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FUZZY ANALYSIS OF QUEUING MODELS WITH C SERVERS

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ABSTRACT

This paper proposes a single transmit and multi transmit fuzzy queuing models with single and multiple servers using various aspects. Here we consider the arrival rate to follow Poisson distribution and assume to follow heptagonal and octagonal fuzzy numbers. Based on that we evaluate the performance measures by applying the ranking technique. A numerical examples are also evaluated to show the methodology.

KEY WORDS: fuzzy numbers, ranking technique, single and multi transmit fuzzy queue, heptagonal and octagonal fuzzy numbers.

INTRODUCTION

Queuing model have a great extend of applications in service organizations, manufacturing firms, telecommunication networks, computer systems, inventory systems, etc. The services are done in any one of the following queue namely “First In First Out”, “Last In First Out”, service in random and selection priority order.

The queuing theory or waiting line theory is developed by Erlang in 1903 based on congestion of telephone traffic. He directed his first efforts at finding the delay for one operator and later on the results were extended to find the delay for many operators. Moline and Thornton D-Fry who was further developed this telephone traffic in 1927 and 1928 respectively.

In general waiting line(queue) is one of the unavoidable situation in our daily life. Queuing theory is studying about such waiting line through performance measures. The queuing model comprises one or more queue and one or more service facilities under a set of rules, The parameters arrival rate λ and service rate μ follows Poisson distribution and exponential distribution.

Fuzzy logic was initiated by Zadeh[8]. Fuzzy queuing model was first introduced by R.J.Lie and E.S.Lee in 1989, further developed this model by many authors. Later, [1]Deveraj.J, and Jayalakshmi.D, Developed a fuzzy approach to priority queues in 2012. [4]Mueen.Z, Ramli.R, and Zabidi.N, investigate analysis of performance measures with single channel fuzzy queues under two class by ranking method in

2017. Also, [3]Kumar.R, and Som .B.K. developed a finite single server queuing system with reverse reneging in 2015. Later, [6]Rao.S.H, Vemuri.V.K, Rao.T.S, and Kumar.B.S, investigate the Analysis of both arrival two-ohase MX/M/1 queuing system with impatient customers and unreliable server in 2018. Aria.M, investigate a new fuzzy logic system for controlling multiple traffic intersections with dynamic phase selection and pedestrian crossing signal in 2019. [5]Rajalakshmi.R and Julia Rose Mary.K investigated the fuzzy analysis for M/M/C finite capacity queuing model in 2017. [7]Usha Prameela.K and Pavan Kumar developed the single transmit fuzzy queuing model with two-classes by the execution proportins by ranking technique in 2020. [2]Hepshiba.B and Julia Rose Mary.K investigate the application of queuing model for Healthcare centre in 2020.

In this paper we dicussed about the fuzzy analysis of queuing model with C servers using heptagonal and octagonal fuzzy numbers using ranking technique.

Basic definition for fuzzy

A fuzzy set is specified by a membership function containing the components of a domain space or universe X in the interval [0,1] , that is $\tilde{A} = \{(z, \mu_{\tilde{A}}(z); z\epsilon Z\}$

Here $\tilde{\mu}_{\tilde{A}}: z \to [0,1]$ is interval called the degree of membership function of the fuzzy set $\tilde{A}$ and $\mu_{\tilde{A}}(z)$ represents the membership value of $z\epsilon Z$ in the fuzzy set $\tilde{A}$. Also, these membership degree are defined by $R \to [0,1]$

Fuzzy Queuing Model with Two Classes of Arrivals and Single Server

In this model, clients arrive in gatherings by a solitary channel spoken to by $\tilde{\lambda}_1, \tilde{\lambda}_2$ and $\tilde{\mu}$ separately. Let $\tilde{\phi}\lambda_1(x)$, $\tilde{\phi}\lambda_2(y)$ and $\tilde{\phi}\mu(z)$ at that point be the fuzzy sets spoken to by three sets as in Eq.(1), Eq.(2) and Eq.(3).

$$\tilde{\lambda}_1 = \{x, \tilde{\phi}\lambda_1(x) \,|x\epsilon X \} \quad ......(1)$$

$$\tilde{\lambda}_2 = \{y, \tilde{\phi}\lambda_2(y) \,|y\epsilon Y\} \quad ......(2)$$

$$\tilde{\mu} = \{z, \tilde{\phi}\mu(z) \,|z\epsilon Z\} \quad ......(3)$$

where X,Y and Z are crisp universal gathering of the landing rate and administration rate. Moreover, let $f(x, y, z)$ be the mean of specific arrangement of interest. Consequently x, y and z are fuzzy numbers and allegedly $f(x, y, z)$ are fuzzy numbers.

