BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY

Department of Computer Science and Engineering

January 2020 CSE 412 Assignment on Real Life Simulation and Making Decision Choices

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In this assignment, you will implement two real-life scenarios on server-queue simulation and make some decision choices based on the results.

Task 1: In this task, you will implement a job-shop model. The model is a manufacturing system consisting of n workstations, and at present stations $1, 2, \cdots, n$ consist of $n_i, i \in \{1, \cdots, n\}$ identical machine(s), respectively, as shown in Figure 1. In effect, the system is a network of n multiserver queues. Assume that jobs arrive at the system with interarrival times that are IID exponential random variables with mean t hours. There are k types of jobs, and arriving jobs are of type $1, 2, \cdots, k$ with respective probabilities $p_1, p_2, \cdots, p_k$. A job of type i requires s_i tasks to be done, and each task must be done at a specified station and in a prescribed order. For example, the Figure 1, the sequence for job 1 is $3 \rightarrow 1 \rightarrow 2 \rightarrow 5$.

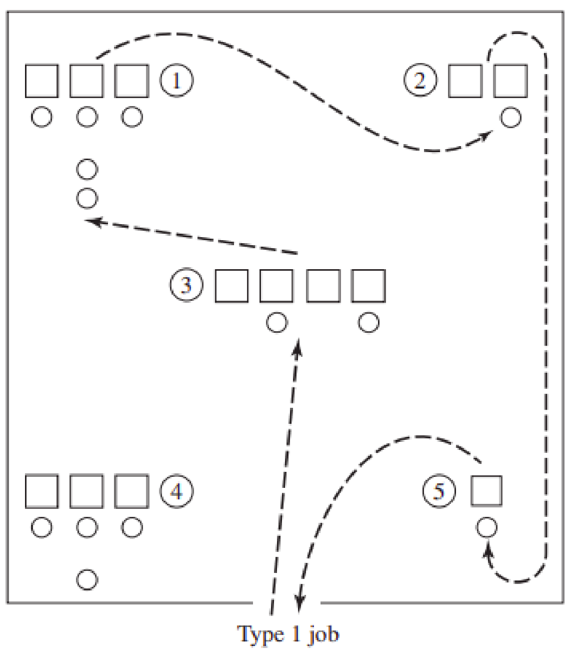

Figure 1: Job-shop example for Task-1

If a job arrives at a particular station and finds all machines in that station already busy, the job joins a single FIFO queue at that station. The time to perform a task at a particular machine is an independent 2-Erlang random variable whose mean r depends on the job type and the station to which the machine belongs. Use the sum of two exponential random variables each with mean $\frac{1}{2}r$ to sample from 2-Erlang.

All inputs will be read from a text file, a detailed description of a text file is given below:

Input
`5 #number of stations`(n)
`3 2 4 3 1 #number of machines in each station` (n_i)
`0.25 #inter-arrival time for jobs` (t)
`3 #number of job types` (k)
`0.3 0.5 0.2 #job probabilities` (p_i)
`4 3 5 #number of stations for each task` (s_i)
`3 1 2 5 #job 1 station routing`
`0.50 0.60 0.85 0.50 #job 1 mean service time for each station`
`4 1 3 #job 2 station routing`
`1.10 0.80 0.75 #job 2 mean service time for each station`
`2 5 1 4 3 #job 3 station routing`
`1.20 0.25 0.70 0.90 1.00 #job 3 mean service time for each station`

Table 1: A sample input for job-shop simulation

You have to run 30 simulations each having 8-hour run-time. You have to report the following:

1. Expected average total delay in queue (exclusive of service times) for each job type and the expected overall average job total delay.

2. Expected average number in each queue and average number of jobs in the whole system

3. Expected average delay in queue for each station

Decision choice: Suppose that all machines cost approximately the same and that the system has the opportunity to purchase one new machine with an eye toward efficiency improvement. You have to determine where you will fit the new machine. (You may use the results from the previous simulation, or run new simulations with the added machine. The latter will incur some penalty.)

Task 2: The cafeteria at your university is trying to improve its service during the lunch rush from 1PM to 2:30PM. Customers arrive together in groups of size $1, 2, 3$, and 4, with respective probabilities $0.5, 0.3, 0.1$, and 0.1. Inter-arrival times between groups are exponentially distributed with mean 30 seconds. Initially, the system is empty and idle, and is to run for the 90-minute period. Each arriving customer, whether alone or part of a group, takes one of three routes through the cafeteria (groups in general split up after they arrive):

