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MEASURING PERFORMANCE OF ONLINE TRADING – A QUEUING THEORY APPROACH

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Abstract;

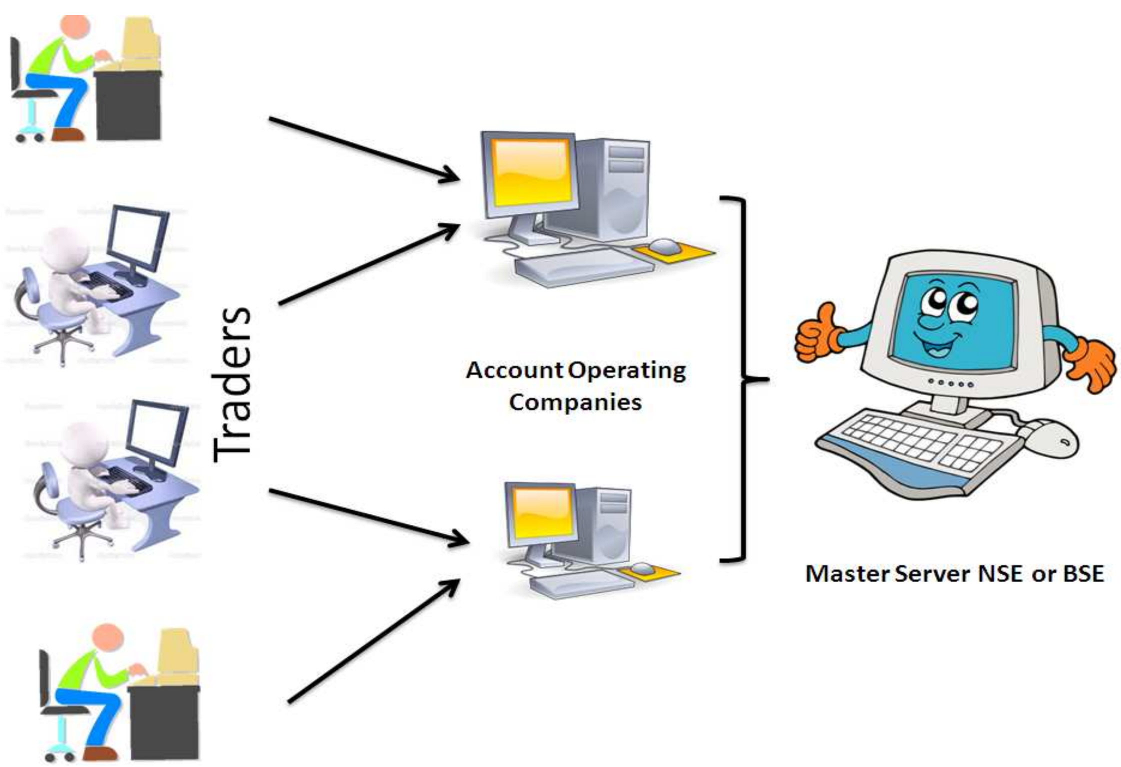
Online trading is an attraction now days, number of users of online trading are increasing day by day in metros or else. The customers trade through a single server; they purchase and sell stocks through same portal. Mismatch of number of buyers and sellers is nothing new and expected. The situations when number of sellers is more than number of buyers, there arrives a situation of queue or waiting time. In this paper book keeping approach of queuing theory is

used, to know various measures of performances of the system. Further total time spent by a customer in the system and the time spent in the queue has been calculated by Little's Law.

Keywords; Queuing Theory, Book Keeping, Little's Law

Introduction and Literature Review;

Making money through share market is an attraction now days. People trade by themselves in a large number instead of trading through brokers. People have their DMAT accounts with various financial firms and trade through their portal ultimately all the DMAT account operating companies' trade through a master portal of NSE or BSE. The process can be described as under;



