International Journal of Engineering, Science and Mathematics
Vol. 9 Issue 4, April 2020,
ISSN: 2320-0294 Impact Factor: 6.765
Journal Homepage: http://www.ijesm.co.in, Email: ijesmj@gmail.com
Double-Blind Peer Reviewed Refereed Open Access International Journal - Included in the International Serial Directories Indexed & Listed at: Ulrich's Periodicals Directory ©, U.S.A., Open J-Gage as well as in Cabell's Directories of Publishing Opportunities, U.S.A

QUEUING SYSTEM OF FIXATION PROCESS

s.maragatha sundari*

M.Manimala**

Joliya V.Vikrant**

ABSTRACT

This paper manages the Queuing issue of various fix process. Clients show up individually follows a Poisson conveyance process. During the hour of administration, server gets hindered and gets into a fix procedure by going through two phases of deferral. During the second phase of postponement, clients leave the framework subsequent to joining the line. This procedure is characterized to renege. Next it gets into an obligatory fix process and if out of luck, it joins the discretionary fix process. Here all the parameters follow a general dissemination process. The issue is all around comprehended by advantageous variable strategy and the shut structure arrangement of Queue execution measures including the force parameter, the mean inert time, the mean number of clients in the line, the mean number of clients in the framework, the mean holding up time in the line and the mean reaction time are inferred. Numerical outline and a grow graphical evaluation are done at the end to support the model.

KEYWORDS:

Reneging;
Two stage service delay;
Compulsory repair;
Optional repair;
Service interruption.

1. INTRODUCTION

Queuing hypothesis assumes a significant job in displaying genuine issues including clogs in wide regions of science, innovation and the board. Uses of queuing with client eagerness can be found in rush hour gridlock demonstrating, business and enterprises, PC correspondence, wellbeing area and clinical science and so on. Administration stations that are not precisely controlled like checkout counters, markets, banks and so forth have heterogeneous assistance rates since one can't anticipate that human servers should work at steady rate. Client restlessness (reneging) has negative effect on the exhibition of queuing frameworks. On the off chance that we talk from business perspective, firms lose their potential clients because of client anxiety which influences their business all in all. It is imagined that on the off chance that the organizations utilize certain client maintenance techniques, at that point there are chances that a specific part of anxious clients can be held in the queuing framework for their further help. Chandrasekaran, V. M et.al[1] made a survey report on working vacation queuing models. Mobile adhoc networks was studied through a queuing approach by Dhanalakshmi K.S. and Maragathasundari S [2].The optional control of a M^x/G/1 unreliable server queue was well investigated by Gautam chodhury and Lotfi Tadj[3]. 4.Maragathasundari, S.[4] studied the different vacation policies of a Queuing system. Maragathasundari. S and Manikandan P.[5] designed a Queuing system modeling for supermarkets and studied the performance measures. Maragathasundari. S and Kishore eswar[6] Examined a Queuing Classification in Non-Destructive Testing.Rajadurai et.al[7] made a analysis on retrial queue with K optional phases of service under multiple working vacations and random breakdown..Vignesh S. and Maragathasundari S.[8] derived the exection measures for a queuing system of a non markovian single server batch arrival with compulsory three stages of services

2. MODEL APPLICATION (RAILWAYS)

All the model parameters are explained in detail in the following application:

Customers (input) and service

It is additionally called as calling populace. One of the fundamental qualities is its size, that is the absolute quantities of clients which might be limited or unbounded. For a Case Study, Public, understudies, and voyagers essentially this area is for clients, who need to book the ticket or seat reservation for journey. So they will look for trains ETA excursion and insights regarding accessible trains between the courses in IRCTC portal. One utilizes its login id and secret key and gets into the IRCTC gateway for booking seat compartment.

