Application of Queuing Model to Minimize the Waiting Time in Fuel Stations

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Abstract **- The purpose of this paper is to study how the queuing model is applied to minimize the waiting time in fuel stations. In many fuel stations there had been long queues to collect the fuel as a result there may be a rare of the products in recent time. This type of station makes the customers to wait for more than hours. The service station in cities sells products to the available customers in a random order, which results to long queue in fuel stations. In this paper a single channel multiple server model is considered to reduce the waiting time of the customers.**

Keywords **- Queuing Model, Kendall's Notation, Poisson Probability, Average Waiting Time**

I. INTRODUCTION

In today's life each and every person is facing a problem of Queuing. This problem is very much common in many of fields for example marking, business management, information technology, reservation of tickets, library management, traffic control, paying various bills etc. Queuing model is applied to such problems to analyze it and apply it to improve and modify the system to minimize the waiting time of customers. In queuing theory we use the Kendall's notation to describe the queue model. The arrival, service and departure of the customers are independent to one another. The process is continues. The arrivals per unit length of time are calculated using Poisson Probability Distribution. The queue discipline is FCFS(First Come First Server) with infinite queue system.

This ensures that the waiting time of the customers waiting time of the customers is greatly reduced [1]. The search to stop the frequently arising problem of delays experienced in the queuing system in cities. As a result a long queue is normally exists in fuel station on daily bases. Scarcity of fuel products from the supply will results in creating confusions among the customers.

(i) Customers have to wait for a long time without being served.
(ii) Returning of the customers.

II. METHODOLOGY

We collect the data from Golden Lion Fuel Station at Hinthada from 4.00 pm to 7.00 pm. Five days data was collected from this fuel station. The arrival time of customers was calculated by the help of stop-watch. Analysis of this type is helpful in the calculation of inter arrival time and service time. A simple activity of the queuing system is given in below:

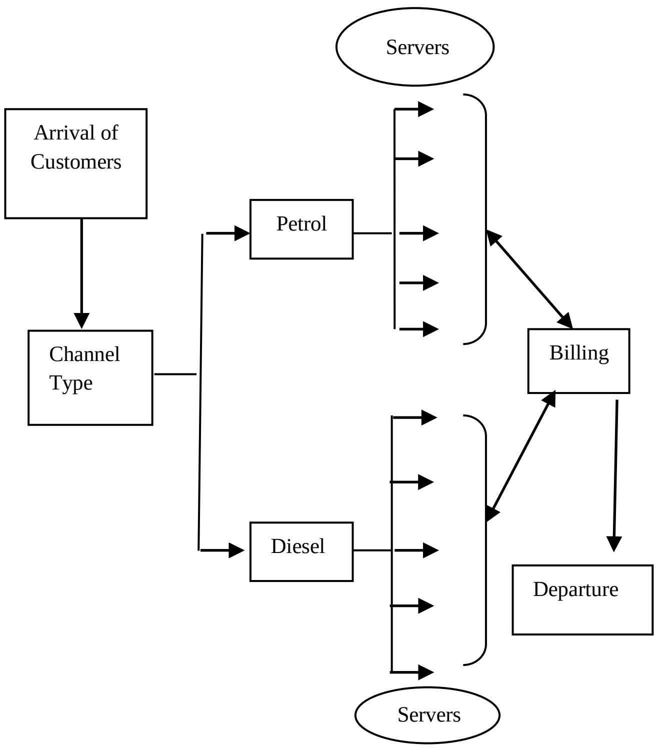

Fig 1. Block diagram of golden lion fuel station filling station

System analysis describes the activity and to find the problem area to provide immediate solution by reducing the waiting time. Let D_1, D_2, D_3, D_4, D_5 the observed Inter arrival time for day 1, 2, 3, 4, 5 respectively.

(**See Table I**)

For day 1

Mean Inter - arrival time is

$$t_1 = \frac{\sum D_1 t}{D_1} = \frac{7920.5}{171} = 46.32 \approx 46$$

$t_1 = 46$ sec/bike.

Arrival rate is

$$\lambda_1 = \frac{1}{t_1} = \frac{1}{46} = 0.0217 \text{bike/sec}$$

$$\lambda_1 = 2.17 \text{ bike / min} \approx 2$$

$\lambda_1 = 2$ bike/min.

For day 2

Mean Inter - arrival time is

$$t_2 = \frac{\sum D_2 t}{D_2} = \frac{7500.5}{155} = 48.39 \approx 48$$

$t_2 = 48$ sec/bike.

