UNIVERSITI TUNKU ABDUL RAHMAN

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JANUARY 2020 TRIMESTER

FINAL ASSESSMENT

ANSWER SCRIPT

Candidate is required to fill in ALL the information below:

Name : (as stated in Student Identity Card)	Ngu Yi Hui		
Faculty /Institute/ Centre:	FSc	Programme :	Statistical Computing And Operations Research
Index No. (in numbers) :	A00082DBSCF	Index No. (in words) :	AZeroZeroZeroEightTwoDBSCF
Course Code :	UDPS2293	Course Description :	Queuing Models
Submission Date :	8^{th} MAY 2020	Submission Time :	9am

QUESTION NUMBER	**FOR EXAMINER'S USE ONLY**	
	MARKS	
	Internal	**External**
Q1		
Q2		
TOTAL MARKS		

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DECLARATION STATEMENT

I, Ngu Yi Hui (Name), Student ID No. 18ADB01438, hereby solemnly and fully declare and confirm that during my programme of study at Universiti Tunku Abdul Rahman, I shall abide and comply with all the rules, regulations and lawful instructions of Universiti Tunku Abdul Rahman and endeavour at all times to uphold the good name of the University.

I hereby declare that my submission for this Final Assessment is based on my original work, not plagiarised from any source(s) except for citations and quotations which have been duly acknowledged. I am fully aware that students who are suspected of violating this pledge are liable to be referred to the Examination Disciplinary Committee of the University.

Programme:	Statistical Computing And Operations Research
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Student's I.C / Passport No.:	991110-14-6378
Index No:	A00082DBSCF
Date of Submission:	8th MAY 2020

<u>Question1. Article Review</u>

A. Introduction

Queuing can be observed in many service industries, and will directly affect the satisfaction of the customers. Thus, Manchester and Leeds-Bradford airports are interested to measure the performance of their airport check-in services through queuing model. Besides that, two types of simulation models are used in this project, which is Simulation Model (SM) and Analytical Model (AM), to estimate the changes in the system's behaviour. The objective of this project is to increase the Level of Service (LOS) for the customers.

B. Methodology

We obtained the data for Manchester and Leeds-Bradford airports directly from the United Kingdom Civil Aviation Authority database. It is taken from 5am to 11am as peak hours during a regular day. The unit of travel demand is in Million Passengers Per Annum (mppa), while the unit of travel demand rate is in persons per hour (pers/hour). From the database, we obtain 22 mppa and 3.3 mppa for the travel demand of Manchester and Leeds-Bradford airports. Meanwhile, we get the information on the travel demand rate which is 2511 (pers/hour) and 377 (pers/hour) for the two airports.

Analytical Model (AM)

Deterministic system (D|D|s) has been applied in this model, which means the arrival rate and service rate is a constant value. Limited capacity occurs in this model and the customers are served on First-Come-First-Served (FCFS) basis.

Simulation Model (SM)

In this project, SimEvents in MATLAB is used as a tool to simulate the arrival and service process of the check-in system. We choose exponential arrival distribution for this project and the queuing disciplinary is FCFS with finite capacity.

C. Result and Discussion

Utilization Rate (ρ)

The number of scanners generated in the model fulfilled the equilibrium state. Also, AM and SM both generate similar results. The models generate the range of 22 to 37 scanners for Manchester airport, while 5 to 13 scanners for Leeds-Bradford airport. Both airports show that lesser scanners used will cause a higher utilization rate. In Manchester airport, when the number of scanners is 22, both models yield $\rho > 0.9$. It drops to 0.5-0.6 when the number of scanners increases to 37. This is true as scanners represent servers in this project.

Average Queue Length (L_q)

We noticed that AM is having a longer queue compared with SM when lesser scanners are used. This is because the consistency of the input variables of AM might not be real. However, both models show a longer queue for lesser scanners. In SM, around 5 passengers are observed in the queue when 22 scanners are used, while the number of passengers is less than one when 37 scanners are used at Manchester airport. When the number of scanners increases to 30 scanners, no obvious queue is observed since the demand is met.

Average waiting time on queue (W_q)

The result of average waiting time on queue reacts similarly with the result of average queue length. In general, longer waiting time is observed when lesser scanners are used. When the number of scanners increases to 30 scanners and 9 scanners in Manchester and Leeds-Bradford airports respectively, there is no obvious waiting time on queue.

Average Arrivals and Throughputs

AM and SM are both getting similar utilization rate (ρ) and average service time. However, since AM is a deterministic model and SM is a stochastic model, this causes them to obtain different results on queue length and waiting time. Besides that, the maximum arrivals and throughputs of the two models are also different. SM seems to have the ability to cater to a larger scope of variation. Therefore, SM is more reliable as it follows random distribution uses discrete-time analysis techniques.