Administration Interruption

As indicated by normal day by day offer of train tickets through the entrance, which is the world's second busiest with 3 crore enrolled clients, is around 5.5 to 6 lakh. So there is enormous tussle over seat reservation. Service gets hindered because of high traffic among customers. If the inquiry is identified with Service Interruption. These kinds of conditions are kept up by having a bunch of high performing servers oversaw by a wise guardian (entryway/load balancer).

Less number of servers: This is significant issue for any poor performing site.

Overloaded servers: The servers are clearly over-burden which can/are because of numerous reasons. It very well may be either because of poor questions or an excessive number of solicitations which is principle reason make my excursion or some other ticket booking site additionally utilizes their servers for data and exchanges (ticket booking).

Ill-organized programming: can be the reason,will just lead to horrible showing with such a major site. It's a major issues for the individuals who are looking Tatkal ticket compliance. The main motivation is: At a solitary opportunity numerous clients come and login to book Tatkal Tickets. The recurrence of IRCTC Website is 1200 clients for each moment, on the off chance that in excess of 1200 individuals are hitting webpage at same time, at that point website is going down. Following barely any moment it's likewise running in same speed.

TWO STAGE DELAY (RENEGING)

Defer Stage 1

Here, before going in the fix procedure the server is tied for first request of defer where servers need to sit tight for refreshment of the framework. IRCTC site application is over-burden by an excessive number of solicitations and thus not ready to react to you.'Service not accessible'. This postponement is for support. Indian railroads go for routine checks, some adjustment, entire day income etc.Actual reviving time is somewhat more than 00:30. That is on the grounds that a site like IRCTC doesn't run on a solitary server. It might be running on numerous servers.So when they start their servers at 00:30 servers take a smidgen time (extends between 2 min-10 min relying upon OS and other arrangement of server) to turn out to be completely operational. With the goal that User can get information productively after around 00:35.

DEFER STAGE 2

Here IRCTC webpage may get delay due un-needed mistakes, bugs or some other characteristic catastrophe for the same.The genuine time for IRCTC support is 11:40 to 12:20 am and right now sort of bugs are fixed and information reinforcements are done and a new beginning is given to the site by the upkeep group.

OBLIGATORY REPAIR PROCESS

IRCTC required an exceptionally solid fix process in which they built up another design.The Railway group planned their new e-ticketing framework around the offer nothing disseminated engineering of Gem Fire to improve load adjusting at the web and application levels. The framework is structured with the goal that each layer gives adaptability and high accessibility and all processing serious capacities and operational information are served through various hubs of the appropriated in-memory operational database instead of questioning the back-office reservation framework. Furthermore, CRIS changed the equipment engineering, yet additionally changed the application design which gave the sensational exhibition enhancements at high burden.

DISCRETIONARY REPAIR

In any case, on the off chance that you know web engineering, it's the solicitation, reaction and meeting support on CRIS web servers. In any case, it simply doesn't stop here.With demand and reaction, CRIS servers need to deal with simultaneousness issues, issues with Latency, Out-of memory issues, DB locks, information repetition, halts to give some examples. In the event that you see ticket booking, you see that clients' needs information rapidly and in a flash, so CRIS database needs a No-SQL database which implies its level document design.

CONCLUSION

So IRCTC need to expand the recurrence of site, they are likewise doing many analysis to partition guest. They changed the hour of AC Tatkal Ticket Booking and Sleeper Class Ticket booking to isolate guests. They likewise square operators booking at Tatkal Ticket booking time. So, fundamentally every information should be approved before submitting the change.

3. MATHEMATICAL ASSUMPTIONS OF THE MODEL

Customer's arrival follows a Poisson distribution with arrival rate $\lambda > 0$ .The other parameters follows a general distribution.Break down arrival rate is$\alpha > 0$.

Let $H^*(x)$ and $h^*(x)$, be the distribution function and the density function of phase service

Let $\mu(x)$ be the conditional probability of a completion of phase of service and it is given by

$$\mu(x) = \frac{h^*(x)}{1 - H^*(x)} \qquad h^*(x) = \mu*(x) e^{-\int_0^x \mu(t) dt}$$

Similarly, the process is repeated for delay stages and repair processes.