- Hot-food service, then drinks, then cashier

- Specialty-sandwich bar, then drinks, then cashier

- Drinks (only), then cashier

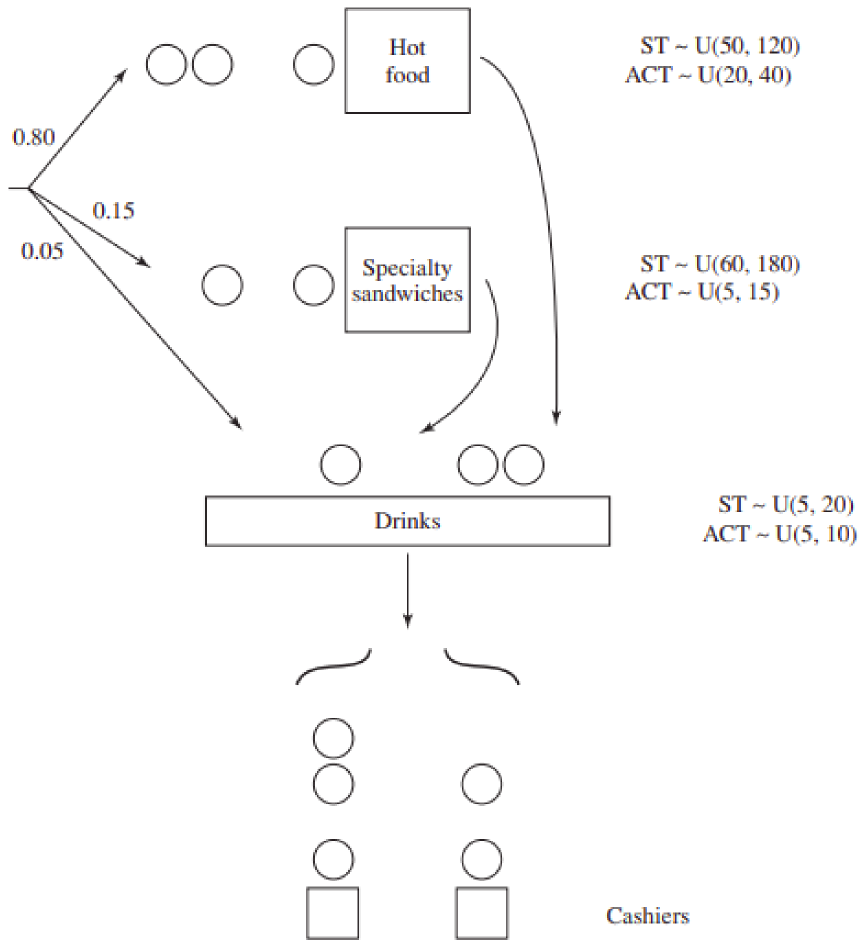

Figure 2: Cafeteria example for Task-2

The probabilities of these routes are respectively $0.80, 0.15$, and 0.05; see Figure 2. At the hot-food counter and the specialty-sandwich bar, customers are served one at a time (although there might actually be one or two workers present, as discussed below). The drinks stand is self-service, and assume that nobody ever has to queue up here; this is equivalent to thinking of the drinks stand as having infinitely many servers. There are either two or three cashiers (see below), each having his own queue, and there is no jockeying; customers arriving to the cashiers simply choose the shortest queue. All queues in the model are FIFO.

In Figure 2, ST stands for service time at a station, and ACT stands for the accumulated (future) cashier time due to having visited a station; the notation $U(a, b)$ means that the corresponding quantity is distributed uniformly between a and b seconds. For example, a route 1 customer goes first to the hot-food station, joins the queue there if necessary, receives service there that is uniformly distributed between 50 and 120 seconds, "stores away" part of a (future) cashier time that is uniformly distributed between 20 and 40 seconds, then spends an amount of time uniformly distributed between 5 seconds and 20 seconds getting a drink, and accumulates an additional amount of (future) cashier time distributed uniformly between 5 seconds and 10 seconds. Thus, his service requirement at a cashier will be the sum of the $U(20, 40)$ and $U(5, 10)$ random variates he "picked up" at the hot-food and drinks stations.

Report the following measures of system performance:

- The average and maximum delays in queue for hot food, specialty sandwiches, and cashiers (regardless of which cashier)
- The time-average and maximum number in queue for hot food and specialty sandwiches (separately), and the time-average and maximum total number in all cashier queues
- The average and maximum total delay in all the queues for each of the three types of customers (separately)
- The overall average total delay for all customers, found by weighting their individual average total delays by their respective probabilities of occurrence
- The time-average and maximum total number of customers in the entire system

The minimum number of employees is 4; run this as the "base-case" model. Then, consider adding employees, in several ways:

1. Five employees, with the additional person used in one of the following ways:
    - As a third cashier
    - To help at the hot-food station. In this case, customers are still served one at a time, but their service time is cut in half, being distributed uniformly between 25 seconds and 60 seconds.
    - To help at the specialty-sandwich bar, meaning that service is still one at a time, but distributed uniformly between 30 seconds and 90 seconds
2. Six employees, in one of the following configurations:
    - Two cashiers, and two each at the hot-food and specialty-sandwich stations
    - Three cashiers, two at hot food, and one at specialty sandwiches
    - Three cashiers, one at hot food, and two at specialty sandwiches
3. Seven employees, with three cashiers, and two each at the hot-food and specialty-sandwich stations

Run the simulation for all seven expansion possibilities, and make a recommendation as to the best employee deployment at each level of the number of employees.

While you are highly encouraged to discuss with your peers, ask help from teachers, and search relevant resources online, under no circumstances should you copy code from any source. If found out, you will receive full 100% penalty.