Improving the Queueing of a Light Rail Transit

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***Abstract*—** This study will share enough knowledge and experience on how to deal with people and employees, at the same time it will broaden up their abilities in handling simple problems in their field of specialization. This study will help them to be more productive and to have more effective ways on how to prevent and to handle simple problem. This study can be their reference in future, it will be easier for them to identify common problems that may occur in the company. The coverage of this study is focus on the queing system of LRT Line 2 A particular Station. This Study will only cover the time starting from inter-arrival time to service time which is buying of ticket but delimit the process on queueing before entering the station and the process of checking of bags. The researcher also focus and conduct their study during 5:30 to 6:30 pm of The day (Tuesday), the researcher pick the said time because it is the peak hours during summer. The researchers conclude that the single server will not be good enough especially during 5:30 to 6:30 pm operation due to huge arrival rate in the system. The researchers also proposed that the multi-server which will compose of 2 servers will be more efficient taking 98.54% higher than the single server operation. Through the researchers proposal the waiting time in line will become 0.02 minutes per customer.

***Index Terms*—** Queueing, Arrival Rate, Single-server, Service Rate, Utilization, Waiting

Chapter I

THE PROBLEM AND ITS BACKGROUND

1.1 Background of the Study

Queueing theory is a mathematical application where the analyst and researcher and use it to verify and identify the service rate, arrival rate, probability idle time, number of customer waiting in system and number of waiting time in the system. According to Ndkwe H.C of Nigerice, there is usual of queueing. He also states that queueing in Health and Nutrition public sectors in like Hospitals in indeed of reducing the idle time because of the risk of life of every patient. Emergency room is also one of the most critical sector and department at any hospitals.

Operational research is about a discipline that deals with the application of advanced analytical methods to help make better decisions. It is often considered to be a sub-field of mathematics. The terms management science and decision science are sometimes used as synonyms.

We usually don't notice that there would be a great effect if there would always be proper analysis on the product we do and how the process should be made because good management will always be complete if the planning and execution are good. In a big production operational research takes a big role on the whole process of the production especially if the company wanted to have a good profit and smooth process.

1.2 Statement of the problem

1.2.1 General Problem

The existing system that makes the queue longer

1.2.2 Specific Problem

Too long waiting time in the line which is 1.38 minutes per customer.

1.3 Objectives of the Study

1.3.1 General Objective

To propose a solution which the researcher will apply their knowledge in Queueing theory to solve the problem

1.3.2 Specific Objective

A proposal of improvement through application of Queueing theory to reduce the waiting time in line by half.

1.4 Significance of the Study

Proponents

This study will give them enough knowledge and experience on how to deal with people and employees, at the same time it will broaden up their abilities in handling simple problems in their field of specialization.

Company

This study will help them to be more productive and to have more effective ways on how to prevent and to handle simple problem.

