CSC465/665: Operating Systems

Spring 2019

Assignment 3

Due Date: April 5, 2019 -- Due Time: 23:59

Exercise: CPU Scheduling [20 Points: 4 points per simulation]

Consider three processes P1, P2, P3

- Burst times for P1: 14,12,17
- Burst times for P2: 2,2,2,3,2,2,2,3,2
- Burst times for P3: 6,3,8,2,1,3,4
- All three arrive at time 0, in order P1, P2, P3
- Each CPU burst is followed by an I/O operation taking 6 time units
- Simulate the scheduling algorithms
    - FCFS
    - Round Robin (quantum=5)
    - Non-preemptive SJF
    - Preemptive SJF
    - Round robin (quantum=5) with Priority scheduling, priorities are P2=P3>P1

For each algorithm:

1) Show the Gantt chart
2) Calculate
    a. the CPU utilization
    b. the throughput
    c. the turnaround time for process P1
    d. the waiting time for process P2
    e. the response time for process P3

Project: Process Synchronization using C/Linux and Java [80 points = 40 + 40]

Implement the following project using:

a) C/Linux, and
b) Java

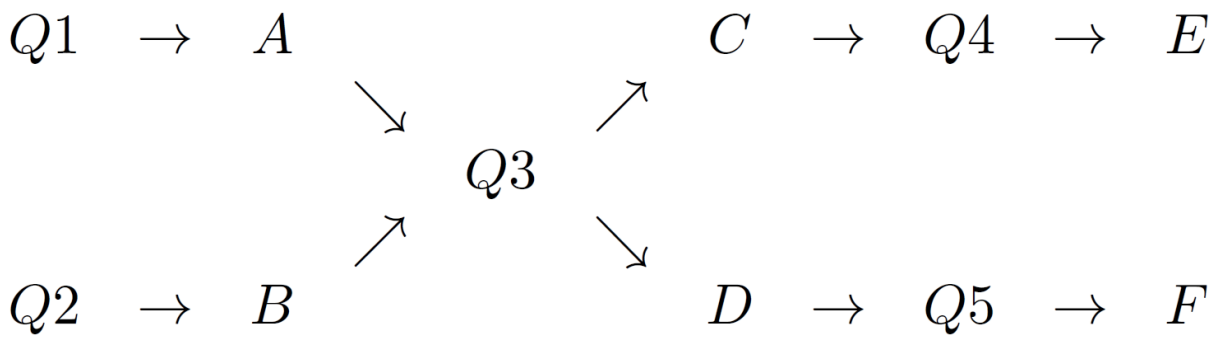
A sausage factory has 6 machines: machines A and B are fat trimming machines, machines C and D are sausage cutting machines, and machines E and F are packaging machines. Packages of meat come in either packages of 20 lb or packages of 25 lb. The inputs and outputs of each machine are stored in queues.

A takes as input 20 lb of sausage mixture from Q1 while B inputs 25 lb of sausage mixture from Q2. Both A and B "output" 15 lb packages of leaner mixture to Q3, however, A produces a "lean" mixture while B produces an "extra lean" mixture. Thus the contents of Q3 are heterogenous; it contains 15lb blocks of "lean" and "extra lean" mixture: they do not mix.

Both C and D input 15 lb of sausage mixture from Q3. However, C cuts large sausages and produces 100 large sausages while D cuts small sausages and produces 400 small sausages. Since Q3 contained both "lean" and "extra lean" blocks, this means that depending on the kind of block processed, C may produce large & "lean" or large and "extra lean" sausages. Similarly, D may produce small & lean or small & "extra lean" sausages. C outputs its sausages to Q4. D outputs its sausages to Q5.

Finally, E takes as "input" 100 large sausages and produces 20 packages of 5 sausages each. F takes as input 400 small sausages and produces 20 packages of 20 small sausages at a time.

Each machine does its job in a random amount of time that can fall anywhere between 3 and 7 minutes (i.e., 180 and 420 seconds). This is simulated by generating a number n between 180 and 420 at random and running a "for loop" that increments a variable n times. Every time E or F completes a package, it updates a database that records the number and types of packages produced.



Here are the restrictions for the machines in the factory:

A and B can work concurrently. They can only process one package of meat at a time.