Hence we have the following:

In case of Delay stages, we have $\theta_1(x) = \frac{a(x)}{1-A(x)}$, $a(x) = \theta_1(x) e^{-\int_0^x \theta_1(t) dt}$ and have $\theta_2(x) = \frac{c(x)}{1-C(x)}$, $c(x) = \theta_2(x) e^{-\int_0^x \theta_2(t) dt}$

For the Repair process, we have $\varphi_1(x) = \frac{f(x)}{1-F(x)}$, $f(x) = \varphi_1(x) e^{-\int_0^x \varphi_1(t) dt}$ and have $\varphi_2(x) = \frac{g(x)}{1-G(x)}$, $g(x) = \varphi_2(x) e^{-\int_0^x \varphi_2(t) dt}$

The concept of Reneging follows exponential distribution with parameter χ and $f(t) = \chi e^{-\chi t}\, dt,\ \ \chi > 0$ and it occurs during second stage of delay process

4. GOVERNING EQUATIONS OF THE MODEL DEFINED

The equations governing the system are as follows:

$$\frac{\partial}{\partial x} P_n(x) + (\lambda + \mu(x) + \alpha) P_n(x) = \lambda P_{n-1}(x) \tag{1}$$

$$\frac{\partial}{\partial x} P_0(x) + (\lambda + \mu(x) + \alpha) P_0(x) = 0 \tag{2}$$

$$\frac{\partial}{\partial x} D_n^{(1)}(x) + (\lambda + \theta_1(x)) D_n^{(1)}(x) = \lambda D_{n-1}^{(1)}(x) \tag{3}$$

$$\frac{\partial}{\partial x} D_0^{(1)}(x) + (\lambda + \theta_1(x)) D_0^{(1)}(x) = 0 \tag{4}$$

$$\frac{\partial}{\partial x}D_n^{(2)}(x)+(\lambda+\theta_2(x)+\chi)D_n^{(2)}(x)=\lambda D_{n-1}^{(2)}(x)+\chi D_{n+1}^{(2)}(x) \quad (5)$$

$$\frac{\partial}{\partial x}D_0^{(2)}(x)+(\lambda+\theta_2(x))D_0^{(2)}(x)=\chi D_1^{(2)}(x) \quad (6)$$

$$\frac{\partial}{\partial x}R_n^{(c)}(x)+(\lambda+\varphi_1(x))R_n^{(c)}(x)=\lambda R_{n-1}^{(c)}(x) \quad (7)$$

$$\frac{\partial}{\partial x}R_0^{(c)}(x)+(\lambda+\varphi_1(x))R_0^{(c)}(x)=0 \quad (8)$$

$$\frac{\partial}{\partial x}R_n^{(e)}(x)+(\lambda+\varphi_2(x))R_n^{(e)}(x)=\lambda R_{n-1}^{(e)}(x)$$

(9) $$\frac{\partial}{\partial x}R_0^{(e)}(x)+(\lambda+\varphi_2(x))R_0^{(e)}(x)=0$$

(10) $$\lambda Q=\int_0^\infty P_0(x)\mu(x)dx+(1-l)\int_0^\infty R_0^{(c)}(x)\varphi_1(x)dx+\int_0^\infty R_0^{(e)}(x)\varphi_2(x)dx$$

(11)