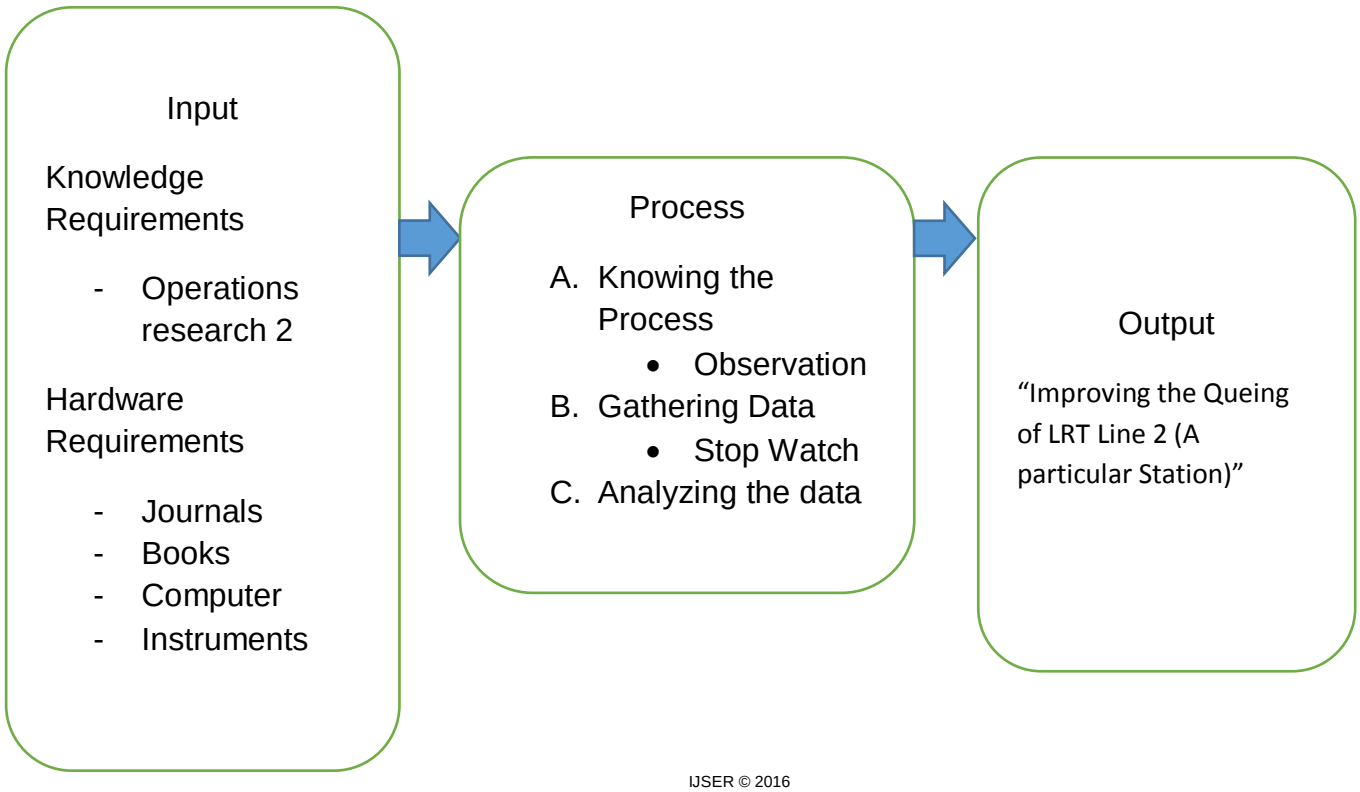
Researchers

This study can be their reference in future, it will be easier for them to identify common problems that may occur in the company.

1.5 Scope and Delimitation

The coverage of this study is focus on the queing system of LRT Line 2 A particular Station. This Study will only cover the time starting from inter-arrival time to service time which is buying of ticket but delimit the process on queueing before entering the station and the process of checking of bags. The researcher also focus and conduct their study during 5:30 to 6:30 pm of The day (Tuesday), the researcher pick the said time because it is the peak hours during summer.

1.6 Research Paradigm



CHAPTER II

METHODOLOGY

This Chapter presents the methods we used in this study. It includes the methods of research, location of the study, sources of the data gathered, procedures on how to gather data and the instruments used.

2.1 Research Design

In conducting this study we used simple techniques such as time and motion study and application of Operational Research 2, actual observation and analysis. We gathered data through having a time and motion on the service process of the LRT line 2 A particular station.

2.2 Source of Data

Primary- Light Railway Transit Line 2 (A particular Station)

Secondary- Internet sites and books, Technological Institute of the Country A city library and formers research study of the students in an Institute.

2.3 Procedure

In conducting the research paper in operations research 2, the researcher use simply techniques such as observation on how fast the service per person and its inter-arrival rate of the LRT. The researcher also listed down the important details they need to accomplish the problem that they have seen through time and motion study.

2.4 Research Instruments

The researcher conducted an observation and time and motion study through the use of stop watch. The researchers also use software such as Microsoft word, Visio, PQM and specially the Pro Model.

2.5 Data Gathering Instruments

In conducting the research paper in operations research 2, the researcher used recording sheet for observation of patterns that they follow on purchasing tickets and stop watch for the time and motion study, also Microsoft Visio for the company layout which can be used on developing the present workplace.

CHAPTER III

PRESENTATION, ANALYSIS AND INTERPRETATION OF DATA

DEFINING THE PROBLEM:

3.1 Fish Bone Diagram

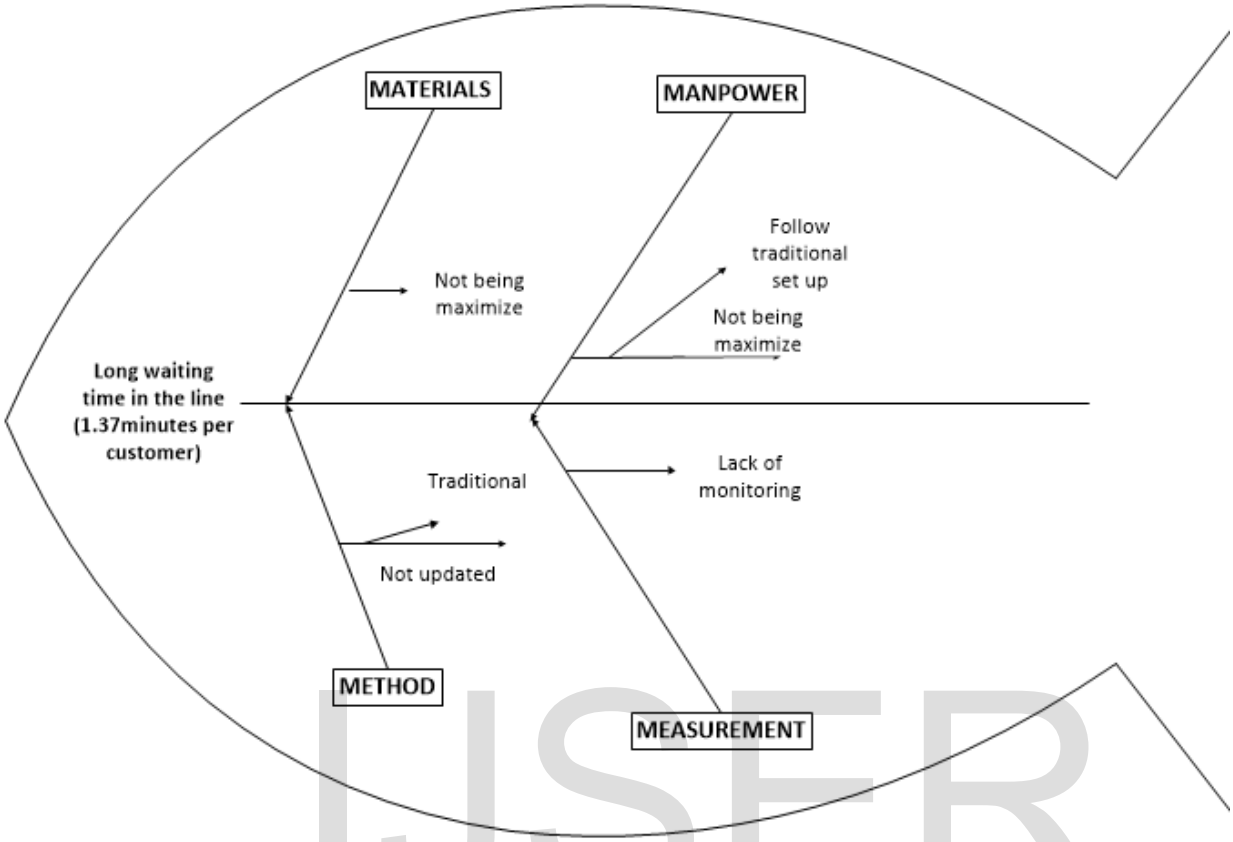


Figure 3.1

3.2 Five Why Analysis

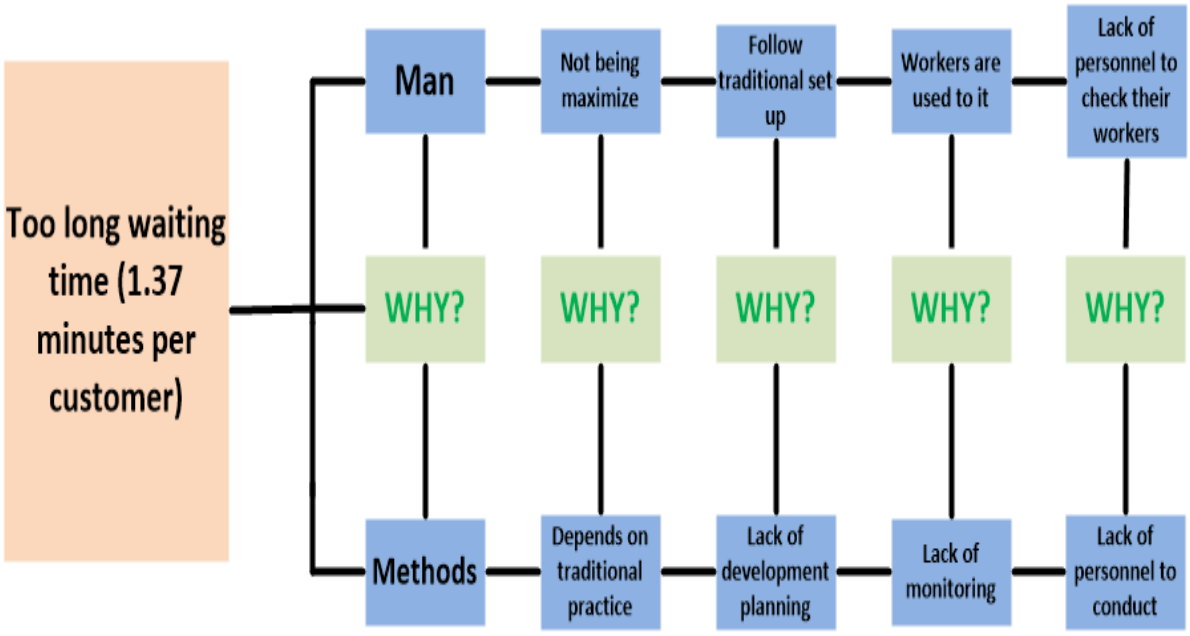


Figure 3.2

3.3 SAMPLE SURVEY

SURVEY FORM (CUSTOMER OF LRT LINE 2 LEGARDA STATION)

NAME (OPTIONAL):

What will be your rate in the performance of LRT line 2 (Legarda Station)?

1 (Unacceptable), 2 (needs improvement), 3 (Fair), 4 (Satisfactory) and 5 (Excellent).

What will be your rate with regards to their queing (time on waiting in line) in buying tickets?

1 (Unacceptable), 2 (needs improvement), 3 (Fair), 4 (Satisfactory) and 5 (Excellent).

Are you satisfied on their service time and queing time (waiting time in line)?

YES OR NO

3.4 SURVEY RESULTS

What will be your rate in the performance of LRT line 2 (A particular Station)?

