CSE 412 (Simulation and modeling lab)

Assignment-2 (Multiple-server queueing system simulation)

- Consider an office building with 12 floors (numbered 1–12). There are four elevators (servers) which service the building. Each elevator has a maximum capacity of 12 passengers.

- People (customers) enter the lobby of the building at floor 1 and take an elevator to their destination floor (floor 2 to floor 12). Each customer selects the first available elevator (numbered 1–4). When a person enters an elevator and selects the floor of destination, the elevator waits 15 sec (door holding time) before closing its doors. If another person arrives within the 15-sec interval, the waiting cycle is repeated. If no person arrives within the 15-sec interval, the elevator departs to deliver all of its passengers. It is assumed that, even if fully loaded with 12 passengers, the elevator waits 15 sec before departing. We assume no other passengers are picked up along the way. After delivering its last passenger, the elevator returns to the main floor, picking up no passengers on the way down. When a person arrives in the lobby and no elevator is available (because all four elevators are transporting their load of passengers), a queue begins to form in the lobby.

- We assume that it takes 5 sec for an elevator to travel between floors, 3 sec to open and 3 sec close its doors, and 3 sec for each passenger to disembark. We also assume that it takes 3 sec for each passenger in a queue to enter the next available elevator.

- A customer chooses a floor with equal likelihood [uniform probability distribution U (2, 12)].

- The interarrival times of customers are exponentially distributed with mean 1.50 minutes. Customers arrive in batches with the maximum batch size of 6. We may generate this random variate in the following way. Consider 5 coins (fair coin) are tossed. The total number of heads, x, is binomially distributed between 0 to 5 [binomial (t, p) with t = 5, p = 0.5]. Next, 1 is added to this number x [a shift or change of location by +1]. Then we get a number y between 1 to 6 which is the random variate for batch size.

- The simulation terminates when the simulation clock value exceeds 10000 sec.

- For performance measure, we consider the following quantities:
  1) Total number of customers serviced during the entire simulation
  2) queue length means the number of customers in queue
  3) $(\text{delay time})_i$ means the time customer *i* waits in a queue before stepping into an elevator
  4) $(\text{elevator time})_i$ means the time customer *i* spends in an elevator
  5) $(\text{delivery time})_i$ means the time required to deliver customer *i* to destination floor from time of arrival, including any waiting time.
  6) $(\text{load size})_j$ means number of occupants of elevator *j* when it departs from floor 1
  7) $(\text{operation time})_j$ means the total time elevator *j* operates (running between floors) during the entire simulation
  8) $(\text{available time})_j$ means the total time elevator *j* spends in floor 1 being available for loading
  9) $(\text{number of max loads})_j$ means the total number of times elevator *j* departs from floor 1 with full load of 12 customers during the entire simulation
  10) $(\text{number of stops})_j$ means the total number of stops made by elevator *j* during the entire simulation

  For quantities 2, 3, 4, and 5, you should keep track of both the average and the maximum. For quantity 6, you should keep track of the average. Quantity 1 is directly available from a counter variable. Quantity 2 can be calculated as a time-average similar to the way average number in queue was calculated in assignment-1. Quantity 3, 4, and 5 can be calculated similar to the way average delay in queue was calculated in assignment-1. The rest of the quantities can be obtained by keeping statistical counters. For example, for calculation of quantity 6, for each elevator, you may keep two statistical counters: One variable to keep track of how many times it departed from

floor 1, and another variable to accumulate the total number of passengers it carries while it departs from floor 1.

Format of the Input:

```
10000   // simulation termination
12      4       12      6       // number of floors, elevators, capacity, batch size
15      5       3       3       //door holding time, inter-floor traveling time, opening time, closing time
3       3       // passenger embarking and disembarking time
1.5     // mean interarrival time
```

Format of the Output: The output can be presented in a tabular format like the following table:

Table B.1 Results of elevator simulation for 15 consecutive days

Simulation number	Numbers of customers serviced	Average delivery time	Maximum delivery time	Average time in elevator	Maximum time in elevator	Number of customers in longest queue	Average time in a queue	Longest time in a queue	Total number of stops for each elevator				Percentage of total time each elevator is in transport			
									1	2	3	4	1	2	3	4
1	328	147	412	89	208	12	40	166	67	76	56	52	84	87	80	75
2	322	146	409	88	211	18	43	176	74	62	52	61	88	80	78	77
3	309	139	385	87	201	12	37	161	62	61	61	62	85	83	80	80
4	331	149	371	89	205	13	42	149	72	69	68	44	85	82	87	73
5	320	146	404	87	208	15	48	178	72	52	58	58	86	78	80	74
6	313	153	405	91	211	13	45	146	69	62	72	47	85	82	82	74
7	328	138	341	88	195	10	35	120	59	66	70	61	86	81	84	82
8	312	147	377	86	198	12	46	163	69	60	61	43	82	82	81	73
9	329	139	352	87	208	11	37	155	58	63	70	57	86	86	82	78
10	314	143	325	88	205	9	35	128	65	68	57	65	83	84	78	83
11	317	137	344	85	202	10	38	129	64	75	64	56	86	85	81	77
12	341	153	396	90	211	18	45	177	83	63	63	53	87	82	78	77
13	318	136	345	80	208	11	36	140	58	64	63	55	91	82	83	73
14	319	140	356	88	208	13	33	135	64	67	58	65	84	83	82	81
15	323	147	386	91	218	15	39	166	76	64	70	54	86	81	87	76
Averages (rounded)	322	144	374	88	206	13	40	153	67	65	63	56	86	83	82	77

All times are measured in seconds and rounded to the nearest second.

You may present the result by having 10 simulation runs and taking averages of the quantities rounded to nearest integer. The above table was an example taken from a text book. You may present your obtained result by multiple tables (for example, one table showing elevator statistics, another one showing customer statistics).