Deadlock

CSE 410, Spring 2006
Computer Systems

http://www.cs.washington.edu/education/courses/410/06sp/

Readings and References

• Reading
  » Chapter 8, *Operating System Concepts*, Silberschatz, Galvin, and Gagne

• Other References

Deadlock

• Circular waiting for resources
  » Task A wants what task B has
  » Task B wants what task A has
• No progress possible!
  » Neither can make progress without the other’s resource
  » Neither will relinquish its own resource

Simple Traffic Gridlock Example

...$	ext{lockOne} \rightarrow \text{Acquire}()$
...
...$	ext{lockTwo} \rightarrow \text{Acquire}()$
...$	ext{lockTwo} \rightarrow \text{Acquire}()$

DEADLOCK!
System Model

- There are **tasks** and **resources**
- A task follows these steps to utilize a resource
  - Acquire the resource
    - If the resource is unavailable, block
  - Use the resource
  - Release the resource

Necessary Conditions for Deadlock

- Mutual Exclusion
  - The resource can’t be shared
- Hold and Wait
  - Task holds one resource while waiting for another
- No Preemption
  - If a task has a resource, it cannot be forced to give it up
- Circular Wait
  - A waits for B, B for C, C for D, D for A

Is Gridlock an Example of Deadlock?

- Mutual Exclusion
  - space-time can only hold one car at a time
- Hold and wait
  - I’m here, and I want to turn left, so watch out
- No preemption
  - cannons are not allowed in cars at this time
- Circular wait
  - blue is waiting for red’s space and vice versa

Dealing with Deadlock

- Deadlock Prevention
  - Ensure statically that deadlock is impossible
- Deadlock Avoidance
  - Ensure dynamically that deadlock is impossible
- Deadlock Detection and Recovery
  - Allow deadlock to occur, but notice when it does and try to recover
- Ignore the Problem
  - Let the operator untangle it, that’s what they’re paid for
Deadlock Prevention

- There are four necessary conditions for deadlock
- Take any one of them away and deadlock is impossible
- Let’s attack deadlock by
  » examining each of the conditions
  » considering what would happen if we threw it out

Condition: Mutual Exclusion

- Usually can't eliminate this condition
  » some resources are intrinsically non-sharable
- Examples include printer, write access to a file or record, entry into a section of code
- However, you can often mitigate this by adding a layer of abstraction
  » For example, use a print spooler, not direct connection to the printer.

Condition: Hold and Wait

- Eliminate partial acquisition of resources
- Task must acquire all the resources it needs before it does anything
  » if it can’t get them all, then it gets none
- Issue: Resource utilization may be low
  » If you need P for a long time and Q only at the end, you still have to hold Q’s lock the whole time
- Issue: Starvation prone
  » May have to wait indefinitely before popular resources are all available at the same time

Condition: No Preemption

- Allow preemption
  » If a process asks for a resource not currently available, block it and take away all of its other resources
  » Add the preempted resources to the list of resources the process is waiting for
- This strategy works for some resources:
  » CPU state (contents of registers can be spilled to memory)
  » memory (can be spilled to disk)
- But not for others:
  » printer - rip off the existing printout and tape it on later?
Condition: Circular Wait

- To attack the circular wait condition:
  » Assign each resource a priority
  » Make processes acquire resources in priority order
- Two processes need the printer and the scanner, both must acquire the printer (higher priority) before the scanner
- This is a common form of deadlock prevention
- The only problem: sometimes forced to relinquish a resource that you thought you had locked up

Deadlock Avoidance

- Deadlock prevention is often too strict
  » low device utilization
  » reduced system throughput
- If the OS had more information, it could do more sophisticated things to avoid deadlock and keep the system in a safe state
  » “If” is a little word, but it packs a big punch
  » predicting all needed resources a priori is hard

The Banker’s Algorithm

- Idea: know what each process might ask for
- Only make allocations that leave the system in a safe state
- Inefficient

Deadlock Detection

- Build a wait-for graph and periodically look for cycles, to find the circular wait condition
- The wait-for graph contains:
  » nodes, corresponding to tasks
  » directed edges, corresponding to a resource held by one task and desired by the other

A waits for B
B waits for D
D waits for A
deadlock!
Deadlock Recovery

- Once you’ve discovered deadlock, what next?
- Terminate one of the tasks to stop circular wait?
  » Task will likely have to start over from scratch
  » Which task should you choose?
- Take a resource away from a task?
  » Again, which task should you choose?
  » How can you *roll back* the task to the state before it had the coveted resource?
  » Make sure you don’t keep on preempting from the same task: avoid starvation

Ignoring Deadlock

- Not a bad policy for operating systems
- The mechanisms outlined previously for handling deadlock may be expensive
  » if the alternative is to have a forced reboot once a year, that might be acceptable
- However, for thread deadlocks, your users may not be quite so tolerant
  » “the program only locks up once in a while”