5. BOUNDARY CONDITIONS

$$P_n(0)=\int_0^\infty P_{n+1}(x)\mu(x)dx+\int_0^\infty R_{n+1}^{(c)}(x)\varphi_1(x)dx+\int_0^\infty R_{n+1}^{(e)}(x)\varphi_2(x)dx+\lambda Q \quad (12)$$

$$D_n^{(1)}(0)=\alpha\int_0^\infty P_{n-1}(x)dx=\alpha P_{n-1} \quad (13)$$

$$D_n^{(2)}(0)=\int_0^\infty D_n^{(1)}(x)\theta_1(x)dx \quad (14)$$

$$R_n^{(c)}(0)=\int_0^\infty D_n^{(2)}(x)\theta_2(x)dx \quad (15)$$

$$R_n^{(e)}(0)=l\int_0^\infty R_n^{(c)}(x)\varphi_1(x)dx \quad (16)$$

We apply the concept of supplementary variable technique for (1) to (16). As a result we get the probability generating queue size of the system defined.

$$\frac{\partial}{\partial x}P_q(x,z)+(\lambda-\lambda z+\alpha+\mu(x))P_q(x,z)=0 \quad (17)$$

$$\frac{\partial}{\partial x}D_q^{(1)}(x,z)+(\lambda-\lambda z+\theta_1(x))D_q^{(1)}(x,z)=0 \quad (18)$$

$$\frac{\partial}{\partial x}D_q^{(2)}(x,z)+(\lambda-\lambda z+\theta_2(x)+\chi-\frac{\chi}{z})D_q^{(2)}(x,z)=0 \quad (19)$$

$$\frac{\partial}{\partial x}R_q^{(c)}(x,z)+(\lambda-\lambda z+\varphi_1(x))R_q^{(c)}(x,z)=0 \quad (20)$$

$$\frac{\partial}{\partial x}R_q^{(e)}(x,z)+(\lambda-\lambda z+\varphi_2(x))R_q^{(e)}(x,z)=0 \quad (21)$$

$$zP_q(0,z)=\int_0^\infty P_q(x,z)\mu(x)dx+(1-l)\int_0^\infty R_q^{(c)}(x,z)\varphi_1(x)dx+\int_0^\infty R_q^{(e)}(x,z)\varphi_2(x)dx-$$

$$\left[\int_0^\infty P_0(x)\mu(x)dx+(1-l)\int_0^\infty R_0^{(c)}(x)\varphi_1(x)dx+\int_0^\infty R_0^{(e)}(x)\varphi_2(x)dx\right]+\lambda zQ \quad (22)$$

$$D_q^{(1)}(0,z) = \alpha z P_q(z) \quad (23)$$

$$D_q^{(2)}(0,z) = \int_0^\infty D_q^{(1)}(x,z)\theta_1(x)dx \quad (24)$$

$$R_q^{(c)}(0,z) = \int_0^\infty D_q^{(2)}(x,z)\theta_2(x)dx \quad (25)$$

$$R_q^{(e)}(0,z) = l\int_0^\infty R_q^{(c)}(x,z)\varphi_1(x)dx \quad (26)$$

Integrating equation (17), we get

$$P_q(x,z) = P_q(0,z)e^{-(\lambda-\lambda z+\alpha)x-\int_0^\infty \mu(t)dt} \quad (27)$$

Again integrating (27) by parts, we get

$$P_q(z) = P_q(0,z)\left(\frac{1-H^*(a)}{a}\right) \quad (28)$$

Where $a = \lambda - \lambda z + \alpha$ and $H^*(a) = \int_0^\infty e^{-(\lambda-\lambda z+\alpha)x}dH(x)$ is the Laplace Stieltjes transform of the service time H(x).

Multiplying both sides of equation (27) by $\mu(x)$, we get

$$\int_0^\infty P_q(x,z)\mu(x)dx = P_q(0,z)H^*(a) \quad (29)$$

Applying the same procedure for equation (18) to (21),

$$D_q^{(1)}(z) = D_q^{(1)}(0,z)\left(\frac{1-A^*(b)}{b}\right) \quad \text{where } b = \lambda - \lambda z \quad (30)$$

