Announcements

- Midterm is Thursday (3/10/16)
  - Covers up through this Th lecture

- Project #2 is due Th at 5:00 PM
- Project #1 Re-grade request deadline is Wed 3/2/16 at 11:00 am

Deadlock Avoidance

- Require additional information about how resources are to be requested - decide to approve or disapprove requests on the fly
- Assume that each process lets us know its maximum resource request
- Safe state:
  - system can allocate resources to each process (up to its maximum) in *some order* and still avoid a deadlock
  - A system is in a safe state if there exists a *safe sequence*

Safe Sequence

- Sequence of processes <P_1, .. P_n> is a safe sequence if for each P_i, the resources that P_i can request can be satisfied by the currently available resources plus the resources held by all P_j, $j<i$
- If the necessary resources are not immediately available, P_i can always wait until all P_j, $j<i$ have completed

Banker's Algorithm

- Each process must declare the maximum number of instances of each resource type it may need
- Maximum can't exceed resources available to system
- Variables:

  n is the number of processes

  m is the number of resource types

  – Available - vector of length m indicating the number of available resources of each type
  – Max - n by m matrix defining the maximum demand of each process
  – Allocation - n by m matrix defining number of resources of each type currently allocated to each process
  – Need: n by m matrix indicating remaining resource needs of each process
  – Work: a vector of length m (resources)
  – Finish: a vector of length n (processes)

Safe State Predicate

1. Work = Available; Finish[*] = false
2. Find an *i* such that Finish[i] = false
   and Need[i,*] <= Work[i,*] if no such i, go to 4
3. Work[i,*] += Allocation[i,*];
   Finish[i] = true;
   goto step 2
4. If Finish[i] = true for all i, system is in a safe state

all elements in the vector are <=

Note this requires m x n^2 steps

Safe State Predicate - Example

Three resources: A, B, C (10, 5, 7 instances each)

Consider the snapshot of the system at this time

	Alloc	Max	Avail	Need (Max - alloc)
	A B C	A B C	A B C	A B C
P0	0 1 0	7 5 3	3 3 2	7 4 3
P1	2 0 0	3 2 2		1 2 2
P2	3 0 2	9 0 2		6 0 0
P3	2 1 1	2 2 2		0 1 1
P4	0 0 2	4 3 3		4 3 1

System is in a safe state, since the sequence <P1, P3, P4, P2, P0> satisfy the safety criteria.

Resource Request Algorithm

(1) If $Request_i$ <= $Need_i$ then goto 2

- otherwise - the process has exceeded its maximum claim

(2) If $Request_i$ <= Available then goto 3

- otherwise process must wait since resources are not available

(3) Check request by having the system pretend that it has allocated the resources by modifying the state as follows:

- Available = Available - $Request_i$
- Allocation = Allocation + $Request_i$
- $Need_i$ = $Need_i$ - $Request_i$

- Find out if resulting resource allocation state is safe, otherwise the request must wait.