Modeling and Sim Hw1

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Some notes on my program:
The input format for the program I wrote called tandum_queue is the following (put in a file named tandum_queue.in):

[number of queues] [number of minutes to run for]
[interval time mean] [first service time mean]
[second service time mean]
...
[nth service time mean]

The program should support n servers and not just 2.

The repatitions loop can be found on line 61 of tandum_queue.c. The decreasing means for problem 3.1 can be found commented out on lines 142 and 143.

To compile the program use make tandum_queue.
To compile the book code you can use make mm1.

problem 1
Output for problem one can be found at the bottom of this pdf, or in mm1.out. Here we have 10 independent replications, and we should see varriation between then as we do since we are random sampling for each case.

problem 2
Output for problem can be found at the bottom of this pdf or in tandum_queue_problem_2,out.

problem 3
Output can be found at the bottom or in tandum_queue_problem_3-1,out.

My output for the 2 queues in tandum with decreasing interarrival times, and decrease serving time for queue 0, indicates the affect of this is that the second queue becomes more and more crowded while the first queue can still manage more customers, because its serving time is also decreasing. It is worth noting

that the average wait time in queue 0 also goes up but not nearly as much as in queue 1.

From a programming stand point, the addition of a second queue means that the arrival times for queues past queue 0 are purely determined by the departure time from the last queue. This means that when a customer departs from a queue we must also schedule an arrival at the next queue unless it is the last queue. Secondly almost all data when dealing with multiple queues can be stored in arrays, where the array is indexed by queue number, so that we can have an arbitrary number of queues in tandum.

Problem 1 output:
Single-server queueing system
Mean interarrival time 1.000 minutes
Mean service time 0.700 minutes
Number of customers 5
Simulation number: 1
Average delay in queue 0.465 minutes
Average number in queue 0.767
Server utilization 0.696
Time simulation ended 4.282 minutes
Simulation number: 2
Average delay in queue 0.196 minutes
Average number in queue 0.354
Server utilization 0.633
Time simulation ended 2.763 minutes
Simulation number: 3
Average delay in queue 0.807 minutes
Average number in queue 0.435
Server utilization 0.550
Time simulation ended 9.269 minutes
Simulation number: 4
Average delay in queue 1.161 minutes
Average number in queue 2.521
Server utilization 0.714
Time simulation ended 6.001 minutes
Simulation number: 5
Average delay in queue 0.641 minutes
Average number in queue 0.846
Server utilization 0.971
Time simulation ended 3.786 minutes
Simulation number: 6
Average delay in queue 0.093 minutes
Average number in queue 0.061
Server utilization 0.376
Time simulation ended 7.585 minutes
Simulation number: 7
Average delay in queue 0.108 minutes
Average number in queue 0.063
Server utilization 0.290
Time simulation ended 8.644 minutes
Simulation number: 8
Average delay in queue 0.000 minutes
Average number in queue 0.000
Server utilization 0.247
Time simulation ended 8.602 minutes
Simulation number: 9

Average delay in queue 0.076 minutes
Average number in queue 0.056
Server utilization 0.322
Time simulation ended 6.810 minutes
Simulation number: 10
Average delay in queue 0.055 minutes
Average number in queue 0.125
Server utilization 0.424
Time simulation ended 2.214 minutes

problem 2 output:

System of 2 servers in tandem running 1000.00 minutes

Mean arrival time: 1.00 Mean service time of server 1: 0.70 Mean service time of server 2: 0.90

Repatition #1

Average delay in queues:

Queue 0 Queue 1

————————————

0.45211 0.79435

Average number in queues:

Queue 0 Queue 1

————————————

0.93165 1.60709

Server utilization:

Queue 0 Queue 1

————————————

0.48249 0.34030

Repatition #2

Average delay in queues:

Queue 0 Queue 1

————————————

0.45524 0.78762

Average number in queues:

Queue 0 Queue 1

————————————

1.19039 3.01690

Server utilization:

Queue 0 Queue 1

————————————

0.50807 0.33140

Repatition #3

Average delay in queues:

Queue 0 Queue 1

————————————

0.42222 0.63463

Average number in queues:

Queue 0 Queue 1

————————————

0.76961 1.37543

Server utilization:

Queue 0 Queue 1

————————————

0.46696 0.32029

Repatition #4

Average delay in queues:

Queue 0 Queue 1

————————————

0.44971 0.87961

Average number in queues:

Queue 0 Queue 1

————————————

0.92600 3.47738

Server utilization:

Queue 0 Queue 1

————————————

0.48056 0.35766

Repatition #5

Average delay in queues:

Queue 0 Queue 1

————————————

0.48508 0.78433

Average number in queues:

Queue 0 Queue 1

————————————

1.15975 3.02944

Server utilization:

Queue 0 Queue 1

————————————

0.51142 0.34452

Repatition #6

Average delay in queues:

Queue 0 Queue 1

————————————

0.47200 0.80295

Average number in queues:

Queue 0 Queue 1

————————————

1.14344 1.96459

Server utilization:

Queue 0 Queue 1

————————————

0.49449 0.35561

Repatition #7

Average delay in queues:

Queue 0 Queue 1

————————————

0.42687 0.74208

Average number in queues:

Queue 0 Queue 1

————————————

1.33535 1.79163

Server utilization:

Queue 0 Queue 1

————————————————

0.49295 0.33580
Repatition #8
Average delay in queues:
Queue 0 Queue 1

————————————————

0.52284 0.77525
Average number in queues:
Queue 0 Queue 1

————————————————

1.19481 1.93199
Server utilization:
Queue 0 Queue 1

————————————————

0.50994 0.33564
Repatition #9
Average delay in queues:
Queue 0 Queue 1

————————————————

0.45470 0.78204
Average number in queues:
Queue 0 Queue 1

————————————————

0.89740 1.63204
Server utilization:
Queue 0 Queue 1

————————————————

0.47993 0.34736
Repatition #10
Average delay in queues:
Queue 0 Queue 1

————————————————

0.45008 0.78338
Average number in queues:
Queue 0 Queue 1

————————————————

0.88713 2.26395
Server utilization:
Queue 0 Queue 1

————————————————

0.45888 0.34738

problem 3 output:
System of 2 servers in tandem running 1000.00 minutes
Repatition #1
Mean arrival time: 1.00
Mean service time of server 1: 0.70
Mean service time of server 2: 0.90
Average delay in queues:
Queue 0 Queue 1
0.45211 0.79435
Average number in queues:
Queue 0 Queue 1
0.93165 1.60709
Server utilization:
Queue 0 Queue 1
0.48249 0.34030
Repatition #2
Mean arrival time: 0.94
Mean service time of server 1: 0.67
Mean service time of server 2: 0.90
Average delay in queues:
Queue 0 Queue 1
0.44502 0.85674
Average number in queues:
Queue 0 Queue 1
1.25821 10.30189
Server utilization:
Queue 0 Queue 1
0.51616 0.34403
Repatition #3
Mean arrival time: 0.88
Mean service time of server 1: 0.65
Mean service time of server 2: 0.90
Average delay in queues:
Queue 0 Queue 1
0.45955 0.85203
Average number in queues:
Queue 0 Queue 1
1.30149 15.08329
Server utilization:
Queue 0 Queue 1
0.54434 0.32738
Repatition #4
Mean arrival time: 0.83
Mean service time of server 1: 0.62
Mean service time of server 2: 0.90
Average delay in queues:

Queue 0 Queue 1
0.43887 0.75582
Average number in queues:
Queue 0 Queue 1
2.19332 27.99343
Server utilization:
Queue 0 Queue 1
0.56738 0.31718
Repatition #5
Mean arrival time: 0.77
Mean service time of server 1: 0.59
Mean service time of server 2: 0.90
Average delay in queues:
Queue 0 Queue 1
0.45330 0.73172
Average number in queues:
Queue 0 Queue 1
2.00770 36.38109
Server utilization:
Queue 0 Queue 1
0.58899 0.29804
Repatition #6
Mean arrival time: 0.71
Mean service time of server 1: 0.56
Mean service time of server 2: 0.90
Average delay in queues:
Queue 0 Queue 1
0.41078 0.73270
Average number in queues:
Queue 0 Queue 1
1.72747 28.79179
Server utilization:
Queue 0 Queue 1
0.57219 0.31349
Repatition #7
Mean arrival time: 0.65
Mean service time of server 1: 0.54
Mean service time of server 2: 0.90
Average delay in queues:
Queue 0 Queue 1
0.45908 0.69106
Average number in queues:
Queue 0 Queue 1
1.97453 46.37239
Server utilization:
Queue 0 Queue 1

0.60717 0.27013
Repatition #8
Mean arrival time: 0.60
Mean service time of server 1: 0.51
Mean service time of server 2: 0.90
Average delay in queues:
Queue 0 Queue 1
0.47956 0.59277
Average number in queues:
Queue 0 Queue 1
4.74412 72.42811
Server utilization:
Queue 0 Queue 1
0.67666 0.26546
Repatition #9
Mean arrival time: 0.54
Mean service time of server 1: 0.48
Mean service time of server 2: 0.90
Average delay in queues:
Queue 0 Queue 1
0.40870 0.57002
Average number in queues:
Queue 0 Queue 1
4.66802 85.57726
Server utilization:
Queue 0 Queue 1
0.68554 0.23739
Repatition #10
Mean arrival time: 0.48
Mean service time of server 1: 0.45
Mean service time of server 2: 0.90
Average delay in queues:
Queue 0 Queue 1
0.43152 0.45394
Average number in queues:
Queue 0 Queue 1
11.49265 98.54865
Server utilization:
Queue 0 Queue 1
0.75104 0.21077