## Module 5 – Assignment

## Weiyu Li

## Screenshot of Simulation Program Output:

liviali@Livias-iMac Quet				
mulation.java && java Qu		iali/Documents/NJIT/Spring_2025/C	S610852 Data Stru	cture Alg/Code File/Java File/QueueSimu
Welcome to the Service S Initial Simulation Input Total Duration: 74 minut Initial Waiting Customer Average Service Rate: 27 First Customer Arrival 1 Average Waiting Time per	ts: tes 1: 45 1 minutes/per customer Time: 02:23:49			
Drace any kay to continu	us simulation tune 0 to suit	or type 1 to display the most e	fficient commiss	atation.
f This simulation Customer			Tricient service	Statzun.
Station   Cus	stomers ID	Waiting Time	Max Length	Occupancy Rate
27 28 29 30 31 32 33 34	18 19 20 21 22 23 24 25 26	Max Waiting Time: 5 min Max Waiting Time: 0 min	5 people   5 people	3.33%
RegularQ1	45   Hax Harring Fille. 145 III	Max Waiting Time: 0 min	w	0.00%
RegularQ2		Max Waiting Time: 0 min	<b> </b> ∞	0.00%
d This simulation Customer		or type 1 to display the most e	fficient service	station:
d This simulation Customer Next quickest service st	r Arrival Time: 02:29:49 tation: SingleQueue (Estimated	waiting time: 5 minutes)	fficient service	station:
d This simulation Customen Next quickest service st  Station   Cus SingleQueue   47 RoundRobinQueue   12 ShortestQueue   24 34 35 36 37 38 39 40 41	r Arrival Time: 02:29:49 tation: SingleQueue (Estimated  stomers ID   48 49   25 26 27 28 29 30 31 32 33	waiting time: 5 minutes) Waiting Time Max Waiting Time: 15 min Max Waiting Time: 0 min		
d This simulation Customen Next quickest service st  Station   Cus SingleQueue   47 RoundRobinQueue   24 ShortestQueue   24 34 35 36 37 38 39 40 41 44 45   Max Waiting Time RegularQI	r Arrival Time: 02:29:49 tation: SingleQueue (Estimated  stomers ID   48 49   25 26 27 28 29 30 31 32 33	waiting time: 5 minutes)  Waiting Time  Max Waiting Time: 15 min  Max Waiting Time: 0 min    88.00%  Max Waiting Time: 0 min	Max Length   5 people   5 people	Occupancy Rate   12.00%   0.00%
d This simulation Customer Next quickest service st  Station   Cus SingleQueue   47 RoundRobinQueue	r Arrival Time: 02:29:49 tation: SingleQueue (Estimated  stomers ID   48 49   25 26 27 28 29 30 31 32 33	Waiting Time: 5 minutes)  Waiting Time  Max Waiting Time: 15 min  Max Waiting Time: 0 min	Max Length   5 people   5 people	Occupancy Rate   12.00%   0.00%
d This simulation Customen Next quickest service st Station   Cus SingleQueue   47 RoundRobinQueue   24 34 15 36 37 38 39 40 41 44 45   Max Waiting Time RegularQl   RegularQl   RegularQl   Customers Total Waiting Customers	r Arrival Time: 02:29:49 tation: SingleQueue (Estimated stomers ID   48 49     25 26 27 28 29 30 31 32 33 42 43 e: 110 min   \( \times\)   , Average Waiting Time of Each in System: 25	Waiting time: 5 minutes)  Waiting Time  Max Waiting Time: 15 min  Max Waiting Time: 0 min    88.00%  Max Waiting Time: 0 min  Max Waiting Time: 0 min	Max Length   5 people   5 people	Occupancy Rate   12.00%   0.00%
d This simulation Customer Next quickest service st  Station   Cus SingleQueue   47 RoundRobinQueue   24 30 35 36 37 38 39 40 41 44 45   Max Waiting Time RegularQ1   RegularQ2   On all Waiting Customers Total Waiting Customers Total Duration of the Si	r Arrival Time: 02:29:49 tation: SingleQueue (Estimated stomers ID   48 49     25 26 27 28 29 30 31 32 33 42 43 e: 110 min   \operatorname{o}   , Average Waiting Time of Each in System: 25 imulation: 6 minutes	Waiting time: 5 minutes)  Waiting Time  Max Waiting Time: 15 min  Max Waiting Time: 0 min    88.00%  Max Waiting Time: 0 min  Max Waiting Time: 0 min	Max Length   5 people   5 people   °	Occupancy Rate   12.00%   0.00%   0.00%
d This simulation Customen Next quickest service st  Station   Cus SingleQueue   47 RoundRobinQueue   24 34 35 36 37 38 39 40 41 44 45   Max Waiting Time Regular01   Regular02 On all service stations, Total Waration of the 5; Press any key to contint f This simulation Customer	r Arrival Time: 02:29:49 tation: SingleQueue (Estimated stomers ID   48 49     25 26 27 28 29 30 31 32 33 42 43 e: 110 min   \operatorname{o}   , Average Waiting Time of Each in System: 25 imulation: 6 minutes	waiting time: 5 minutes)  Waiting Time  Max Waiting Time: 15 min  Max Waiting Time: 0 min  [ 88.00%  Max Waiting Time: 0 min  Max Waiting Time: 0 min  Customer: 5 minutes  or type 1 to display the most e	Max Length   5 people   5 people   °	Occupancy Rate   12.00%   0.00%   0.00%
d This simulation Customen Next quickest service st  Station   Cus SingleQueue   47 RoundRobinQueue   24 34 35 36 37 38 39 40 41 44 45   Max Waiting Time RegularQi   RegularQi   RegularQi   RegularQi   The Single Press any key to contint Press an	r Arrival Time: 02:29:49 tation: SingleQueue (Estimated stomers ID  48 49  25 26 27 28 29 30 31 32 33 42 43 e: 110 min   \( \infty \) , Average Waiting Time of Each in System: 25 imulation: 6 minutes ue simulation, type 0 to exit, r Arrival Time: 02:34:49 tation: SingleQueue (Estimated	Waiting time: 5 minutes)  Waiting Time  Max Waiting Time: 15 min  Max Waiting Time: 0 min    88.00%  Max Waiting Time: 0 min  Max Waiting Time: 0 min  1 Customer: 5 minutes  or type 1 to display the most e	Max Length   5 people   5 people   °	Occupancy Rate   12.00%   0.00%   0.00%

