Slide 1

Administrivia

- Reminder: Homework 7 due today.
- One more short homework, to be on the Web soon.

Slide 2

Deadlocks — Introduction

- Some resources should not be shared — among processes, computers, etc.
- To enforce this, o/s (or whatever) provides mechanism to give one process at a time exclusive use, make others wait.
- Possibility exists that others will wait forever — deadlock.

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Resources

- "Resource" is anything that should be used by only one process at a time — hardware device, piece of information (e.g., database record), etc.

  Can be unique (e.g, particular database record) or non-unique (e.g., one block of a fixed-size disk area such as swap space).
- Preemptible versus non-preemptible — preemptible resources can be taken away from current owner without causing something to fail (e.g., memory); non-preemptible resources can't (e.g., hardware device).
- Normal sequence for using a resource — request it, use it, release it. If not available when requested, block or busy-wait.

  Can easily implement this using semaphores, but then deadlock is possible if processes aren't disciplined.

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Deadlocks — Definitions and Conditions

- Definition — set of processes is "deadlocked" if each process in set is waiting for an event that only another process in set can cause.
- Necessary conditions:
  - Mutual exclusion — resources can be used by at most one process at a time.
  - Hold and wait — process holding one resource can request another.
  - No preemption — resources cannot be taken away but must be released.
  - Circular wait — circular chain of processes exists in which each process is waiting for resource held by next.
- Modeling deadlock — "resource graphs" (examples in textbook).
- What do about them? Various approaches.

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What To Do About Deadlocks — Nothing

- One strategy for dealing with deadlocks — "ostrich algorithm" (ignore potential for deadlocks, hope they don't happen).
- Does this work?

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Do Nothing, Continued

- Doesn't always work, of course.
- But simple to implement, and in practice works most of the time.

Slide 7

What To Do About Deadlocks — Detection and Recovery

- How to detect deadlocks — DFS on resource graph, (or if more than one resource of each type, algorithm from text).
- When to check for deadlocks:
  - Every time a resource is requested.
  - At regular intervals.
  - When CPU utilization falls below threshold.
- What to do if deadlock is found?
  - Preemption.
  - Rollback.
  - Process termination.
- Does this work?

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Detection and Recovery, Continued

- Does work.
- But potentially time-consuming, and “what to do” choices aren’t very attractive!

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What To Do About Deadlocks — Avoidance

- Can base on idea of "safe" states (in which it's possible to schedule to avoid deadlock) versus "unsafe" states (in which it's not). Idea is to avoid unsafe states. (Details in textbook.)
- "Banker's algorithm" (Dijkstra, 1965) — idea is to never satisfy request for resource if it leads to unsafe state. (Details in textbook.)
- Does this work?

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Avoidance, Continued

- Does work.
- But not much used because it assumes a fixed number of processes, resource requirements known in advance.

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What To Do About Deadlocks — Prevention

- Idea here is to make it impossible to satisfy one of the four conditions for deadlock:
  - Mutual exclusion — don't allow more than one process to use a resource. E.g., define a printer-spool process to manage printer.
  - Hold and wait — require processes to request all resources at the same time and either get them all or wait.
  - No preemption — allow preemption.
  - Circular wait — impose strictly increasing ordering on resources, and insist that all processes request resources "in order".
- Do these work?

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Prevention, Continued

- Don't allow more than one process to use a resource:

  Solves immediate problem but may produce others.
- Require processes to request all resources at the same time and either get them all or wait:

  Works but may not be possible or efficient.
- Allow preemption.

  Not usually possible/desirable.
- Impose strictly increasing ordering on resources, and insist that all processes request resources "in order".

  Works, but finding an ordering may be difficult.

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Deadlocks — Related Issues

- Classical description is in terms of “resources”, but other kinds of deadlock are possible (e.g., involving communication).
- Other situations that aren’t classical deadlock but are also not good include “livelock” and “starvation” (see textbook).

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Deadlocks — Summary

- Take-home message — there’s some interesting theory related to this topic, but not a lot of practical advice, except for deadlock prevention.

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Minute Essay

- What's the smallest number of resources needed to have a deadlock?

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Minute Essay Answer

- Two — with only one, a process may wait a long time for another process to release it, but that's not true deadlock.