$$\int_0^\infty D_q^{(1)}(x,z)\theta_1(x)dx = D_q^{(1)}(0,z)A^*(b) \quad (31)$$

$$= \alpha z P_q(0,z)\left(\frac{1-H^*(a)}{a}\right)A^*(b)$$

$$D_q^{(2)}(z) = D_q^{(2)}(0,z)\left(\frac{1-C^*(d)}{d}\right) \quad \text{where } d = \lambda - \lambda z + \chi - \frac{\chi}{z} \quad (32)$$

$$\int_0^\infty D_q^{(2)}(x,z)\theta_2(x)dx = \alpha z P_q(0,z)\left(\frac{1-H^*(a)}{a}\right)A^*(b)C^*(d) \quad (33)$$

$$R_q^{(c)}(z) = R_q^{(c)}(0,z)\left(\frac{1-F^*(b)}{b}\right) \quad (34)$$

$$\int_0^\infty R_q^{(c)}(x,z)\varphi_1(x)dx = \alpha z P_q(0,z)\left(\frac{1-H^*(a)}{a}\right)A^*(b)C^*(d)F^*(b) \quad (35)$$

$$R_q^{(e)}(z) = R_q^{(e)}(0,z)\left(\frac{1-G^*(b)}{b}\right) \tag{36}$$

$$\int_0^\infty R_q^{(e)}(x,z)\varphi_2(x)dx = l\left[\alpha z P_q(0,z)\left(\frac{1-H^*(a)}{a}\right)A^*(b)C^*(d)F^*(b)G^*(b)\right] \tag{37}$$

Using equation (31),(33),(35),(37) in (22) , we get

$$P_q(0,z) = \frac{\lambda(z-1)Q}{z - H^*(a) - \alpha z\left(\frac{1-H^*(a)}{a}\right)A^*(b)C^*(d)F^*(b)\left[(1-l)+lG^*(b)\right]} \tag{38}$$

6. PROBABILITY GENERATING FUNCTION OF THE QUEUE SIZE

Let $R_q(z)$ be the probability generating function of the queue size.
Using equations (28),(30) (32),(34) and (36) we get,

$$R_q(z) = P_q(z) + D_q^{(1)}(z) + D_q^{(2)}(z) + R_q^{(c)}(z) + R_q^{(e)}(z)$$
(39)

$$R_q(z) = \frac{Q\lambda(z-1)\left(\frac{1-H^*(a)}{a}\right)\left[1+\alpha z\left(\frac{1-A^*(b)}{b}\right)+A^*(b)\left\{\left(\frac{1-C^*(d)}{d}\right)+C^*(d)\left[\left(\frac{1-F^*(b)}{b}\right)+lF^*(b)\left(\frac{1-G^*(b)}{b}\right)\right]\right\}\right]}{z-H^*(a)-\alpha z\left(\frac{1-H^*(a)}{a}\right)A^*(b)C^*(d)F^*(b)\left[(1-l)+lG^*(b)\right]} \tag{40}$$

7. IDLE TIME AND NORMALIZATION TIME

To find idle time we use the normalization condition
$R_q(z) + Q = 1$, At $z = 1$,$R_q(z)$ attains indeterminate form.

Hence, by the usage of L'Hopital's rule, we get

$$\lim_{z\to 1} R_q(z) = R_q(1) = \frac{N'(1)}{D'(1)}$$

Now from the above idle time V is given by

$$Q = \frac{D'(1)}{N'(1) + D'(1)}$$

By condition $\rho = 1 - V$, utilization factor is determined.

8. PERFORMANCE MEASURES OF THE QUEUING SYSTEM

To find the steady state average queue length, L_q, we adopt the following method
$L_q = \frac{d}{dz}R_q(z)$at $z = 1$

This attains indeterminate form $\frac{0}{0}$. Consider (40) as $R_q(z) = \frac{N(z)}{D(z)}$

$N(z)$and$D(z)$ are the numerator and denominator of the R.H.S. of (40)