Press any key to continue simulation, type 0 to exit, or type 1 to display the most efficient service station: sf This simulation Customer Arrival Time: 05:17:49 Next quickest service station: RegularQ2 (Estimated waiting time: 5 minutes)						
Station	Customers ID	Waiting Time	Max Length	Occupancy Rate		
SingleQueue RoundRobinQueue ShortestQueue RegularQ1 RegularQ2	129   140   133   136 137 138   141	Max Waiting Time: 5 min Max Waiting Time: 5 min Max Waiting Time: 5 min Max Waiting Time: 15 min Max Waiting Time: 5 min	5 people   5 people   ∞   ∞   ∞	14.29%   14.29%   14.29%   42.86%   14.29%		
On all service stations, Average Waiting Time of Each Customer: 5 minutes Total Waiting Customers in System: 7 Total Duration of the Simulation: 174 minutes  Press any key to continue simulation, type 0 to exit, or type 1 to display the most efficient service station: dg This simulation Customer Arrival Time: 05:18:49  Next quickest service station: SingleQueue (Estimated waiting time: 5 minutes)						
Station	Customers ID	Waiting Time	Max Length	Occupancy Rate		
SingleQueue RoundRobinQueue ShortestQueue RegularQ1 RegularQ2	142 	Max Waiting Time: 5 min Max Waiting Time: 0 min Max Waiting Time: 0 min Max Waiting Time: 5 min Max Waiting Time: 0 min	5 people   5 people   ∞   ∞	50.00%   0.00%   0.00%   50.00%   0.00%		
On all service stations, Average Waiting Time of Each Customer: 5 minutes Total Waiting Customers in System: 2 Total Duration of the Simulation: 175 minutes  Press any key to continue simulation, type 0 to exit, or type 1 to display the most efficient service station:  S This simulation Customer Arrival Time: 05:24:49  Next quickest service station: SingleQueue (Estimated waiting time: 5 minutes)						
Station	Customers ID	Waiting Time	Max Length	Occupancy Rate		
SingleQueue RoundRobinQueue ShortestQueue RegularQ1 RegularQ2	143 144 145 	Max Waiting Time: 15 min Max Waiting Time: 0 min Max Waiting Time: 0 min Max Waiting Time: 0 min Max Waiting Time: 0 min	5 people   5 people   ∞   ∞   ∞	100.00%   0.00%   0.00%   0.00%   0.00%		
On all service stations, Average Waiting Time of Each Customer: 5 minutes Total Waiting Customers in System: 3 Total Duration of the Simulation: 181 minutes						
Press any key to continue simulation, type 0 to exit, or type 1 to display the most efficient service station: 1 Most efficient service station (next quickest frequency): RegularQ1 (9 times)						
Press any key to continue simulation, type 0 to exit, or type 1 to display the most efficient service station: 0 liviali@Livias-iMac QueueSimulation %						