Depending on the value, prediction and fluctuation of the stock people buy or sell the particular stock. There is a tendency that if the stock price is falling and the prediction is that it will fall further, traders have a high tendency to sell that stock away to minimize their losses. This behavior of the people can be understood as customer impatience. In these situations sellers become more than buyers, and the orders are queued according to the time of placing an order, for instance if there are X sellers and Y buyers and Y < X. x_1, x_2, x_3, … represents the sellers s.t. ∑ x = X, if the seller x_1, places his/her order online at time t, and seller x_2 places his/her order at time t + €, (however small € may be), and so on, the orders get queued on companies server according to the preference of time of order. In above case x_1 stands in front of queue while x_2 queued 2nd and so on. Moment the sellers appears on the portal with required number of stocks the orders of the person in front of the queue is executed, hence it can be observed that companies server follow FCFS (First Come First Serve Mechanism). This mechanism doesn't get affected from the quantity of stocks ordered. For instance, if x_1 put *n* stock for sale and the buyer is interested only in *m* shares, if *n* < *m* the order for *m* stocks is executed (*m* stocks are sold to buyer) and the seller goes waiting again with *n* - *m* stocks remaining with his/her portfolio.

Various authors have applied queuing theory approach in studying the stock market.

R. Kumar et. Al. [1] has applied a queuing theory approach to obtain optimum service time for any insurance firm and optimized the total expected profit. S. Alfarano et. al. [4] in their work analytical solutions of a simple variant of the seminal herding model is obtained. Embedding the herding framework into a simple equilibrium asset pricing model, we are able to derive closed-form solutions for the time-variation of higher moments as well as related quantities of interest enabling us to spell out under what circumstances the model gives rise to realistic behavior of the resulting. Various authors applied queuing theory approach to study financial markets like A. Baltrunas et. al. [8] in 2008, P.P. Bocharov et. al, [10] in 2004, H. Lamba [3] and many more as [1] – [15]. The survey shows that queuing theory can be effectively applied to study and solve the problems in various sectors of finance ranging from insurance sector to stock market analysis. The survey leaves a great scope of applying queuing theory in identifying; studying and solving the complex problems exist in the sectors of finance.

Estimating, the expected system size, expected total waiting time, expected queue length and other performance measures involved in queuing become very important and of vital use in this situation, as it can help in better customer care and that leads to less impatient customers. A queuing theory book keeping approach can be applied to know all performance measures stated above.

Description:

Bookkeeping for queues is a table format to show how the random events of arrivals and service completions interact for a sample single – server system to form a queue. We begin at time 0, (when the first buyer places and order) with first arrival and then update the system when events (arrivals or departures) occur thus, the name event-oriented bookkeeping is used for this sort of table.

Consider the elementary case of a constant rate of arrivals (order placements) to a single channel (a company's server may be) which possesses a constant service rate (with constant availability of buyers of orders). (Figure 1.1 is an illustration of this with inter - arrival times of 3 and serve times of 5.) These regularly served arrivals are served through first come first served mechanism. Let it also be assumed that at time $t = 0$ there are no customers waiting for their orders to be executed and the channel is empty (at the time of opening of the market). Let λ be defined as the number of arrivals per unit time and $1/\lambda$ then will be the constant time between successive arrivals. The particular unit of time (minutes, hours, etc.) is up to the choice of analyst.