C and D can work concurrently; They can only start working once outputs from A or B have been produced. They can take outputs from either A or B. **Also, and very importantly, D can produce a package only after C has produced 4 and only one out of three outputs from B can go to D. In other words, we don't want more than 1/5th packages of small sausages and only 1/4th of these packages can be extra lean.** As soon as an output from A or B arrives, if C and D are both ready to produce (based on the restrictions highlighted in bold above), they must race to process it. The one who wins the race takes it. C and D can only race if they have finished their previous job.

E and F can work concurrently. E can only take as input the output of C while F can only take as input the output of D. They can only do so when they are done with their previous task. Once they've done their jobs, E and F will each modify a table of 4 integers that reports the number of packages of 1) small lean sausages; 2) large lean sausages; 3) small extra lean sausages; 4) large extra lean sausages. This table should be a global array shared between E and F.

Use semaphores (Mutex and Counting Semaphores) to synchronize C and D's processing of the 15 lb lean or extra lean meat packages according to the rules stated above in bold; as well as E and F's access to the shared table.

Please test your system in the following three scenarios:

- 30 packages of 20 lb and 20 packages of 25 lb
- 100 packages of 20 lb and 200 packages of 25 lb
- 3,000 packages of 20 lb and 600 packages of 25 lb

The results should be:

	Large	Small
Lean	22	8
Extra Lean	18	2

	Large	Small
Lean	52	48
Extra Lean	188	12

	Large	Small
Lean	2460	540
Extra Lean	420	180

Interface

C Interface

For this to work requires three different files. Your code, which we'll call `ASSN3_example.c`, a set of functions I wrote called `ASSN3_grader.o`, and a header file `ASSN3_declarations.h` which allows your code in `ASSN3_example.c` to access some of the functions in `ASSN3_grader.o`. In order for C to see all the functions, put all three of these files in the ~/OS-VM directory. You can then compile and run the program in your VMs `/vagrant` directory with:
`gcc -pthread ASSN3_example.c ASSN3_grader.o -o ASSN3_example; ./ ASSN3_example`
Be sure that your program contains the line `#include "ASSN3_declarations.h"`, so that its definitions can be linked into your program.

Declare an array of two integers, called `input` in your main program. Call the `get_input` function with a pointer to `input` in order to fill the `input` array. The values in this array represent the amounts of 20lb packages in Q1 and 25lb packages in Q2. Run your program to process the input. Then save your output to a 2x2 array (say `output`), whose i,jth entry has the same interpretation as in the examples above.
Call `return done(&output)`, which will check the correctness of the program, printing correct and returning 0, or not correct and returning 1.

Algorithm 1 ASSN3_example.c

```c
#include <stdio.h>
#include <stdlib.h>
#include <time.h>
#include "ASSN3_delarations.h"

int main()
{
    //srand(time(0));       //set the rng seed
    int input [2];          // declare input array
    get_input(&input);     // initialize the input array
    /***** YOUR PROGRAM HERE *****/
    // the correct output for the default RNG seed
    int output [2][2]= {{52, 48},{188, 12}};
    return done(&output);
}
```

Java Interface

The Java interface works similarly. We define a class called `Grader.class`, which the student's program (say `Example_Program.java`) must call. With both files in the same directory, your program should begin by creating a `Grader` object. `Grader`'s instance variable `input` contains a randomly generated test input `[a,b]`, where a is the amount of 20lb blocks of sausage in Q1, and b is the amount of 25lb blocks of sausage in Q2. Run your program to determine the correct output. Save your output to a 2D array (say `ouput`), via:

`int [][] output = { { 22, 8 }, { 18, 2 } };` An example program is shown below. **Be sure your program ends with the if-else conditions shown in 12-17**.

Algorithm 1 Example_Program.java

```
1  import java.util.*;
2  import java.lang.*;
3  class Example_Program
4  {
5      public static void main(String args[]){
6          Grader obj = new Grader();
7          int[] input = obj.input;                          // get random input array
8          System.out.println("The input is: " + Arrays.toString(input));
9          /***** YOUR PROGRAM HERE *****/
10         int [][] output = { { 22, 8 }, { 18, 2 } };      // Correct ouput for [30, 20] input
11         System.out.println("The output is: " + Arrays.deepToString(output));
12         if (Grader.done(output)==0) {  // 0 is a normal exit
13             System.exit(0);
14         }
15         else {
16             System.exit(1);
17         }
18     }
19 }
```

Lastly, please don't compress your files: just upload each file to blackboard individually. Please try to give your files unique and identifiable names, e.g:

`lastname_firstname_ASSN3.c`
`lastname_firstname_myclass1.java`
`lastname_firstname_myclass2.java`