The simulation was designed to evaluate different queuing policies by modeling 5 interchangeable service stations where arriving customers are assigned to FIFO queues. The implementation uses multi-threading so that each station processes its queue independently (with a fixed 3-second processing delay per customer), while the main simulation loop dynamically generates customer arrivals over a randomly determined total duration (between 30 and 120 minutes). New customer arrivals are computed based on the duration of each round (on average, one new customer every 2 minutes) and the simulation continually updates the current "Customer Arrival Time" by adding the round's duration to the previous time. The simulation outputs a neatly formatted table that shows, for each service station, the list of customer IDs, the maximum waiting time of current service station, the station's maximum capacity (5 for SingleQueue and RoundRobinQueue and ∞ for the others), and an occupancy rate (the percentage contribution of each station's waiting time relative to the system's total waiting time).

The simulation system provides output key performance metrics such as total simulation duration, maximum queue length per station, average and maximum waiting times, and occupancy rates—allowing for an analysis of system efficiency under dynamic and crowded conditions.

According to the output of the simulation system, the ShortestQueue consistently builds up a high waiting time (e.g. 230 minutes in one round) and thus exhibits an occupancy rate of over 80%, indicating that it becomes overloaded and therefore inefficient under heavy load. In contrast, the SingleQueue and RoundRobinQueue tend to maintain lower occupancy rates (ranging from about 8% to 25%), although their usage depends on their capacity (I set them limited to 5 customers each in current system). Per the output, RegularQ1 was selected as the "next quickest" service station more frequently (with a frequency of 9 times) than the others. Even though its occupancy rate in rounds when it is active may be higher (around 40–42%), this consistent selection suggests that RegularQ1 is able to clear customers effectively—maintaining a low estimated waiting time (5 minutes) for new arrivals despite a higher load. Thus, while the occupancy metrics alone might suggest that a lower-loaded station (like RoundRobinQueue or SingleQueue) is "better," the fact that RegularQ1 is chosen more often for new assignments indicates that it is the most efficient option in terms of keeping overall waiting times low when the system is crowded.

Interestingly, this result ran counter to my initial intuition regarding the 5-service-station system. I originally expected that the ShortestQueue would prove most efficient—after all, it is designed to always accept new arrivals when it has the fewest customers. However, the simulation reveals that RegularQ1, despite sometimes operating at a higher occupancy level, is consistently selected as the next quickest station and ultimately demonstrates a more balanced performance in terms of waiting times. This outcome suggests that factors beyond simply having the fewest customers—such as the station's ability to process a heavy load efficiently—play a critical role in overall system performance.

This analysis demonstrates that by significantly increasing the service time (setting S much greater than 5×A), the simulation shows that some service station could be unintentioanlly in a congested state. It reveals that RoundRobin and ShortestQueue is no longer efficient when data variable is significantly increasing, on the contrary, RegularQ1 or Q2 could be more efficient, despite the Random distribution of customers could also create unpredictable results.