Apply L'Hopital's rule twice on (39) we obtain

$$L_q = \lim_{z\to 1} \frac{D'(z)N''(z)\text{-}D''(z)N'(z)}{2(D'(z))^2} = \frac{D'(1)N''(1)\text{-}D''(1)N'(1)}{2(D'(1))^2}$$

Where

$$N'(1) = \lambda\left(\frac{1-H^*(\alpha)}{\alpha}\right)$$

$$N''(1) = \lambda\left(\frac{1-H^*(\alpha)}{\alpha}\right) + \lambda(-H^{*'}(\alpha)) + \lambda\left(\frac{1-H^*(\alpha)}{\alpha}\right)\alpha[E(A)+E(C)+E(F)+lE(G)]$$

$$D'(1) = 1 + H^{*'}(\alpha)(\lambda+\alpha) - \alpha\left(\frac{1-H^*(\alpha)}{\alpha}\right)[1+\lambda E(A)+E(C)(-\lambda+\chi)+\lambda E(F)+l\lambda E(G)]$$

$$\begin{aligned} D''(1) = & -H^{*''}(\alpha)\lambda^2 + \alpha H^{*'}(\alpha) - (1-H^*(\alpha))[\lambda E(A)+E(C)(-\lambda+\chi)+\lambda E(F)+l\lambda E(G)] \\ & -\alpha H^{*'}(\alpha)[1+E(A)\lambda+E(C)(-\lambda+\chi)+\lambda E(F)+l\lambda E(G)] - \alpha\lambda H^{*''}(\alpha) - \lambda(1-H^*(\alpha))E(A) \\ & -\alpha(-H^{*'}(\alpha))\lambda E(A) - (1-H^*(\alpha))\left[\lambda^2 E(A^2)+\lambda E(A)E(C)(-\lambda+\chi)+\lambda^2 E(A)E(F)+\lambda^2 E(A)lE(G)\right] \\ & -\lambda(1-H^*(\alpha))E(F) - \alpha(-H^{*'}(\alpha)\lambda E(F)) - (1-H^*(\alpha))\left[\lambda^2 E(F^2)+\lambda^2 E(F)E(A)+\lambda E(C)(-\lambda+\chi)E(F)+\lambda^2 lE(F)E(G)\right] \\ & +(1-H^*(\alpha))E(C)(-\lambda+\gamma) + \alpha E(C)(-H^{*'}(\alpha))(-\lambda+\gamma) - (1-H^*(\alpha))E(C^2)(-\lambda+\chi)^2 - (2\chi)\alpha E(C) - \lambda^2 l(1-H^*(\alpha)E(G^2)) \\ & +E(C)(-\lambda+\chi)(1-H^*(\alpha))[\lambda E(A)+\lambda E(F)+l\lambda E(G)] - l\lambda E(G)(1-H^*(\alpha))[\lambda E(A)+\lambda E(F)+E(C)(-\lambda+\chi)] \end{aligned}$$

Other performance measures of the Queuing system can be found using Little's law

9.NUMERICAL JUSTIFICATION

The model is well explained by means of numerical illustration as follows:

$$H^*(\alpha) = \frac{\mu}{\mu+\alpha} \qquad H^{*'}(\alpha) = \frac{-\mu}{(\mu+\alpha)^2} \qquad H^{*''}(\alpha) = \frac{2\mu}{(\mu+\alpha)^3}$$

$$\mu = 2.5 \qquad \lambda = 3 \qquad E(A) = \frac{1}{\theta_1} \qquad E(G) = \frac{1}{\varphi_2} \qquad E(F) = \frac{1}{\varphi_1} \qquad E(C) = \frac{1}{\theta_2}$$

$$\theta_1 = 4 \qquad \theta_2 = 3.5 \qquad \varphi_1 = 2.5 \qquad \varphi_2 = 3 \qquad l = 0.4$$

