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Minimize the waiting time of Costumer and Gain more Profit in Restaurant Using Queuing Model

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Abstract—Today no body interested to wait for food in restaurant. Some restaurants initially provide more waiting chairs for customers However, waiting chairs alone would not solve a problem, and the service time may need to be improved. This shows a need of a numerical model for the restaurant management to understand the situation better. This paper aims that, using queuing theory satisfies the model when tested with a real-case scenario. We obtained the data from a restaurant in Ahmedabad. We then derive the arrival rate, service rate, utilization rate, waiting time in queue and the probability of potential customers to balk based on the data using Little's Theorem and M/M/1 queuing model. The arrival rate at **Born Vivant** during its busiest period of the day is **2** customers per minute (cpm) while the service rate is **2.05**cpm. The average number of customers in the restaurant is **90** and the utilization period is **0.976**. We conclude the paper by discussing the benefits of performing queuing analysis to a busy restaurant.

Keywords*—*Queue; Little's Theorem; Restaurant; Waiting Lines

I. INTRODUCTION

There are several determining factors for a restaurant to be considered a good or a bad one. Taste, cleanliness, therestaurant layout and settings are some of the most important factors. These factors, when managed carefully, will be ableto attract plenty of customers. However, there is also main factor that needs to be considered especially when therestaurant has already succeeded in attracting customers. This factor is the **customers queuing time.**
Queuing theory is the study of queue or waiting lines. Some of the analysis that can be derived using queuing theory include the expected waiting time in the queue, the average time in the system, the expected queue length, the expected number of customers served at one time, the probability of balking customers, as well as the probability of the system to be in certain states, such as empty or full.

Waiting lines are a common sight in restaurants especially during lunch and dinner time. Hence, queuing theory is suitable to be applied in a restaurant setting since it has an associated queue or waiting line where customers whocannot be served immediately have to queue (wait) forservice. Researchers have previously used queuing theory tomodel the restaurant operation [2], reduce cycle time in abusy fast food restaurant [3], as well as to increasethroughput and efficiency [5].

This paper uses queuing theory to study the waiting linesin **Born Vivant**Restaurant at Ahmedabad city, Gujarat. Therestaurant provides 20 tables of 5 people. There are 8 to 9waiters or waitresses working at any one time. On a dailybasis, it serves over 400 customers duringweekdays andover 1000 customers during weekends. This paper seeks toillustrate theusefulness of applying queuing theory in a real casesituation.

II. QUEUING THEORY

In 1908, Copenhagen Telephone Company requestedAgner K. Erlang to work on the holdingtimes in a telephoneswitch. He identified that the number of telephoneconversations andtelephone holding time fit into Poissondistribution and exponentially distributed. This was thebeginning of the study of queuing theory. In this section, wewill discuss two common concepts in queuing theory.

A. Little's Theorem

Little's theorem [7] describes the relationship betweenthroughput rate (i.e. arrival and service rate), cycle time andwork in process (i.e. number of customers/jobs in thesystem). This relationship has been shown to be valid for awide class of queuing models. The theorem states that theexpected number of customers (N) for a system in steadystate can be determined using the following equation:

$$L=\lambda T$$

Here, λ is the average customer arrival rate and T is theaverage service time for a customer. Consider the example ofa restaurant where the customer's arrival rate (λ) doubles butthe customers still spend the same amount of time in therestaurant (*T*). These facts will double the number ofcustomers in the restaurant (*L*). By the same logic, if thecustomer arrival rate (λ) remains the same but the customersservice time doubles this will also double the total number ofcustomers in the restaurant. This indicates that in order tocontrol the three variables, managerial decisions are onlyrequired for any two of the three variables.

Three fundamental relationships can be derived fromLittle's theorem [6]:

- L increases if λ or T increases
- λ increases if L increases or T decreases
- T increases if L increases or λ decreases

Rust [8] said that the Little's theorem can be useful inquantifying the maximum achievableoperationalimprovements and also to estimate the performance changewhen the system is modified.

B. Queuing Models and Kendall'sNotation

In most cases, queuing models can becharacterized bythe following factors:

- ***Arrival time distribution***. Inter-arrival times mostcommonly fall into one of thefollowing distributionpatterns: a Poisson distribution, a Deterministicdistribution, or a General distribution. However,inter-arrival times are most often assumed to beindependent and memoryless, which is the attributesof a Poisson distribution.
- ***Service time distribution***. The service timedistribution can be constant, exponential, hyper exponential,hypo-exponential or general. Theservice time is independent of the inter-arrival time.
- ***Number of servers***. The queuing calculations changedepends on whether there is a single server ormultiple servers for the queue. A single server queuehas one server for thequeue. This is the situationnormally found in a grocery store where there is aline for each cashier. A multiple server queuecorresponds to the situation in a bank in which asingle line waits for the first of several tellers tobecome available.
- ***Queue Lengths (optional)***. The queue in a systemcan be modeled as having infinite or finite queuelength.
- ***System capacity (optional)***. The maximum numberof customers in a system can be from 1 up to infinity.This includes the customers waiting in the queue.
- ***Queuing discipline (optional)***. There are severalpossibilities in terms of the sequence of customers tobe served such as FIFO (First In First Out, i.e. inorder of arrival), random order, LIFO (Last In FirstOut, i.e. the last one to come will be the first to beserved), or priorities.