Arrival rate is

$$\lambda_2 = \frac{1}{t_2} = \frac{1}{48} = 0.0208 \text{bike/sec}$$

$$\lambda_2 = 2.08 \text{ bike / min} \approx 2$$

$\lambda_2 = 2$ bike/min.

For day 3

Mean Inter - arrival time is

$$t_3 = \frac{\sum D_3 t}{D_3} = \frac{7000.5}{148} = 47.3 \approx 47$$

$t_3 = 47$ sec/bike.

Arrival rate is

$$\lambda_3 = \frac{1}{t_3} = \frac{1}{47} = 0.0213 \text{bike/sec}$$

$$\lambda_3 = 2.13 \text{ bike / min} \approx 2$$

$\lambda_3 = 2$ bike/min.

For day 4

Mean Inter - arrival time is

$$t_4 = \frac{\sum D_4 t}{D_4} = \frac{6772}{153} = 44.26 \approx 44$$

$t_4 = 44$ sec/bike.

Arrival rate is

$$\lambda_4 = \frac{1}{t_4} = \frac{1}{44} = 0.0237 \text{bike/sec}$$

$$\lambda_4 = 2.37 \text{ bike / min} \approx 2$$

$\lambda_4 = 2$ bike/min.

For day 5

Mean Inter - arrival time is

$$t_5 = \frac{\sum D_5 t}{D_5} = \frac{6745}{142} = 47.5 \approx 48$$

$t_5 = 48$ sec/bike.

Arrival rate is

$$\lambda_5 = \frac{1}{t_5} = \frac{1}{48} = 0.0208 \text{bike/sec}$$

$$\lambda_5 = 2.08 \text{ bike / min} \approx 2$$

$\lambda_5 = 2$ bike/min.

Average inter arrival time is

$$T = \frac{t_1 + t_2 + t_3 + t_4 + t_5}{5}$$

$$= \frac{46 + 48 + 47 + 44 + 48}{5} = 46.6$$

$T = 47$ sec/ bike

Average Arrival Rate

$$\lambda = \frac{1}{T} = \frac{1}{47} = 0.0213 \text{ bike / sec}$$

$$\approx 2.13 \text{ bike / min} \approx 2$$

$\lambda = 2$ bike / min.

Let F_n, n = 1, 2, 3, 4, 5, 6 be the service time for server 1 to 6.

Table II. Result of computing for t and Fn for server 1 to 6

Service time interval (Mints)	F_1	F_2	F_3	F_4	F_5	F_6
0-4	55	50	63	52	68	60
5-9	10	9	10	7	11	12
Total	65	59	73	59	79	72

	F_1t	F_2t	F_3t	F_4t	F_5t	F_6t
0-4	110	100	126	104	136	120
5-9	70	63	70	49	77	84
Total	180	163	196	153	213	204

Let t_m be the mean service time

$$t_m = \frac{\sum F_m t}{F_m}$$

The service rate is given by $\mu_n = \frac{1}{t_m}$

Table III. Result of tm and μ_s for the 6 servers

No. of Servers	t_m (Mints/car)	μ_s (Mints/car)
1	2.76	0.36
2	2.76	0.36
3	2.68	0.37
4	2.59	0.38
5	2.69	0.37
6	2.83	0.35

Average service time T_m is

$$T_m = \frac{t_1 + t_2 + t_3 + t_4 + t_5 + t_6}{m}$$

$$= \frac{2.76 + 2.76 + 2.68 + 2.59 + 2.69 + 2.83}{6}$$

$$T_m = \frac{16.31}{6} = 2.72 \approx 3 \text{ min/ bike.}$$

Average service rate μ_s is

$$\mu_s = \frac{1}{T_m} = \frac{1}{2.72} = 0.37 \text{ bike / min.}$$

III. M/M/S QUEUE MODEL

Here the queuing system is Fuel Service System. The following assumptions were made for queuing system at the Golden Lion Fuel Station, Hinthada, in accordance with the queuing theory:

- Poisson arrival rate of λ customer per unit time.
- Exponential service times of μ customer per unit time.
- Queue discipline is first come first served basic by any of the server.
- The waiting line has two or more identical servers.
- There is no limit to the number of the queue.
- The average arrival rate is greater than average

The first known values in a calculation performance measure is

(i) Traffic intensity (ρ)

(ii) Probability of the system should be idle (p_0)

The traffic intensity $\rho = \frac{\lambda}{s\mu}$

λ = Arrival rate per minutes

S = Number of servers

μ = Service rate per minute

$$\rho = \frac{213}{6(0.37)} = 0.9594594595 \approx 1.$$

The probability that the system shall be idles

$$P_0 = \left[\sum_{n=0}^{s-1} \frac{1}{n!} (\frac{\lambda}{\mu})^n + \frac{1}{s!} (\frac{\lambda}{\mu})^s \frac{s\mu}{s\mu - \lambda} \right]^{-1}$$

$$= \left[\sum_{n=0}^{5} \frac{1}{n!} (\frac{2.13}{0.37})^n + \frac{1}{6!} (\frac{2.13}{0.37})^6 \frac{6(0.37)}{6(0.37) - 2.13} \right]^{-1}$$

$$= 8.002203671 \times 10^{-4}$$

$$P_0 = 0.00800220367$$

Hence the percent of idleness in the system will be 8%.