Table.1 The effect of change of α

α	Q	P	Lq	L	Wq	W
0.3	0.2564	0.7436	14.0642	14.8078	4.6881	4.9359
0.4	0.2882	0.7118	11.5253	12.2371	3.8418	4.0790
0.5	0.3176	0.6824	9.7347	10.4171	3.2449	3.4724
0.6	0.3448	0.6552	8.4132	9.0684	2.8044	3.0228
0.7	0.3700	0.6299	7.3957	8.0256	2.4652	2.6752

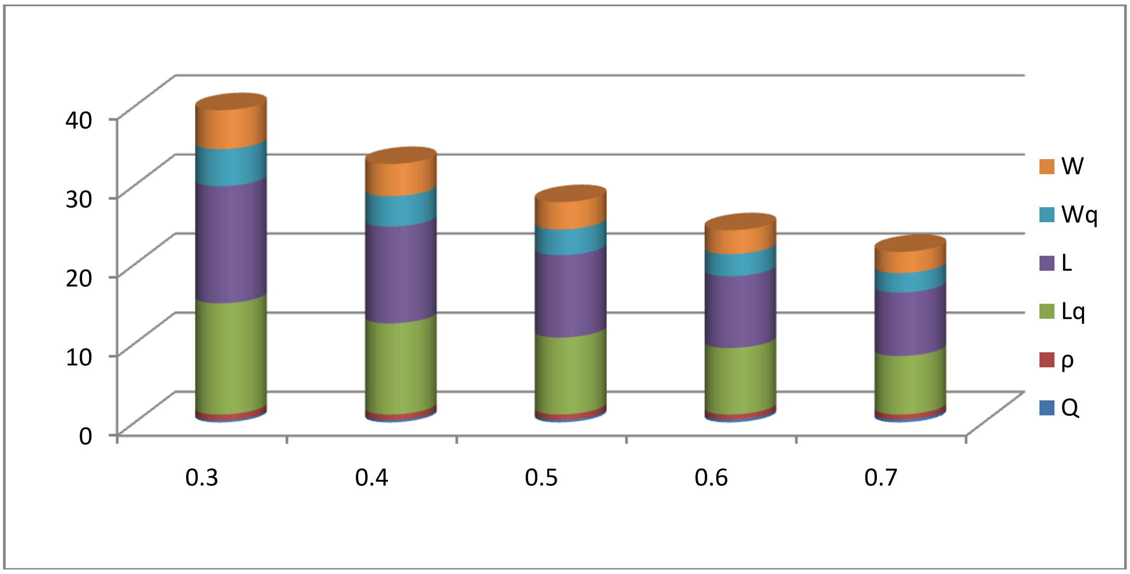

Figure 1

Table.2 The effect of change of χ

χ	Q	ρ	Lq	L	Wq	W
2	0.2564	0.7436	14.0642	14.8078	4.6881	4.9359
2.5	0.2655	0.7345	12.8435	13.5780	4.2812	4.5260
3	0.2744	0.7256	11.8103	12.5359	3.9368	4.1786
3.5	0.2830	0.7169	10.9441	11.6610	3.6480	3.8870
4	0.2915	0.7085	10.2041	10.9126	3.4014	3.6375