Kendall, in 1953, proposed a notation system to representthe sixcharacteristics discussed above. The notation of aqueue is written as:A/B/P/Q/R/Zwhere A, B, P, Q, R and Z describe the queuing systemproperties.

- A describes the distribution type of the inter arrivaltimes.
- B describes the distribution type of the service times.
- P describes the number of servers in the system.
- Q (optional) describes the maximum length of thequeue.
- R (optional) describes the size of the systempopulation.
- Z (optional) describes the queuing discipline.

III. SUSHI TEI QUEUING MODEL

The data were obtained from **Born Vivant** through interviewwith the restaurant manager as well as data collectionsthrough observations at the restaurant.

The daily number of visitors was obtained from therestaurant itself. The restaurant has been recording the dataas part of its end of day routine. We also interviewed therestaurant manager to find out about the capacity of therestaurant, the number of waiters and waitresses, as well asthe number of chefs in the restaurant. Based on the interviewwith the restaurant manager, we concluded that the queuingmodel that best illustrate the operation of **Born Vivant** is M/M/1.

This means that the arrival and service time areexponentially distributed (Poisson process). The restaurantsystem consists of only one server. In our observation therestaurant has severalwaitresses but in the actual waitingqueue, they only have one chef to serve all of the customers.

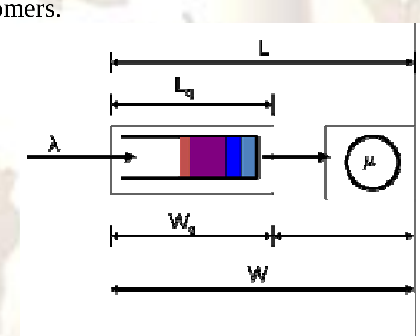

Figure 1 illustrates the M/M/1 queuing model.
For the analysis of the **Born Vivant** M/M/1 queuing model,the following variables will beinvestigated [6]:

- λ : The mean customers arrival rate
- μ : The mean service rate
- ρ : λ/μ : utilization factor
- Probability of zero customers in the restaurant:

$P_0 = 1 - \rho$(2)

- Pn : The probability of having n customers in therestaurant.

$$P_n = P_0\rho^n = (1-\rho)\rho^n \qquad (3)$$

- L: average number of customers dining in therestaurant.

$L = \frac{\rho}{1-\rho} = \frac{\lambda}{\mu - \lambda}$ (4)

- Lq: average number in the queue.

$$L_q = L \times \rho = \frac{\rho^2}{1-\rho} = \frac{\rho\lambda}{\mu - \lambda} (5)$$

- W: average time spent in Sushi Tei, including the waiting time.

$W = \frac{L}{\lambda} = \frac{1}{\mu - \lambda}$ (6)

- Wq : average waiting time in the queue.

$W_q = \frac{L_q}{\lambda} = \frac{\rho}{\mu - \lambda} (7)$

IV. RESULT AND DISCUSSION

The one month daily customer data were shared by therestaurant manager as shown in following table.

Mon	Tue	Wed	Thu	Fri	Sat	Sun
200	220	250	190	225	300	509
310	335	340	344	326	425	564
421	520	500	480	524	600	870
450	570	590	600	697	900	1050

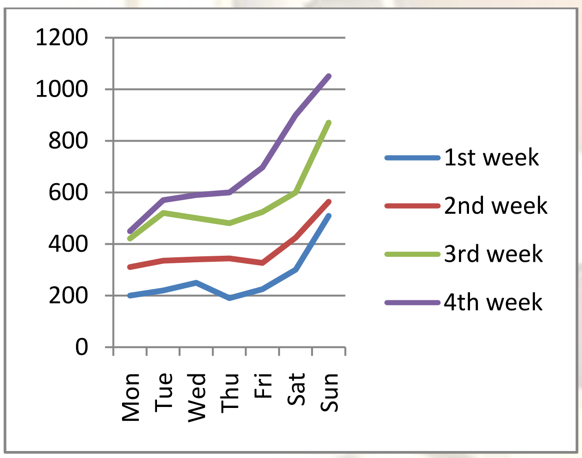

Figure 2. One month daily customer counts

As can be seen in Figure 2, the number of customers onSaturdays and Sundays are double the number of customersduring weekdays. The busiest period for the restaurant is onweekend during dinner time. Hence, we will focus ouranalysis in this time window.

