i$**
   Finish[i] = true
   go to step 2

4. If **Finish[i] == false**, for some **i**, $1 \leq$ **i** $\leq$ **n**, then the system is in deadlock state. Moreover, if **Finish[i] == false**, then **P$_i$** is deadlocked

Algorithm requires an order of O(m x n^2) operations to detect whether the system is in deadlocked state

Example of Detection Algorithm

- Five processes P_0 through P_4; three resource types A (7 instances), B (2 instances), and C (6 instances)
- Snapshot at time T_0:

	Allocation	Request	Available
	A B C	A B C	A B C
P_0	0 1 0	0 0 0	0 0 0
P_1	2 0 0	2 0 2	
P_2	3 0 3	0 0 0	
P_3	2 1 1	1 0 0	
P_4	0 0 2	0 0 2	

Example of Detection Algorithm contd..

- ***P_2*** requests an additional instance of type ***C***

Request

	A B C
P_0	0 0 0
P_1	2 0 2
P_2	0 0 1
P_3	1 0 0
P_4	0 0 2

- State of system? :
- Can reclaim resources held by process ***P_0***, but insufficient resources to fulfill other processes; requests
  - Deadlock exists, consisting of processes ***P_1***, ***P_2***, ***P_3***, and ***P_4***

Detection-Algorithm Usage

- When, and how often, to invoke depends on:
  - How often a deadlock is likely to occur?
  - How many processes will need to be rolled back?
    - one for each disjoint cycle

- If detection algorithm is invoked arbitrarily, there may be many cycles in the resource graph and so we would not be able to tell which of the many deadlocked processes caused the deadlock.

Recovery from Deadlock: Process Termination

- Abort all deadlocked processes
- Abort one process at a time until the deadlock cycle is eliminated
- In which order should we choose to abort?
  1. Priority of the process
  2. How long process has computed, and how much longer to completion?
  3. Resources the process has used
  4. Resources process needs to complete
  5. How many processes will need to be terminated?
  6. Is process interactive or batch?

Recovery from Deadlock: Resource Preemption

- **Selecting a victim** – minimize cost

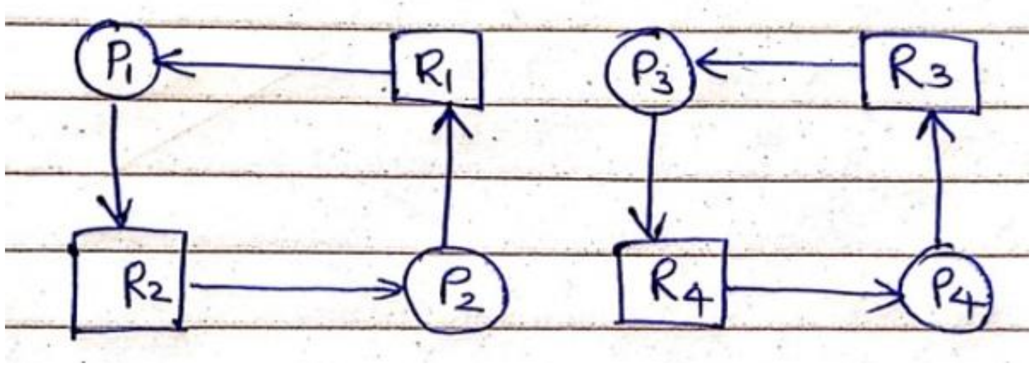
- **Rollback** – return to some safe state, restart process for that state

- **Starvation** – same process may always be picked as victim, include number of rollback in cost factor

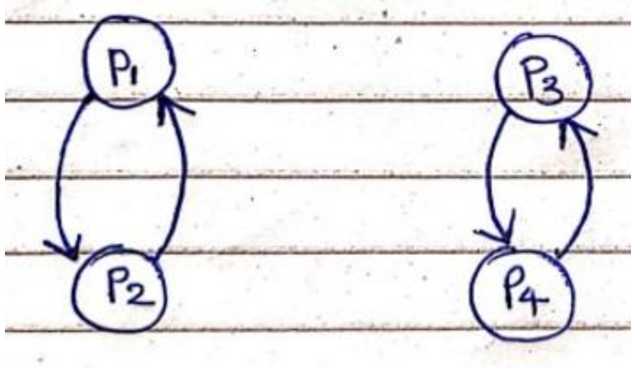
Resource Allocation and Wait for Graphs

Q1: Consider 4 process P1, P2, P3 & P4 and 4 single instance resources R1, R2, R3 & R4. Each Pi is holding a resource Ri and requesting for another resource Rj, where j≠i. Draw the resource allocation graph and wait for graph for this system, such that there exists more than one cycle in both the graphs.

Resource Allocation Graph



Wait for Graph



Thank You