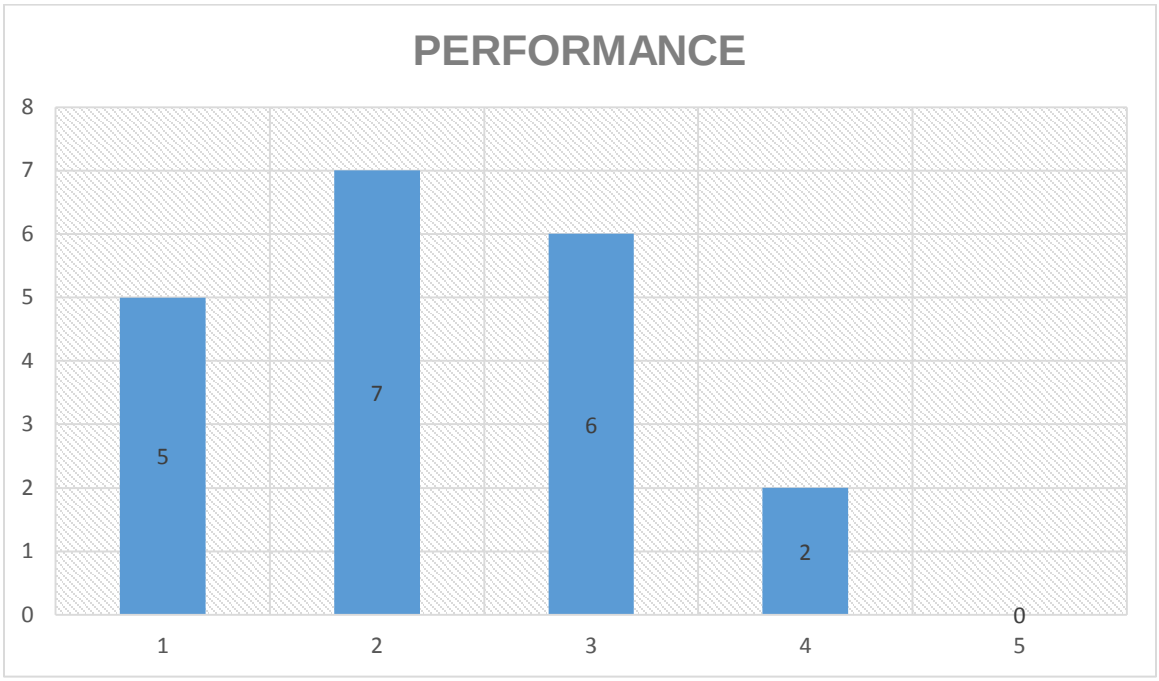


Figure 3.3

The result chart shows that 7 out of 30 (23.33%) respondents said that the performance of LRT Line 2 in A particular Station needs improvement.

What will be your rate with regards to their queing (time on waiting in line) in buying tickets?

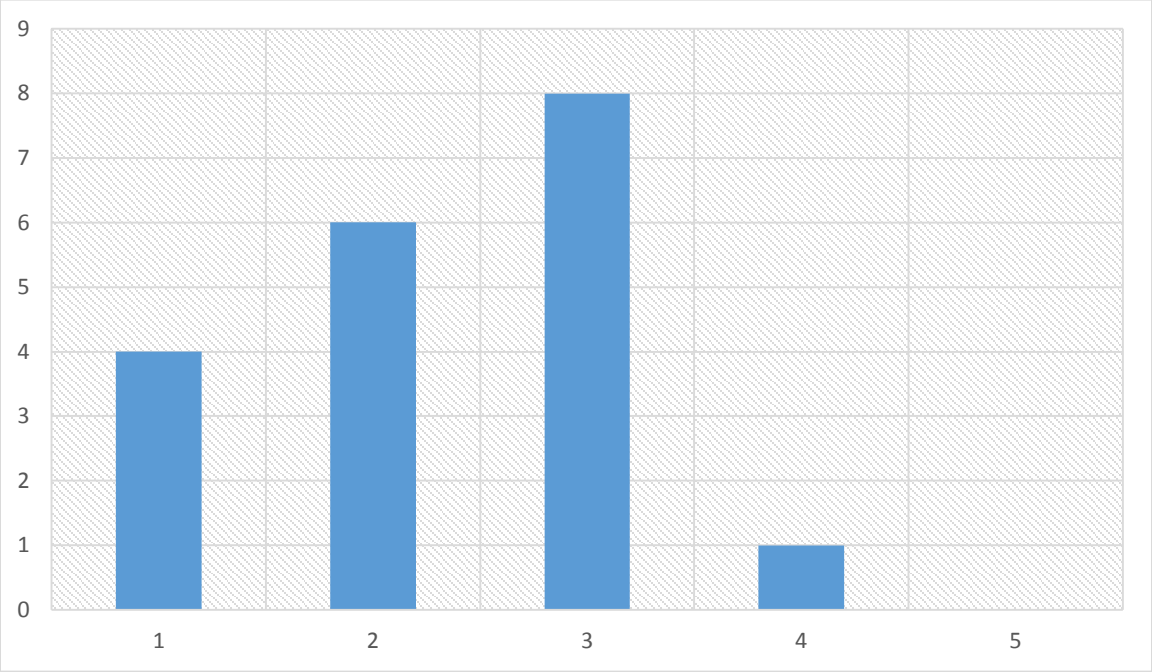


Figure 3.4

The results shows that 8 out of 30 (26.67) respondents tells that the queing time in LRT Line 2 A particular station needs an improvement.

Are you satisfied on their service time and queing time (waiting time in line)?

