CS4328: Homework #2

Due on Tuesday, March, 5, 2019

Mina Guirguis

You may discuss this problem set with other students. However, you must write up your answers on your own. You must also write the names of other students you discussed any problem with. Each problem has a different weight. Please state any assumptions you are making in solving a given problem. Late assignments will not be accepted with prior arrangements. Assignments are due in class.

Problem 1

Consider a disk subjected to I/O requests arriving at an average rate of λ requests/sec. It was observed that on average, there was about 5 requests waiting for service and that each request waits for 10 msec, on average. What is the effective arrival rate λ for this disk that led to those numbers? [**4 pts**]

Problem 2

Assume processes arrive to the CPU based on a Poisson distribution with an arrival rate λ of 5 processes per second. Assume also that the service times are exponential. Given that the CPU is, on average, busy 70% of the time. What is the average turnaround time of these processes? How many processes you expect to see waiting, on average, in the Ready Queue? [**4 pts**]

Problem 3

A system is composed of CPU, Disk and Network. The execution of a process proceeds as follows:

1. The process uses the CPU and then with probability 0.2 proceeds to step 2, with probability 0.3 proceeds to step 3, and with probability 0.5 proceeds to step 4.
2. The process performs Disk I/O and then with probability 0.3 proceeds to step 1, and with probability 0.7 proceeds to step 4.
3. The process performs Network I/O and then with probability 0.4 proceeds to Step 1 and with probability 0.6 proceeds to step 4.
4. The process is leaves the system (perhaps due to an I/O error).

The following information is known about this system:

- Processes arrive according to a Poisson process with an average rate of 40 processes per second.
- The service time of the CPU is exponentially distributed with an average of 15 msec.
- The service time of the Disk is exponentially distributed with an average of 50 msec.
- The service time of the Network is exponentially distributed with an average of 60 msec.
- All buffers are of infinite sizes.

Answer the following questions [**3 points each**]:

(a) Draw a queuing diagram depicting the system above.

(b) Which resource is the bottleneck resource?

(c) What is the average total turnaround time for a process submitted to the above system?

(d) What is the probability that a process would not experience any waiting time once it gets submitted to the CPU?

(e) What arrival rate would render this system unstable?

Problem 4

Using the rand() function (that returns a random number uniformly distributed between 0 and $RAND_MAX$), write a simple program the generates the arrival times of 1000 processes (i.e., when each process arrives) that follow a Poisson distribution with an average arrival rate λ of 10 processes per second. Submit the arrival times of the first 10 processes and the *actual* average arrival rate over the 1000 processes. [Hint 1: A Poisson arrivals means Exponential inter-arrival times. Hint 2: Use the CDF of Exponential Distribution.] [**10 pts**]

Problem 5

Consider the following processes:

Process	Arrival Time	Processing Time
A	0	3
B	1	4
C	3	3
D	6	2
E	12	5

Show how the above processes execute over time on a single CPU system. Compute the completion time for each process, and the average turnaround time for all processes under each of the following schedulers:

(a) FCFS. [**5 pts**]

(b) Round Robin with (q = 1). [**5 pts**]

(c) Shortest Job First. [**5 pts**]

(d) Shortest Remaining Time First. [**5 pts**]

(e) HRRN. [**5 pts**]

(f) Feedback with 2 queues. Queue 1 serves 1 quantum (unit of time) at a time while queue 2 serves 2 quantums at a time. All processes get serviced from queue 1 initially and if they do not complete, they move to queue 2. Queue 2 runs a round robin scheduler. Assume that Queue 1 has a higher priority than Queue 2, and assume that a process arriving to queue 1 cannot preempt an already running process from queue 2 *within* its 2 quantums. [**5 pts**]

Problem 6

Prove that the Shortest Process Next (SPN) scheduling algorithm achieves the minimum average waiting time for a bunch of processes that arrived at the same time.[**5 pts**]

Problem 7

Least Slack Process Next (LSPN) is a real-time scheduler for periodic tasks. Slack is the amount of time between when a task would complete if it started now and its next deadline. Thus it can be expressed as:

$$Slack \quad = \quad D - t - C \tag{1}$$

where D is the deadline time, t is the current time and C is the processor time needed. LSPN selects the task with the minimum slack time to execute next. If two tasks have the same slack, they are serviced based on FCFS. Answer the following questions:

(a) What does it mean for a task to have a slack of 0? [**2 pts**]

(b) What does it mean for a task to have a negative slack? [**2 pts**]

(c) How long may the scheduler delay starting a task (and still meet its deadline), if that task has a slack s? [**2 pts**]

(d) Consider 3 period tasks: A, B and C. Task A has a period 6 and execution time 2, task B has a period of 8 and execution time of 2 and task C has a period of 12 and execution time of 3. Illustrate (by drawing the executions of A, B and C over time) how LSPN would schedule these tasks in comparison to Earliest Deadline First and Rate Monotonic Scheduling. Assume that preemption *may* occur at 4-ms intervals for LSPN. [**9 pts**]

Problem 8

Please make a copy of your solutions since you will not receive the graded homework before the midterm. We will discuss the solutions in the review session before the midterm.