UMass Boston CS 444
Homework 3
Posted Tuesday, March 25, 2025
Due Tuesday, April 1, 2025 at 11:59pm

Homework must be typeset, converted to PDF and submitted to your course directory on the CS Linux server. Late submission is penalized. To submit your homework, prepare PDF file called `hw3.pdf` — the filename must be exactly `hw3.pdf`.

This hw3 addresses: a) scheduling of Hard Disk Drives(HDD) from Tanenbaum Chapter 5, b) algorithms for deadlock analysis from Chapter 2 and Chapter 6 and c) queueing analysis. Reread Sections 5.4.1, 2.4.0 (first 3 paragraphs), 2.4.1-2.4.3 and 6.0-6.4 before beginning.

1. Hard Disk Drive Arm Motion: Suppose that an HDD has 100 cylinders, numbered 0 to 99. The disk arm is currently located at cylinder 51, and it is moving towards higher numbered cylinders. The queue of pending requests, in FIFO order, is

$$60, 82, 97, 41, 17, 23, 83$$

   What is the total distance (measured in the number of cylinders) that the disk arm moves to satisfy all the pending requests for the following scheduling algorithms? Show how you calculate them.

   (a) First come first served (FCFS)
   (b) Shortest seek first (SSF)
   (c) The (original) elevator algorithm

2. Avoiding Lost Printer Job: Suppose that a printer daemon has a small shared memory queue with two shared variables, nextFileToPrint and nextFreeSlot. See Figure 2-21, p120.

   (a) Explain the print spooler example in Section 2.4.1 by listing events. Change the story so process A never gets the print job. Assume before the list starts that slots 0-3 are empty and slots 4-6 are full (with names of files to print).
   (b) List the four conditions that must hold to have a good solution.
   (c) Use Figure 2-23, p123, to list events to show how strict alternation can fail. Explain how it violates condition 3.
   (d) Explain how Peterson's solution in Figure 2-24, p125 with busy waiting uses the turn variable and the interested array to share access. Draw the timeline for 2 processes.

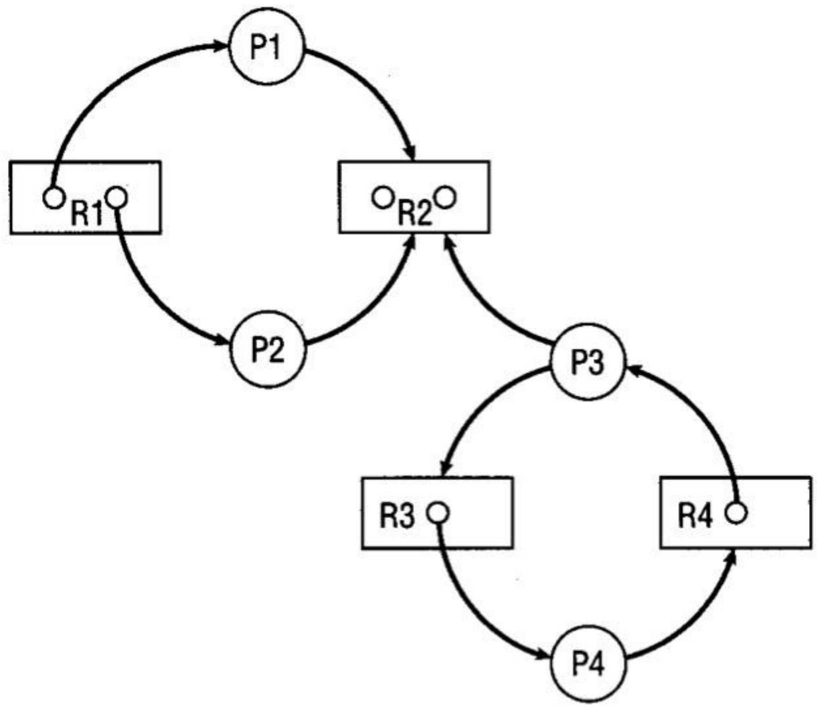

Figure 1: Resource allocation graph

3. Resource allocation graph: A process is blocked if it is requesting a resource that is not currently available. Consider the resource allocation graph of a snapshot of a system in Figure 1. Please note that the small circles in rectangles R1 and R2 indicate that 2 of that resource are available.

   (a) Are there blocked processes? If yes, which ones? Explain.
   (b) Is the system in a deadlock? Explain.
   (c) If the two units of R2 are allocated to P2 and P3, which processes will be blocked? Explain.
   (d) If the two units of R2 are allocated to P1 and P2, which processes will be blocked? Explain.

   Note: If a process is blocked in part (a) and unaffected by c) or d), it remains blocked in parts (c) and (d).

4. Queueing System: Let r be the ratio of the arrival rate to the service rate in an M/M/1 queueing system. See slides from class.

   Example: Suppose arrival rate is 4 per minute and service rate is 10 per minute. Then r = .4. Let p0 be the probability that the system has no customers. Then:

```
for 0 < r < 1 we have:
p0 = 1 - r
```

   Furthermore, the probability that there are k customers in the system, pk, is given by:

```
for k > 0 we have:
  pk = p0 * r ^ k
```

   Prove that the expected number of customers in the system, N, is a function of r, as given by:

```
N = Sum from k=0 to infinity (k * pk)
  = r/(1-r)
```