A. Calculation

Our teams conducted the research at dinner time. Thereare on average 400 people are coming to the restaurant in 3hours' time window of dinner time. From this we can derivethe arrival rateas:

λ = 400/180 = 2.22 customer/minute (cpm)

We also found out from observation and discussion withmanager that each customer spends 55 minutes on average inthe restaurant (*W*), the queue length is around 36 people (*Lq*)on average and the waiting time is around 15 minutes.

It can be shown using (7) that the observed actual waitingtime does not differ by much when compared to thetheoretical waiting time as shown below.

W_q= 36 customer/2.22 cpm = 16.22minutes

Next, we will calculate the average number of people in the restaurant using (1).

L = 2.22 cpmX 55 min = 122.1 customers

Having calculated the average number of customers inthe restaurant, we can also derive the utilization rate and theservice rate using (4).

$$\mu = \frac{\lambda(1+L)}{L} = \frac{2.22(1+122.1)}{122.1} = 2.24\ cpm$$

With the very high utilization rate of 0.991 during dinnertime, the probability of zero customers in the restaurant isvery small as can be derived using (2).

$$P_0 = 1 - \rho = 1 - 0.976 = 0.024$$

The generic formula that can be used to calculate theprobability of having *n* customers in the restaurant is asfollows:

$P_n = P_0\rho^n = (1-\rho)\rho^n$
$= (1\text{-}0.976)0.976^n = 0.024(0.976)^n$

We assume that potential customers will start to balkwhen they see more than 10 people are already queuing forthe restaurant. We also assume that the maximum queuelength that a potential customer can tolerate is 40 people. Asthe capacity of the restaurant when fully occupied is 120people, we can calculate the probability of 10 people in thequeue as the probability when there are 130 people in thesystem (i.e. 120 in the restaurant and 10 or more queuing) asfollows:

Probability of customers going away
=P (more than 15people in the queue)
=P(more than 130) people in therestaurant)

$$P_{131-160} = \sum_{n=131}^{160} P_n = 0.02147 = 2.14\ \%$$

B. Evaluation

- The utilization is directly proportional with the mean number of customers. It means that the mean number of customers will increase as the utilization increases.
- The utilization rate at the restaurant is very high at 0.991. This, however, is only the utilization rate during lunch and dinner time on Saturdays and Sundays. On weekday, the utilization rate is almost half of it. This is because the number of visitors on weekdays is only half of the number of visitors on weekends. In addition, the number of waiters or waitresses remains the same regardless whether it is peak hours or off-peak hours.
- In case the customers waiting time is lower or in other words we waited for less than 15 minutes, the number of customers that are able to be served per minute will increase. When the service rate is higher the utilization will be lower, which makes the probability of the customers going away decreases.

C. Benefits

- This research can help to Management of **Born Vivant** to increase their profit by QOS (Quality of Service), by anticipating if there are many customers in the queue.
- The result of this paper work may become the reference to analyze the current system and improve the next system. Because the restaurant can now estimate of how many customers will wait in the queue and the number of customers that will go away each day.
- By anticipating the huge number of customerscoming and going in a day, the restaurant can set atarget profit that should be achieved daily.
- The formulas that were used during the completionof the research are applicable for future research andalso could be used to develop more complex theories.
- The formulas provide mechanism to model therestaurant queue that is simpler than the creation ofsimulation model in [9,4].

V. CONCLUSION

This research paper has discussed the application ofqueuing theory of **Born Vivant**Restaurant. Here we havefocused on two particularly common decision variables (as avehicle for introducing and illustrating all the concepts. Fromthe result we have obtained that the rate at which customersarrive in the queuing system is 2.22 customers per minuteand the service rate is 2.24 customers per minute. Theprobability of buffer flow if there are 10 or more customersin the queue is 15 out of 100 potential customers. Theprobability of buffer overflow is the probability thatcustomers will run away, because may be they are impatientto wait in the queue. This theory is also applicable for therestaurant if they want to calculate all the data daily. It can beconcluded that the arrival rate will be lesser and the servicerate will be greater if it is on weekdays since the averagenumber of customers is less as compared to those onweekends. The constraints that were faced for the completionof this research were the inaccuracy of result since some ofthe data that we use was just based on assumption orapproximation. We hope that this research can contribute tothe betterment of **Born Vivant** restaurant in terms of its way ofdealing with customers.

As our future works, we will develop a simulation modelfor the restaurant. By developing a simulation model we willbe able to confirm the results of the analytical model that wedevelop in this paper. In addition, a simulation model allowsus to add more complexity so that the model can mirror theactual operation of the restaurant more closely [1].

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