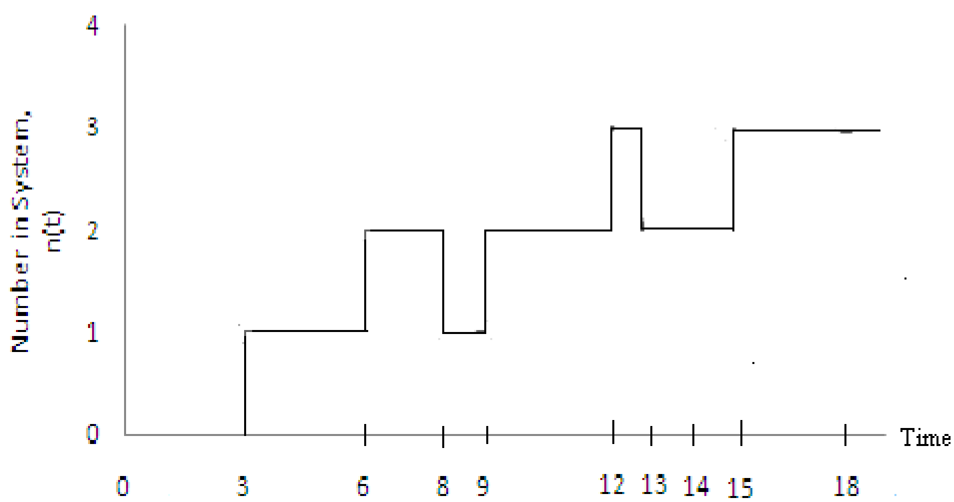


Fig 1.1, Sample path for queuing process

However the consistency must be adhered to once the unit is chosen so that the same basic unit is used throughout the analysis. Similarly, if μ is to be rate of service in terms of completions (executions of orders) per unit time when the server is busy, then $1/\mu$ is the constant service time. We would like to calculate the number in the system at any arbitrary time *t*, say *n(t),* and the time the nth arriving customer must wait in the queue to obtain the service i.e. for the execution of order placed by him say, $W_q^{(n)}$. From these, it then becomes easy to compute the measures of effectiveness.

Under the assumption that there as soon as the service is completed another is begun, the number in the system (including the customer in the service) at time t is determined by;

n(t) ={(number of arrivals in (0, t]} – {number of services completed in (0, t]} (1.1)

It should be pointed out that there are three waiting times of the interest – the time spent by nth customer waiting for service (waiting for the execution of order placed), which is written here as $W_q^{(n)}$, the time that nth customer spent in the system, which we shall call *W(n)*; and what is called the virtual line wait V(t), namely, the wait a fictitious arrival would have to endure if it at time *t*.

To find the waiting times in queue until the service begins, we observe that the line waits $W_q^{(n)}$ and f $W_q^{(n+1)}$ or two successive customers in any single server queue (deterministic or otherwise) are related by the simple recurrence relation.

$$W_q^{(n+1)} = \begin{cases} W_q^{(n+1)}+S^{(n)} - T^{(n)} & (W_q^{(n+1)}+S^{(n)} - T^{(n))}>0), \\ 0 & (W_q^{(n+1)}+S^{(n)} - T^{(n))}\leq 0), \end{cases} \qquad (1.2)$$

Where $S^{(n)}$ is the service time of nth customer and $T^{(n)}$ is the inter-arrival time between the nth and (n+1)th customers. This is shown in figure 1.2

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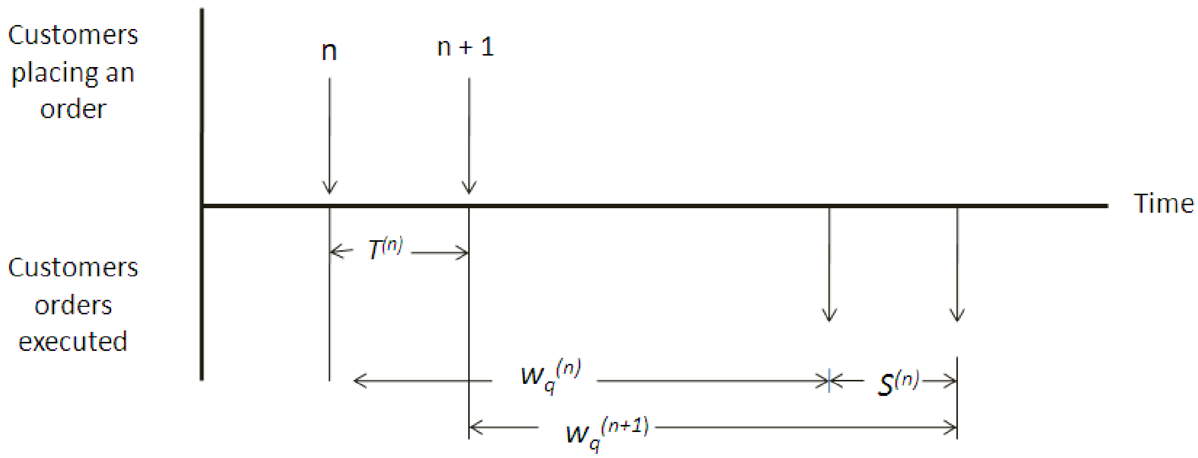

