CS 350 Operating Systems, Fall 2018
Homework Assignment 2

Out: 10/6/2018 Sat.
Due: 10/13/2018 Sat. 23:59:59

Full points: 100
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There are 5 questions, each on a separate page. Read the submission instructions on the last page.

1. (20 points) Suppose the calls to `pthread_create()` and `pthread_join()` in the following code always succeed:

```
int counter = 10;

void *worker(void *arg) {
    counter--;
    return NULL;
}

int main(int argc, char *argv[]) {
    pthread_t p1, p2;
    pthread_create(&p1, NULL, worker, NULL);
    pthread_create(&p2, NULL, worker, NULL);
    pthread_join(p1, NULL);
    pthread_join(p2, NULL);
    printf("%d\n", counter);
    return 0;
}
```

Are the following outputs possible or not for the above code? Give brief justification to your answer for each of the outputs.

(1) 7

(2) 8

(3) 9

(4) 10

2. (20 points) Three jobs, A, B, and C, arrives in a single-CPU system at time 0. They need 20, 30, 20 seconds of CPU time respectively. Answer the following questions ((1) and (2)).

(1) At what time does B finish with the shortest-job-first (SJF) policy?

(2) At what time does B finish with a longest-job-fist (LJF) policy?

The following questions ((3) to (6)) are based on the assumption that the round-robin (RR) policy is used is used. Let us also assume the RR scheduler schedules the three jobs in the order of ABC whey the arrive, and there is no cost for context switching.

(3) At what time does A finish with one-second long time slices?

(4) At what time does B finish with one-second long time slices?

(5) Assuming time slice length is undetermined, is it possible that B finishes before C? If yes, how can this happen (list all such possibilities)? If no, why?

3. (16 points) A MLFQ scheduler has three queues with priorities 3 to 1 respectively (3 is the highest, 1 is the lowest).

Suppose the time allotment for the priority 3 queue and the priority 2 queue are both 1 time unit, and a job, A, whose length is 10 time units, enters the system at time 0. Then the scheduling outcome for the first five time units can be expressed as in the following table:

Time unit	1	2	3	4	5
Priority 3	A	-	-	-	-
Priority 2	-	A	-	-	-
Priority 1	-	-	A	A	A

Now suppose the MLFQ scheduler has the following spec:

- The time allotment for priority 3 queue is 1 time unit, and the time allotment for priority 2 queue is 2 time units.
- The time slice length for round-robin scheduling is 2 time units.
- The scheduler performs a priority boost for all the jobs every 500 time units.
- When adding a job to a queue, the job is added at the **front** of the queue (meaning it will get scheduled before all the existing ready jobs in the same queue).

Suppose there are two jobs, A and B, both are without I/O. The length of both jobs are 10 time units.

(1) (8 points) If both jobs enter the system at time 0, complete the following table, which shows the scheduling decision of the MLFQ scheduler.

Time unit	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
Priority 3											0											
Priority 2																						
Priority 1																						

(2) (8 points) If job A enters at time 0, and job B enters at time 6, complete the following table, which shows the scheduling decision of the MLFQ scheduler.

Time unit	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
Priority 3																						
Priority 2																						
Priority 1																						

4. (12 points) The lottery scheduler relies on a good random number generator to pick the winner of a lottery when making scheduling decisions. Suppose a lottery scheduler uses a random number generator that generate random numbers in the range of 1 to 1000. Answer the following two questions.

(1) If the random numbers generated by the generator are mostly in the range of 1 to 500, what can happen to the jobs with this scheduler?

(2) If the generator rotates through five pseduo-random numbers that are evenly distributed in the range of 1 to 1000 (for example, 600, 200, 1000, 800, 400), what can happen to the jobs with this scheduler?

5. (32 points) This question relates to the homework questions 1 to 8 in OSTEP-26.

OSTEP-26 link: `https://bit.ly/2Pcjr7i`

The needed "`x86.py`" simulator can be downloaded at:

`https://bit.ly/2pENgC0`

(Note: patiently read the README file of the simulator to get to know how the simulator works. Although the README file is a little bit long, it is easy to follow and also provides a good review of simple assembly language.)

(1) (10 points) Try OSTEP-26 homework questions 1 to 3, which run "loop.s" in the simulator with different configurations. Does changing the interrupt frequency (i.e., the `-i` option) affect the program result when running multiple threads? Why?
Hints:

- Recall what are independent and what are shared among threads within the same process.
- Modifying the initial values of the `dx` register for different threads may help you to examine the simulation result better. For example, instead of "`-t 2 -a dx=3,dx=3`", you can do "`-t 2 -a dx=3,dx=5`".

(2) (10 points) Try OSTEP-26 homework questions 4 to 7, which run "looping-race-nolock.s" in the simulator with different configurations. Does changing the interrupt frequency (i.e., the `-i` option) affect the program result when running multiple threads? Why? (Hint: recall what are independent and what are shared among threads within the same process.)

(3) (6 points) Is there a critical section in "looping-race-nolock.s"? If yes, what is the critical section exactly?

(4) (6 points) Try OSTEP-26 homework questions 8 (which sets the initial value of the `bx` register to 100 and varies interrupt intervals). What is the expected value at memory address 2000? Among interrupt intervals 1 to 50 (i.e., the options of "-i 1", "-i 2", ..., "-i 50"), which ones can lead to the expected outcome? Why?

Submission instructions

1. Type your answers using whatever text editor you like, remember to include the index number of each question.
2. Export the file to PDF format.
3. Name the PDF file based on your BU email ID. For example, if your BU email is "abc@binghamton.edu", then the PDF file should be named as "hw2_abc.pdf".
4. Not following the above instructions will lead to 5 points off.
5. Submit the PDF file to myCourses website before the deadline.