Find the expected values.

Numbers of customers wanting in the queue L_q is given by

$$L_q = \left[\frac{1}{(s-1)!} (\frac{\lambda}{\mu})^s \frac{\lambda\mu}{(s\mu - \lambda)^2} \right] P_0$$

$$= \left[\frac{1}{5!} (\frac{2.13}{0.37})^6 \frac{(2.13)(0.37)}{(6 \times 0.37 - 2.13)^2} \right] (0.0808)$$

$$= 23.60871371$$

$$= 23.61 \approx 23$$

Number of customers waiting time in the system L_s is

$$L_s = L_q + (\frac{\lambda}{\mu}) = 23.61 + 5.76 = 29.37$$

$$L_s \approx 29$$

Waiting time of customer in the queue W_q is

$$W_q = \frac{L_q}{\lambda} = \frac{23}{2.13} = 10.79$$

$$W_q \approx 11$$

Waiting time of customer in the queue W_s is

$$W_s = W_q + \frac{1}{\mu} = 11 + \frac{1}{0.37} = 11 + 2.7 = 13.7$$

$W_s \approx 14.$

$L_q = 23.61 \approx 23$

$L_s \approx 29$

$W_q \approx 11$

$W_s \approx 14.$

IV. CONCLUSION

Queuing system is designed to provide fast, efficient, comfortable, cost effective and safe service. The system eliminates time wastage, space constraints and risk. From the above results it has been observed that the utilization factor decreases and percentages of idle workstation has been increased in new suggested queuing model as compared to the existing model. This will definitely reduce the waiting time of customer and will increase the customer will increase the customer satisfaction level.

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REFERENCES

[1] C.O.Ohaneme, "*Performance evaluation of queuing in an established petroleum dispensary system using simulation technique*", IJCNWC, vol.2, no.2, April 2012.

[2] Janos Sztrik, "*Queuing Theory and Its Appilication*", A Personal View , 8th International Conference on Applied Informatics,Vol.1, pp.9-30, 2010.

[3] J.K Sharma, "Operations Research Theory and Applications", fifth edition, 2012.

Table I. Results of inter-arrival time / frequencies for 5 days

Inter Arrival Time	Service Time (T)	D_1	D_1 t	D_2	D_2 t	D_3	D_3 t	D_4	D_4 t	D_5	D_5 t
1-10	2.5	23	57.5	20	50	18	45	25	62.5	22	55
11-20	12.5	24	300	19	237.5	23	287.5	23	287.5	20	250
21-30	22.5	18	408	19	427.5	20	450	21	262.5	19	427.5
31-40	32.5	20	650	21	682.5	17	552.5	20	650	18	585
41-50	42.5	22	935	15	637.5	9	382.5	10	425	8	340
51-60	52.5	16	840	18	945	13	682.5	8	420	10	525
61-70	62.5	14	875	10	625	15	937.5	13	812.5	7	437.5
71-80	72.5	10	725	9	652.5	12	870	10	725	13	942.5
81-90	82.5	1	82.5	2	165	1	82.5	3	247.5	5	412.5
91-100	92.5	3	277.5	3	277.5	2	185	1	92.5	1	92.5
101-110	102.5	2	205	1	102.5	3	307.5	1	102.5	1	102.5
111-120	112.5	4	450	1	112.5	1	112.5	2	225	4	450
121-130	122.5	2	245	2	245	3	367.5	1	122.5	3	367.5
131-140	132.5	1	132.5	2	265	2	265	3	397.5	1	132.5
141-150	142.5	3	427.5	3	427.5	1	142.5	2	285	1	142.5
151-160	152.5	1	152.5	2	305	2	305	3	457.5	2	305
161-170	162.5	5	812.5	1	162.5	1	162.5	1	162.5	3	487.5
171-180	172.5	2	345	7	1207.5	5	862.5	6	1035	4	690
Total		**171**	**7920.5**	**155**	**7500.5**	**148**	**7000.5**	**153**	**6772**	**142**	**6745**