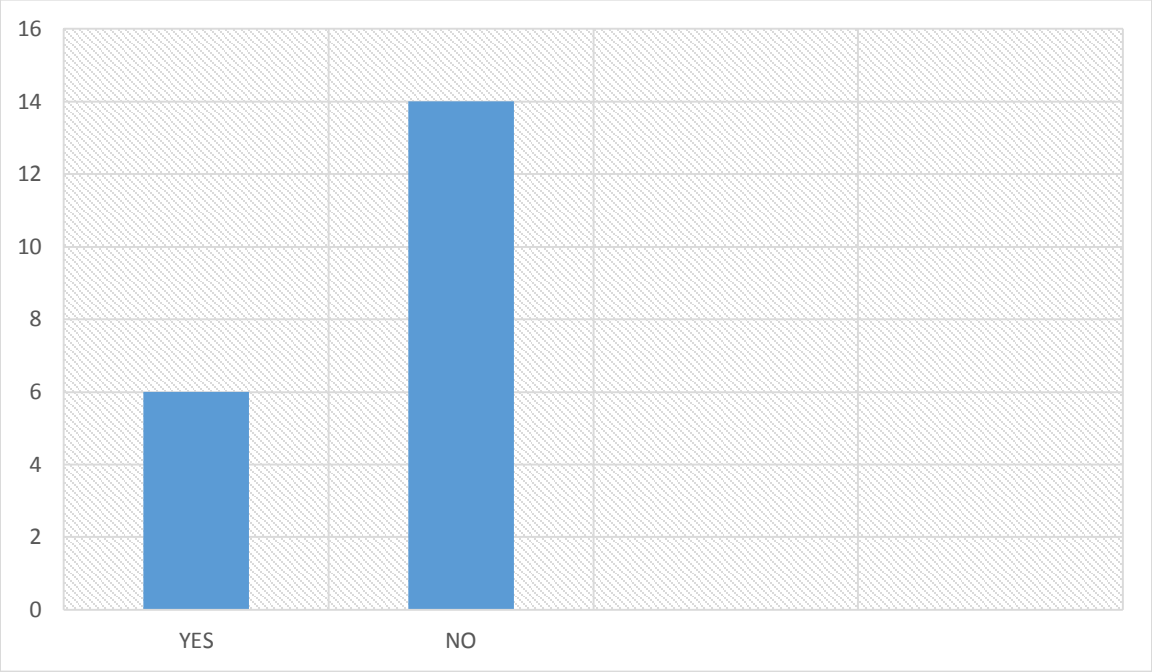


Figure 3.5

The result chart shows that 14 out of 30 respondents (46.67%) are not satisfied with regards to the service time and queing time of LRT Line 2 A particular Station.

3.5 Time & Motion Study

Observation	1	2	3	4	5	6	7	8	9	10
Service Time	4.23	5.12	5.29	6.12	5.34	5.45	4.26	4.44	5.21	5.38

Observation	11	12	13	14	15	16	17	18	19	20
Service Time	5.54	6.06	4.22	5.43	5.33	6.23	4.18	5.13	6.34	5.34

Observation	21	22	23	24	25	26	27	28	29	30
Service Time	6.14	5.21	6.21	4.24	6.13	5.12	4.34	6.23	5.13	4.28

	Observed Time	Service rate in seconds	Service rate in minutes	Service rate in hour
Service Time	5.2557 sec	0.1903	11.418	685.08

Table 3.1

Arrival Rate

Table 3.2

Time (pm)	Number of customer arriving
5:30	45
5:35	55
5:40	64
5:45	54
5:50	53
5:55	57
6:00	54
6:05	48
6:10	45
6:15	43
6:20	47
6:25	36
6:30	43
Total	644

Arrival Rate = $\frac{644 \text{ customer}}{1 \text{ hour}}$

PQM existing

Parameter	Value	Parameter	Value	Minutes	Seconds
M/M/1 (exponential service		Average server utilization	.94		
Arrival rate(lambda)	644	Average number in the queue(Lq)	14.74		
Service rate(mu)	685.08	Average number in the system(Ls)	15.68		
Number of servers	1	Average time in the queue(Wq)	.02	1.37	82.38
		Average time in the system(Ws)	.02	1.46	87.63

Figure 3.6

Single Server

Ratio of Arrival Rate to Service Rate

$$\rho = \frac{\lambda}{\mu}$$

Where:

λ= Arrival Rate

μ = Service Rate

Average Number of Customers in the System

$$Ls = \frac{\rho}{1-\rho}$$

Average Number of Customers Waiting in Line

$$Lq = \frac{\rho^2}{1-\rho}$$

Average Customer Time Spent in the System

$$Ws = \frac{1}{\mu(1-\rho)}$$

Average Customer Time Spent Just Waiting in Line

$$Wq = \frac{\rho}{\mu(1-\rho)}$$

Idle Time

$$P_o = 1 - \rho$$

Probability Graph

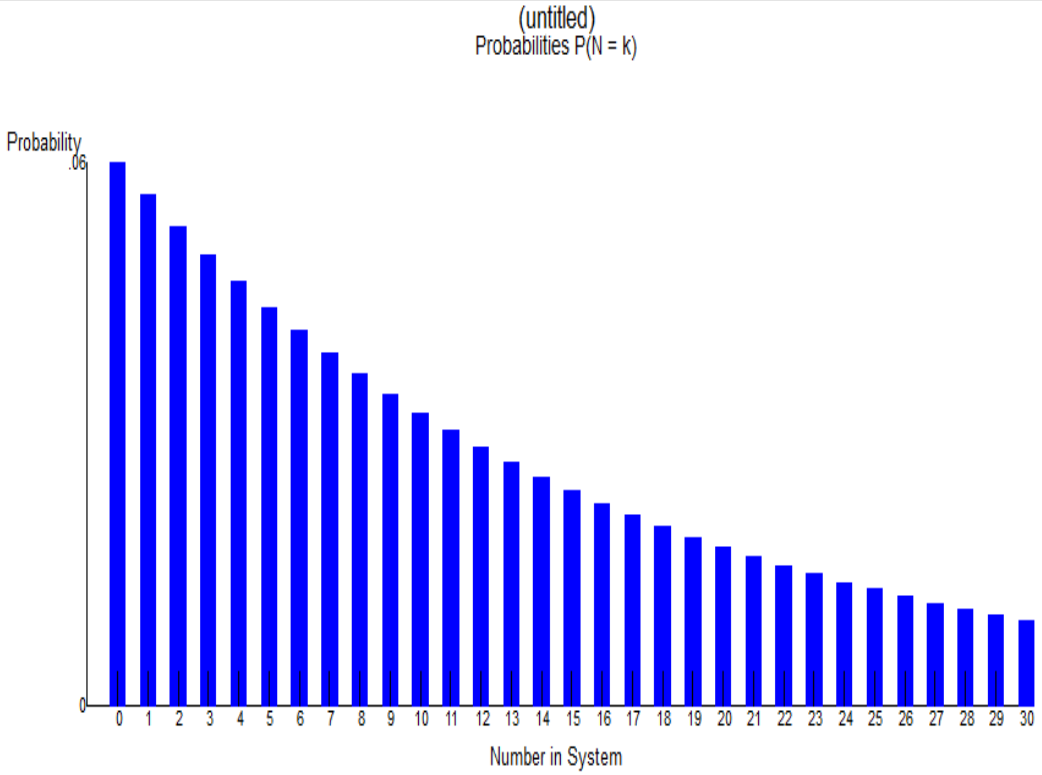


Figure 3.7

Probability

Table 3.3

k	Prob (num in sys = k)	Prob (num in sys <= k)	Prob (num in sys >k)
0	.06	.06	.94
1	.06	.12	.88
2	.05	.17	.83
3	.05	.22	.78
4	.05	.27	.73
5	.04	.31	.69
6	.04	.35	.65
7	.04	.39	.61
8	.04	.43	.57
9	.03	.46	.54
10	.03	.49	.51
11	.03	.52	.48
12	.03	.55	.45
13	.03	.58	.42
14	.03	.6	.4
15	.02	.63	.37
16	.02	.65	.35
17	.02	.67	.33
18	.02	.69	.31
19	.02	.71	.29
20	.02	.73	.27
21	.02	.74	.26
22	.02	.76	.24
23	.01	.77	.23
24	.01	.79	.21
25	.01	.8	.2
26	.01	.81	.19
27	.01	.82	.18
28	.01	.83	.17
29	0	.84	.16
30	0	.85	.15