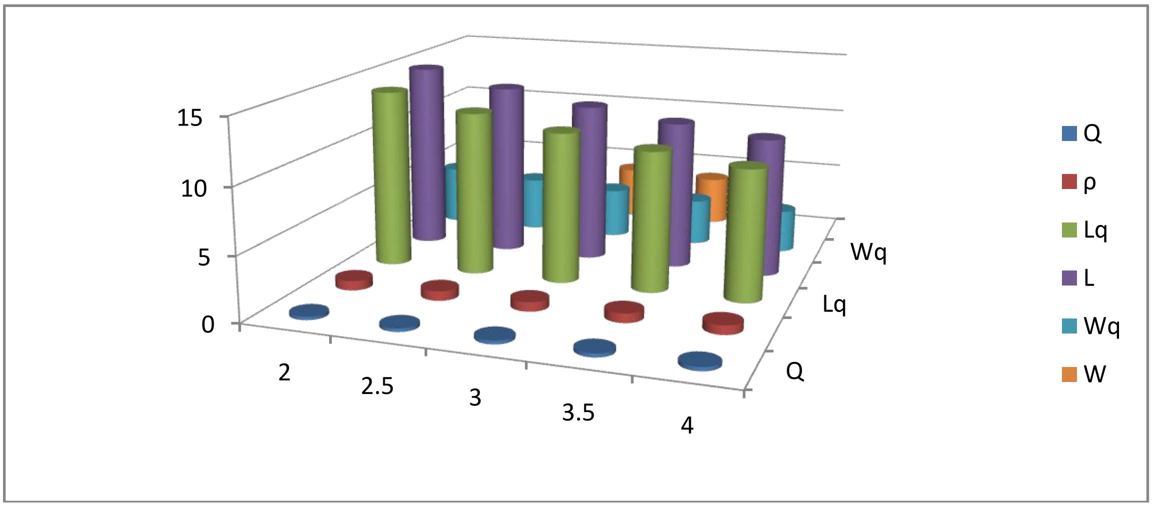

Figure 2

From the table 1, it is clear that, even there is an increase in break down ,as simultaneous constant reneging takes place , queue performance measures decreases. Table 2 indicates the fact that, due to impatience as the customers leaves the system after joining the queue (Reneging),length of the queue decreases and simultaneously all the execution measures also gets reduced. All the results are as expected.

10. CONCLUSION

This paper deals with a queuing model of service interruption followed by stages of Delay. Then it gets into a repair process of compulsory and optional repair process. The model is well explained by means of real life application. Also the system is well justified through numerical illustration. The model is renowned to a great extent by means of diagrammatic representation. In the field of communication process, web designing, production and manufacturing, this Queuing model plays a vital role.

REFERENCES

[1] Chandrasekaran, V. M., Indira, K., Saravanarajan, M. C. and Rajadurai, P. (2016). “A survey on working vacation queuing models”. *International journal of Pure and Applied Mathematics, 106* (6), pp. 33-41.

[2] Dhanalakshmi K.S. and Maragathasundari .S(2018), “Mobile ad hoc networks problem - a queuing approach”,Interntional journal of communication networks and distributed system,Vol 21, No.4,pp.475-495.

[3] Gautam chodhury, Lotfi Tadj. (2011). “The optional control of anM^x/G/1 unreliable server queue with two phases of service and Bernoulli vacation schedule”. *Mathematical and computer modelling, 54*(1-2), pp. 673-688.

[4] Maragathasundari, S. (2015).” A Bulk arrival queuing model of three stages of service with different vacation policies, service interruption and delay time”. *American International Journal of Research in Science, Technology, Engineering and Mathematics.11*(1), pp.52-56.

[5] Maragathasundari. S and Manikandan.P (2019), “Queuing system modeling for supermarkets”, International Journal of Innovative Technology and Exploring Engineering ,ISSN: 2278-3075, Volume-9, Issue-2S2,pp.591-597, December 2019.

[6] Maragathasundari. S and Kishore Eswar.S (2019), “An Examination on Queuing Classification in Non-Destructive Testing”, International Journal of Engineering and Advanced Technology , ISSN: 2249 – 8958, Volume-9 Issue-1S4,pp. 669-674 December 2019.

[7] Rajadurai, P., Saravanarajan, M.C. and Chandrasekaran, V. M. (2018). “Cost optimisation analysis of retrial queue with K optional phases of service under multiple working vacations and random breakdowns”. *International Journal of Industrial and systems Engineering, 29*(2), pp. 193-222.

[8] Vignesh S. and Maragathasundari S. (2017), “Analysis of a non markovian single server batch arrival queueing system of compulsory three stages of services with fourth optional stage service, service interruptions and deterministic server vacations”, International journal of Mathematics in operational research,Vol.11,No.3,pp. 285-309