IE 306.02 Simulation Assignment 1 Report

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1 Introduction

In this simulation, we are assigned to simulate a call center. System will have a two service units and each service unit has its own queue with the capacity of 1. Two service points are front-desk and expert-desk. Each call is expected to visit both of them at the given order. Expert service desk may give a break as explained randomly times. Also, customers may leave from the expert-desk queue by running out of patience. We are expected to run the system with 1000 and 5000 customers to obtain system responses.

System Responses:

- Utilization of the front-desk operator
- Utilization of the expert operators
- Average Total Waiting Time
- Maximum Total Waiting Time to Total System Time Ratio
- Average number of people waiting to be served by the expert operator

Each of the responses will be discussed later

2 Definition of Events

- Arrival time of the call to the system: The time when a call arrives to the system.
- Request time of the front-desk service or front-desk queue entering time: The time when a call requests to enter front-desk service. If front-desk is not available, the call enters to front-desk queue.
- Initial front-desk service time: The time when front-desk service starts for a call.
- Leaving front-desk service time: The time when front-desk service ends for a call.
- Request time of the expert service or expert-desk queue entering time: The time when a call requests to enter expert service. If expert is not available, the call enters to expert-desk queue.
- Initial expert service time: The time when expert service starts for a call.
- Leaving expert service time: The time when expert service ends for a call.
- Reneging time of customers: The time when a caller decides to quit expert-desk queue without getting the service from expert.

- Break request time from expert: The time when the expert wants to break. Before the expert gives a break, the expert must serve the callers that are already in the expert-desk queue.
- Entering break time: The time when the expert gives a break.
- Leaving break time: The time when the expert continues working.
- Leaving time from the whole system: The time when the 1000th or 5000th caller quits the system.

3 Simulation Logic

In our simulation design, we start simulation by defining two shareable resources with capacity "1"(queues), one Call customer, and one expert. Then system starts simulation.

Expert process gets a exponential random value with 1/60 mean(Given Poisson distribution is converted to the exponential distribution). Then waits in the system for this value. This process until now represents, when the expert will be willing to take a break. After wait completes, we put expert to the second queue, its own queue, because it is expected from us to take a break after calls are already in queue. When the system gives a service to the expert, that means it is time to take a break, expert keeps himself in the queue and waits 3 minutes there. Expert does this from the beginning and continues until flag is false(Simulation end point).

Call(Customer) process waits for given inter-arrival time to enter system. Checks if the system ends or not. If system continuing creates another Call process and continues its own task. Call requests front-desk service, if not available put itself on queue. We keep this time to calculate waiting time and working time. After, service turn comes to Call, Call gets a service random variable and waits in the service for given value. After exiting front-desk service, we obtain working and waiting time for this Call.

In the second service, we keep this time again. We create two processes this time. One is a request for second queue and second is patience process. Patience process is the time when the customer will be reneging and leave the queue and system. We run both processes and if customer leaves queue by reneging then we set working time as 0 and waiting time by using this time minus kept value just before going into queue. If customer leaves queue before reneging then expert service serves customer with given random value and Call process waits in the queue. After leaving second service, we calculate both working and waiting times again.

At the end of Call process, we increment left customers by one and if number of left customers are less than given "TOTALCALL", we record waiting and working times on each service point. By using this, we neglect other customers that may affect responses at the end of simulation. At the end we check if the leaving customer is the desired last customer, if it is, then we kept this time

as last time in the system and we rise the flag to stop creating new customers, stop taking break, and stop simulation.

After simulation is done, we obtain 5 datas. Array of waiting time on queue one and two and array of working time on service one and two. All these arrays are synchronized with each other, that means each array indexes corresponds to same index of other arrays. We also have last minute on the service. Then it is time to obtain system responses on the simulation. First, we obtain total waiting time to total system time ratio for all calls. Then taking max of the each customer in array will give us "Maximum Total Waiting Time to Total System Time Ratio". "Utilization of the front desk operator" will be calculated as summation of elements of working one array divided by last minute on the system(We multiply all ratio values by 100 to give percentage values over 100). "Utilization of the expert operators" will be calculated as summation of elements of working two array divided by last minute on the system. "Average Total Waiting Time" will be calculated by summation of elements of both waiting arrays divided by "TOTALCALL", total served customers. "Average number of people waiting to be served by the expert operator" will be calculated average waiting time on queue two(sum of waiting time two divided by "TOTALCALL") times average customer handled on the system at one minute("TOTALCALL" divided by last minute on the system). Then we obtain all desired responses.

4 Simulation Outputs

For this simulation's output, we tried 6 different random seeds to see different results of the simulation. The name of columns are utilization of the front-desk operator (U1), Utilization of the expert operator (U2), Average Total Waiting Time(A1), Maximum Total Waiting Time to Total System Time Ratio(R1), Average number of people waiting to be served by the expert operator(A2).

Random Seed	U1(%)	U2(%)	A1	R1(%)	A2
50	52.89	65.55	15.94	0.94	0.80
555	50.68	61.58	11.58	0.94	0.57
713	49.77	61.99	12.30	0.95	0.56
863	48.06	58.00	11.79	0.94	0.51
978	50.95	62.27	12.85	0.94	0.58
1500	50.03	61.76	12.51	0.94	0.60

Table 1: The results with 1000 callers.

Random Seed	U1(%)	U2(%)	A1	R1(%)	A2
50	50.12	61.97	12.67	0.95	0.59
555	49.67	60.95	11.79	0.94	0.54
713	50.49	62.23	13.11	0.95	0.61
863	49.60	60.78	12.33	0.95	0.55
978	50.56	61.43	12.06	0.96	0.56
1500	50.27	61.51	12.39	0.94	0.60

Table 2: The results with 5000 callers.

5 Observations and Interpretation of Results

We see the the results with 1000 callers and 5000 callers from section 4. Comparing these 2 results, we see clearly that results with 1000 callers have a larger span for utilization of both front-desk and expert operators. The numbers of U1, U2, A1 and A2 in table 1000 has more standar deviation than the numbers of U1, U2, A1 and A2 in table with 5000 callers. Thus we can clearly say that the table with 5000 callers has more stable results in terms of U1, U2, A1 and A2 values. Nevertheless, R1 of these 2 experiments are almost identical. Thus, we can conclude that utilization values of operators, average total waiting time and average number of people waiting to be served by the expert operator should be simulated with larger numbers for a more accurate result. However, maximum total Waiting time to total system time ratio can be calculated accurately with a smaller simulation.

We can say that front-desk service stays idle for half of the simulation time and expert service stays idle for 40 percent of time. Average waiting times are about 12 minutes and at the worst case a customer will spend 95 percent of its time as waiting in the queue. At average 0.5 customer waits in the queue to be served.

Since front-desk service stays idle too much, we can give them break. Expert service stays idle at lower rate so we can send some workload from expert to front-desk service to keep workloads on the services at the same rate. Average waiting times looks acceptable but also depends on the environment, it looks like non-urgent system. At worst case, customer may spend considerable percentage of its time on waiting, those maximum percentages come from reneging customers. Average second queue length looks okay for this system.