3.6 APPLICATION OF PROMODEL (Single Server)

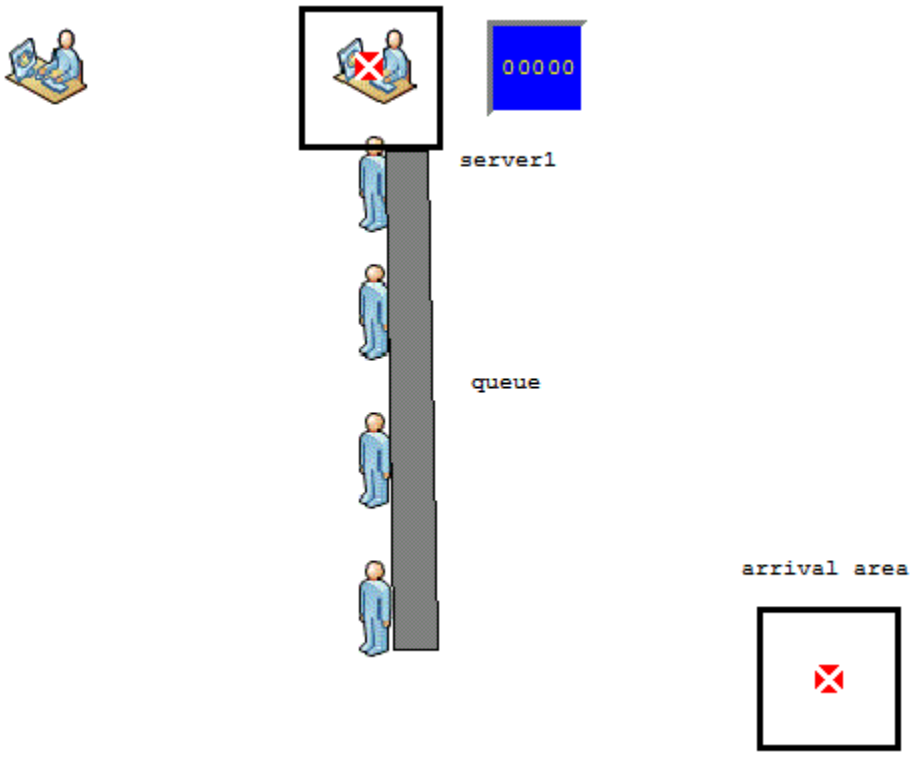


Figure 3.8

single.MOD (Normal Run - Rep. 1)								
Name	Scheduled Time (DAY)	Capacity	Total Entries	Avg Time Per Entry (HR)	Avg Contents	Maximum Contents	Current Contents	% Utilization
arrival area	0.04	999999.00	822.00	0.09	77.47	187.00	185.00	0.01
queue	0.04	15.00	637.00	0.02	14.84	15.00	15.00	98.96
server1	0.04	1.00	622.00	0.00	0.03	1.00	0.00	3.32

single.MOD (Normal Run - Rep. 1)							
Name	Total Exits	Current Qty In System	Avg Time In System (HR)	Avg Time In Move Logic (HR)	Avg Time Waiting (HR)	Avg Time In Operation (HR)	Avg Time Blocked (HR)
customer	622.00	200.00	0.11	0.00	0.00	0.02	0.09

PQM Proposed (MULTI-SERVER)

Parameter	Value	Parameter	Value	Minutes	Seconds
M/M/s		Average server utilization	.47		
Arrival rate(lambda)	644	Average number in the queue(Lq)	.27		
Service rate(mu)	685.08	Average number in the system(Ls)	1.21		
Number of servers	2	Average time in the queue(Wq)	0	.02	1.49
		Average time in the system(Ws)	0	.11	6.74

Average Number of Customers in the System

$$Ls = Lq + \rho$$

Average Number of Customers Waiting in Line

$$Lq = \frac{\rho^{c+1}}{(c-1)!\,(c-\rho)^2} \text{ x } Po$$

Average Customer Time Spent in the System

$$Ws = \frac{Ls}{\lambda}$$

Average Customer Time Spent Just Waiting in Line

$$Wq = \frac{Lq}{\lambda}$$

System Utilization

$$\frac{\rho}{c}$$

Idle Time

$$Po = (\left(\sum_{n=0}^{c-1} \frac{\rho^n}{n!}\right) + \frac{\rho^c}{c!} * \left(\frac{1}{1-\frac{\rho}{c}}\right))\text{^} - 1$$

Probability Graph

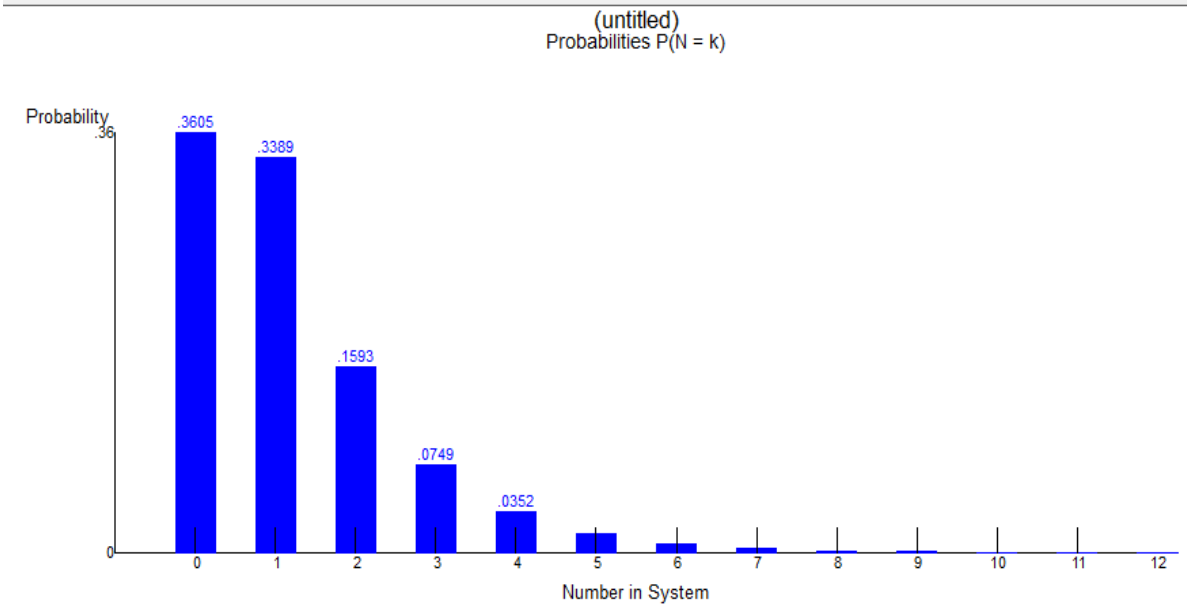


Figure 3.9

Probability Values

k	Prob (num in sys = k)	Prob (num in sys <= k)	Prob (num in sys >k)
0	.36	.36	.64
1	.34	.7	.3
2	.16	.86	.14
3	.07	.93	.07
4	.04	.97	.03
5	.02	.99	.01
6	0	1	0
7	0	1	0
8	0	1	0
9	0	1	0
10	0	1	0
11	0	1	0
12	0	1	0

