University of California, Berkeley
College of Engineering
Computer Science Division – EECS

Spring 2001 Anthony D. Joseph

Midterm Exam

March 7, 2001
CS162 Operating Systems

Your Name:	
SID AND 162 Login:	
TA:	
Discussion Section:	

General Information:
This is a **closed book and notes** examination. You have ninety minutes to answer as many questions as possible. The number in parentheses at the beginning of each question indicates the number of points given to the question; there are 100 points in all. You should read **all** of the questions before starting the exam, as some of the questions are substantially more time consuming.

Write all of your answers directly on this paper. ***Make your answers as concise as possible.*** If there is something in a question that you believe is open to interpretation, then please ask us about it!

Good Luck!!

Problem	**Possible**	**Score**
1	12	
2	24	
3	23	
4	18	
5	23	
Total	**100**	

1. (12 points total) “Lightweight” versus “Heavyweight” processes – Pros and Cons:
   a. (4 points) List two advantages of running a group of applications as single-threaded “heavyweight” processes over running the applications as multiple “lightweight” processes, all in one address space. Be explicit in your answers.
      i)

   b. (8 points) List two reasons why lightweight processes are better than heavyweight ones.
      i)

      ii)

2. (24 points total) Suppose that we have a multiprogrammed computer in which each job has identical characteristics. In one computation period, *T*, for a job, half the time is spent in I/O and the other half in processor activity. Each job runs for a total of *N* periods. Assume that a simple round-robin scheduling scheme is used and that I/O operations can overlap with processor operation. We define the following quantities:
   - Turnaround time = actual time to complete a job.
   - Processor utilization = percentage of time that the processor is active (not waiting).

   For large N, compute approximate values for these quantities for one, two, and four simultaneous jobs, assuming that the period *T* is distributed in each of the following ways:

   a. (15 points) I/O first half, processor second half.
      i) 1 job, Turnaround time and Processor utilization:

      ii) 2 jobs, Turnaround time and Processor utilization:

      iii) 4 jobs, Turnaround time and Processor utilization:

b. (9 points) I/O first and fourth quarters, processor second and third quarters.

i) 1 job, Turnaround time and Processor utilization:

ii) 2 jobs, Turnaround time and Processor utilization:

iii) 4 jobs, Turnaround time and Processor utilization:

3. (23 points total) CPU scheduling.

a. (8 points) Given CPU-bound tasks and a choice between FIFO and Round-Robin scheduling algorithms, choose the best algorithm for each of the following systems and specify why you chose the algorithm:

i) Multiprogrammed batch system:

ii) Interactive, time-sharing system:

b. (15 points) Consider the following processes, arrival times, and CPU processing requirements:

Process Name	Arrival Time	Processing Time
1	0	4
2	1	4
3	4	3
4	8	2

For each of the following scheduling algorithms, fill in the table with the process that is running on the CPU. Assume a 1 unit timeslice for timeslice-based algorithms. For RR, assume that an arriving thread runs at the beginning of its arrival time.

Time	**FIFO**	**RR**	**SRTF**
0	**1**	**1**	**1**
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			
11			
12			
Average response time			

4. (18 points total) Concurrency problem: Building H_2O.

The goal of this exercise is for you to create a monitor with methods `Hydrogen()` and `Oxygen()`, which wait until a water molecule can be formed and then return. Don't worry about actually creating the water molecule; instead only need to wait until two hydrogen threads and one oxygen thread can be grouped together. For example, if two threads call Hydrogen, and then a third thread calls Oxygen, the third thread should wake up the first two threads and they should then all return.

a. (6 points) Specify the correctness constraints. Be succinct and explicit in your answer.

b. (12 points) Observe that there is only one condition any thread will wait for (i.e., a water molecule being formed). However, it will be necessary to signal hydrogen and oxygen threads independently, so we choose to use two condition variables, `waitingH` and `waitingO`. Define `wH` and `wO` to be the number of hydrogen and oxygen threads waiting in the monitor, respectively, and we define `aH` an `aO` as the number of assigned hydrogen and oxygen threads, respectively. These are all initialized to 0.

You start with the following code:

```
Hydrogen() {
  wH++;
  lock.acquire();
  while (aH == 0) {
    if (wH >= 2 && wO >= 1) {
      wH-=2; aH+=2;
      wO-=1; aO+=1;
      waitingH.broadcast();
      waitingO.signal();
    } else {
      lock.release();
      waitingH.wait();
      lock.acquire();
    }
  }
  lock.release();
  aH--;
}

Oxygen() {
  wO++;
  while (aO == 0) {
    if (wH >= 2 && wO >= 1) {
      wH-=2; aH+=2;
      wO-=1; aO+=1;
      waitingH.signal();
      waitingH.signal();
    } else {
      waitingO.broadcast();
    }
  }
  aO--;
}
```

For each method, say whether the implementation either (i) works, (ii) doesn’t work, or (iii) is dangerous – that is, sometimes works and sometimes doesn’t. If the implementation does not work or is dangerous, explain why (there maybe several errors) and show how to fix it so it does work. Also, list and fix any inefficiencies.

i. `Hydrogen()`

ii. `Oxygen()`

(Additional space for question 4)

No Credit – Problem X: (000000000000 points)

Late Night Fun in the Labs (*don't try this tonight*)

From a student in CS ###:
For a computer programming class, I sat directly across from someone, and our computers were facing away from each other. A few minutes into the class, he got up to leave the room. I reached between our computers and switched the inputs for the keyboards. He came back and started typing and immediately got a distressed look on his face.

He called the Lab TA over and explained that no matter what he typed, nothing would happen. The TA tried everything. By this time I was hiding behind my monitor and quaking red-faced.

I started to type, "Leave me alone!"

They both jumped back, silenced. "What the #$?!#$" the TA said.

I typed, "I said leave me alone!"

The student got real upset. "I didn't do anything to it, I swear!" It was all I could do to keep from laughing out loud. The conversation between them and HAL 2000 went on for an amazing five minutes.

Me: "Don't touch me!"

Student: "I'm sorry, I didn't mean to hit your keys that hard."

Me: "Who do you think you are anyway?!" Etc. Finally, I couldn't contain myself any longer and fell out of my chair laughing.

After they had realized what I had done, they both turned beet red.

Funny, I never got more than a C- in that class.

5. (23 points) Deadlock:

Consider the following snapshot of a system. There are no current outstanding queued unsatisfied requests.

currently available resources

r1	r2	r3	r4
2	1	0	0

	current allocation				**max demand**				**still needs**			
process	**r1**	**r2**	**r3**	**r4**	**r1**	**r2**	**r3**	**r4**	**r1**	**r2**	**r3**	**r4**
p1	0	0	1	2	0	0	1	2				
p2	2	0	0	0	2	7	5	0				
p3	2	3	5	4	4	3	5	6				
p4	2	3	5	4	4	3	5	6				
p5	0	3	3	2	0	6	5	2				

a. (5 points) Compute what each process still might request and fill in the "still needs" columns.

b. (8 points) Is this system currently deadlocked, or will any process become deadlocked? Why or why not? If not, give an execution order.

c. (10 points) If a request from p3 arrives for (0, 1, 0, 0). can that request be safely granted immediately? In what state (deadlocked, safe, unsafe) would immediately granting the whole request leave the system? Which processes, if any, are or may become deadlocked if this whole request is granted immediately?

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