Fig 1.2 Successive M/M/I waiting times

Bookkeeping has to do with updating the system status when events occur, recording items of interest, and calculating measures of effectiveness. Event –oriented bookkeeping updates the system state only when events occur i.e. order is placed or executed. Since there is not necessarily an event every basic time unit, in next – event bookkeeping the master clock increased by a variable amount each time, rather than a fixed amount as it would be in time – oriented bookkeeping. The event-oriented approach will be illustrated here by an example, using the arrival service data given in table (1.1).

Table (1.1) – Input Data

i	1	2	3	4	5	6	7	8	9	10	11	12
Inter-arrival time between customers i+1 and i	2	1	3	1	1	4	2	5	1	4	2	-
Service time of customer i	1	3	6	2	1	1	4	2	5	1	1	3

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Table (1.2) – Event Oriented Bookkeeping

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Master Clock Time	Arrival/ Departure of Customer *i*	Time Arrival *i* Enters The Service	Time Arrival *i* Leaves The System	Time in Queue	Time in System	No. in the Queue just after Master Clock Time	No. in the System just after Master Clock Time
0	1-A	0	1	0	1	0	1
1	1-D	-	-	-	-	0	0
2	2-A	2	5	0	3	0	1
3	3-A	5	11	2	8	1	2
5	2-D	-	-	-	-	0	1
6	4-A	11	13	5	7	1	2
7	5-A	13	14	6	7	2	3
8	6-A	14	15	6	7	3	4
11	3-D	-	-	-	-	2	3
12	7-A	15	19	3	7	3	4
13	4-D	-	-	-	-	2	3
14	8-A;5-D	19	21	5	7	2	3
15	6D	-	-	-	-	1	2
19	9-A;7-D	21	26	2	7	1	2
20	10-A	26	27	6	7	2	3
21	8-D	-	-	-	-	1	2
24	11-A	27	28	3	4	2	3
26	12-A;9-D	28	31	2	5	2	3
27	10-D	-	-	-	-	1	2

28	11-D	-	-	-	-	0	1
31	12-D	-	-	-	-	0	0

We can observe from simple averaging calculation for simple average calculations from column (5) and (6) in table (1.2), that the mean line delay of the 12 customer i.e. the mean delay of execution of orders was 40/12 =10/3, while their mean system waiting time i.e. mean time spent by them for execution of placed order turned out to be 70/12 = 35/6. Further, we observe that we can estimate the mean arrival rate i.e. the rate at which customers are placing the order to purchase the particular stock as 12/31 customer per unit time, since there were 12 arrivals (orders) over the 31 – time – unit observation horizon. Thus the application of *Little's Law* to these tells us that the average system size (number of orders in the system) L over the full time horizon was

$$L = \lambda W = \frac{70/12}{31/12} = \frac{70}{31}$$

And the mean queue size of orders waiting to be executed can be given by;

$$L = \lambda W_q = \frac{10/3}{31/12} = \frac{40}{31}$$

Hence by applying a simple bookkeeping approach of queuing theory and using Little's Law the effectiveness measures can be computed. These effectiveness measures can be used for improvisation of the system such as, minimizing the total delay by optimizing the service which ultimately reduces the cost of service, load on the system to distribute the load and avoid sudden failure in case of overcapacity and else.

These measures of effectiveness can be analyzed and the system can provide a better customer service those results in improved satisfaction level of the customers and improvement in goodwill of company that finally results in to more customers and revenue generation.

Conclusions:

By applying book – keeping approach of queuing theory to online trading of stocks one can estimate the measures of performance required. That can help in better customer care, and reneging of impatient customers can be avoided. The cost and load of the system can also be analyzed, that further leaves a scope of optimum utilization of resources such as servers.

Cutting the rate of impatient leads to better revenue generation and any firm can improve on their profit as less impatient customer means less loss of customers. Once the load on the system is known, optimization techniques can be applied to optimize system size, service rate and other parameters of the model used for system.

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