D. Personal review

It is good to compare two types of models in this project. The tool, SimEvents used is favourable to generate the situation near to reality and helps better evaluate the performance of the check-in system. In my opinion, some information can be added to improve the accuracy of measuring the efficiency, such as the number of luggage and domestic or international flight. At last, the number of scanners to be used in the two airports shall be recommended at the end of the project to achieve its objective, increasing the Level of Service (LOS).

Question 2. Comparison on Queuing Systems

A. Necessary assumptions

I plan to open a cake shop in Ipoh. Customers can order at the counters and get their cakes directly after they have paid the price. The queuing discipline is on First-Come-First-Served (FCFS) basis. Customers can queue as long as they are willing to. Assume that the arrivals of customers follow a Poisson distribution and the service time is exponentially distributed. I plan to set up the counter in my shop with three workers.

There are three systems that I consider to place it in my shop: System I (3 servers with 3 queues), System II (3 servers with 1 queue), and System III (1 server with 1 queue). In order to make the question easy for interpretation, the customer arrival rate is set as $\lambda = 45$ per hour. So, the arrival rate in System I for a single server is $\lambda_I = \frac{45}{3}$ per hour, while the arrival rate for System II and III remains $\lambda_{II} = \lambda_{III} = 45$ per hour. The service rate in System I and II is $\mu_I = \mu_{II} = 20$ customers per hour, while the service rate in System III is $\mu_I = 60$ customers per hour.

B. Measure of performance

Queuing System	λ	μ	ρ	p_0	L_s	L_q	W_s	W_q
System I	15	20	0.75	0.25	3	2.25	0.2	0.15
	15	20	0.75	0.25	3	2.25	0.2	0.15
	15	20	0.75	0.25	3	2.25	0.2	0.15
System II	45	20	0.75	0.0748	3.9533	1.7033	0.0879	0.0379
System III	45	60	0.75	0.25	3	2.25	0.0667	0.05

Table 1. Performance measurement of the three systems

Consumer Perspective

For my customers, either System II or III will be their preference. Although System II has more customers in the system, it provides the shortest waiting time for the customers to reach the counter (W_q= 0.038 hour). While in System III, customers can spend the minimum time in the system (W_s= 0.067 hour). System I might not increase their satisfaction since the waiting time is the longest among the three systems.

On the other hand, customers will tend to choose a system that allows them to enjoy the service directly when they reach the shop. In this case, System II is the best choice for them as it offers the customers to have the highest probability to enter the service once they reach the shop ($p_{n\leq 2}$ = 0.432).

Owner Perspective

For me, all the systems are having the same utilization rate (ρ = 0.75). However, System II has the lowest probability of no customers in the system (p_0 = 0.075). This might help in advertising as it shows that my shop is always having customers.

The expected expenses for managing the service system includes two contradict costs, which is the cost of operating each counter (C_S) and the cost for customers to wait in the service system (C_W) (Prasad et al., 2015). Formulas are shown as below:

For System I, $Expected\ Total\ Cost\ E_{TC} = s(C_S + L_S C_W)$

For System II, $Expected\ Total\ Cost\ E_{TC} = sC_S + L_S C_W$

For System III, $Expected\ Total\ Cost\ E_{TC} = C_S + L_S C_W$

where s = number of counters in the shop, L_S = length of queue in the system.

Case	System I	System II	System III
C_S = 100, C_W =200	\$ 2100	\$ 1091	\$ 700
C_S = 100, C_W =100	\$ 1200	\$ 695	\$ 400
C_S = 200, C_W =100	\$ 1500	\$ 995	\$ 500

Table 2. Cost Comparison among the three systems

From Table 2, we observed that no matter we change the C_S to be higher or lower than C_W, System I is always the most expensive system for my shop. System III is an economic system for me since it costs me the least for all the time.

C. Personal recommendation

In my opinion, I will recommend System III as the service system in my shop. This is because System III offers the lowest service costs, meanwhile provides good services for the customers. Although the customers need to wait longer time in queue compared with System II, System III still can save their time because it yields the shortest waiting time in system. This will improve the satisfaction of the customers. In addition, since the utilization rate for all the three systems is the same, System III will be the best choice as it costs the least. In the long run, it will help to save lots of money.

References

Prasad, S.V., Badshah, V.H., Koka, T.A. (2015). Mathematical analysis of single queue multi server and multi queue multi server queuing models: comparison study. *Global Journal of Mathematical Analysis, 3(3)*, 97-104.

Saleh, N. & Ahmad, R. (2017). Efficient system for queues: a case study on a fast-food restaurant in Pahang. *eProceedings Chemistry 2*, 291-296.

Video Link for Question 1:

https://fautar.blogspot.com/