APPLICATION OF PROMODEL (Mulan institutele Server)

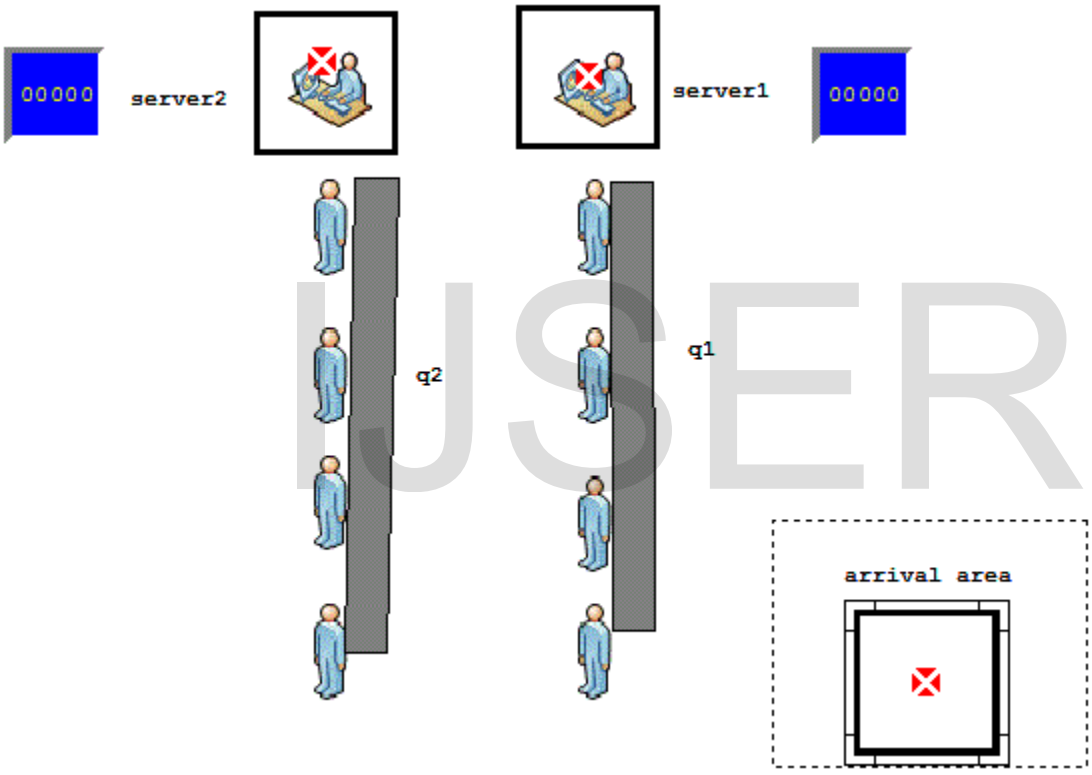


Figure 3.10

Name	Scheduled Time (DAY)	Capacity	Total Entries	Avg Time Per Entry (HR)	Avg Contents	Maximum Contents	Current Contents	% Utilization
arrival area	0.04	999999.00	1708.00	0.01	15.66	51.00	0.00	0.00
q1	0.04	20.00	880.00	0.02	19.60	20.00	20.00	98.00
q2	0.04	20.00	828.00	0.02	18.76	20.00	20.00	93.78
server1	0.04	1.00	860.00	0.00	0.04	1.00	0.00	4.36
server2	0.04	1.00	808.00	0.00	0.04	1.00	0.00	4.37

multiple.MOD (Normal Run - Rep. 1)

Name	Total Exits	Current Qty In System	Avg Time In System (HR)	Avg Time In Move Logic (HR)	Avg Time Waiting (HR)	Avg Time In Operation (HR)	Avg Time Blocked (HR)
customer	1668.00	40.00	0.03	0.00	0.00	0.02	0.01

COMPARISON OF THE RESULTS			
	SINGLE SERVER	2 SERVER	Difference
Average server utilization	.94	.47	
Average Number in queue	14.74	.27	
Average number in system	15.68	1.21	
Average time in queue	1.37 minutes	.02 minutes	1.35 minutes
Average time in the system	1.46 minutes	.11 minutes	1.35 minutes

CHAPTER IV

SUMMARY OF FINDINGS, CONCLUSION AND RECOMMENDATION

4.1 Summary of findings

During the study the researchers use their knowledge in Operations research 2 specially the queueing theory. The researchers conduct an observation in the area and gather the data needed to support the study. An assessment conducted through solving the given data and found out that the single server is not enough to accommodate the customer waiting in the queue which make the queing time 1.38 minutes.

4.2 Conclusion and Recommendation.

The researchers conclude that the single server will not be good enough especially during 5:30 to 6:30 pm operation due to huge arrival rate in the system. The researchers also proposed that the multi-server which will compose of 2 server will be more efficient taking 98.54% higher than the single server operation. Through the researchers proposal the waiting time in line will become 0.02 minutes per customer.