Let $L_q{}^{(1)}$ and $L_q{}^{(2)}$ represent the current equation in the traditional single queuing model as in Eq.(4) and Eq(5).

$$L_q{}^{(1)} = \frac{\lambda_1\left(\frac{\rho_1}{\mu}+\frac{\rho_2}{\mu}\right)}{1-\rho} \quad ....(4)$$

$$L_q{}^{(2)} = \frac{\lambda_2\left(\frac{\rho_1}{\mu}+\frac{\rho_2}{\mu}\right)}{1-\rho} \quad ....(5)$$

The stability steady state is $\rho \equiv \rho_1 + \rho_2 < 1$ and $0 < \rho < 1$. Other estimations are characterized by Eq.(6), Eq.(7), & Eq.(8)

$$W_q{}^{(i)} = \frac{L_q{}^{(i)}}{\lambda_i} \quad .....(6)$$

$$W_s{}^{(i)} = W_q{}^{(i)} + \frac{1}{\mu_i} \quad .....(7)$$

$$L_s{}^{(i)} = \lambda_i W_s{}^{(i)} \;;\; i = 1,2 \quad ....(8)$$

In this session, the way to change over the fuzzy numbers into crisp numbers is explained. Two sorts of fuzzy numbers: heptagonal and octagonal fuzzy numbers are executed with the lift and right ranking technique, which is addressed by $F(R) \to R$.

To begin assigning the innovation for this system, we consider the following cases :

Heptagonal fuzzy number (case 1)

Let a convex heptagonal fuzzy number $\tilde{A}(z) = \tilde{A}(a_1, a_2, a_3, a_4, a_5, a_6, a_7; w)$. Then the ranking Index is portrayed by

$$R(\tilde{A}) = \int_{z=0}^{w} \frac{L^{-1}(z)+R^{-1}(z)}{2} dz \quad .....(9)$$

Where,

$$L^{-1}(z) = [w(b-a)+a] + \frac{1}{2}[w(c-b)-e]$$

$$R^{-1}(z) = \frac{1}{2}[w(d-c)-d] + [w(e-d)-e]$$

From the Eq.(9), after simplification , we have obtain Eq.(10)

$$R(\tilde{A}) = \frac{w(2a_1,7a_2,7a_3,22a_4,7a_5,7a_6,2a_7)}{54} \quad .....(10)$$

Octagonal fuzzy number (case 2)

let a convex octagonal fuzzy number $\tilde{A}(z) = \tilde{A}(a_1, a_2, a_3, a_4, a_5, a_6, a_7, a_8; w)$.Then the ranking index is portrayed by

$$R(\tilde{A}) = \int_{z=0}^{w} \frac{L^{-1}(z)+R^{-1}(z)}{2} dz$$

Proceeding in the same way as in case 1, we obtain

$$R(\tilde{A}) = \frac{w(3a_1,6a_2,4a_3,5a_4,5a_5,4a_6,6a_7,3a_8)}{36} \quad ......(11)$$

Numerical Examples

In this section numerical results are evaluated under fuzzy environment the data was collected from "swarnambigai Bajaj" bike showroom . The service center is run by consecutive 6 working days. Here the service discipline is "First Come First Out(FCFS)" basis. Here we calculated the arrival rate, service and performance measure for $M|M|1$ and $M|M|C$ using the heptagonal and the octagonal fuzzy numbers.

Example 1

Accept that the two classes of arrivals and a single server are heptagonal fuzzy numbers in a first come first serve (FCFS) way, with infinite framework limit and population size, characterized as

$\tilde{\lambda}_1 = [0.012,\ 0.014,\ 0.016,\ 0.018,\ 0.08,\ 0.06,\ 0.04\ ; 1]$

$\tilde{\lambda}_2 = [0.02,\ 0.04,\ 0.08,\ 0.12,\ 0.14,\ 0.16,\ 0.18\ ; 1]$

$\tilde{\mu} = [0.5,\ 0.6,\ 0.7,\ 0.8,\ 0.4,\ 1.6,\ 1.9\ ; 1]$

According to the above Eq.(10), the ranking index of $\tilde{\lambda}$ is

$R(\tilde{\lambda}_1) = 0.031$

$R(\tilde{\lambda}_2) = 0.111$

$R(\tilde{\mu}) = 0.637$

From the Eq.(4),(5),(6),(7) and (8) ,the performance measures for heptagonal fuzzy number are as follows:

$L_q{}^{(1)} = 0.010, W_q{}^{(1)} = 0.309,\ W_s{}^{(1)} = 0.046, L_s{}^{(1)} = 0.046$

$L_q{}^{(2)} = 0.027, w_q{}^{(2)} = 0.241, W_s{}^{(2)} = 1.427, L_s{}^{(2)} = 0.159$

Consider fuzzy in M/M/C queuing system

$\tilde{\lambda}_1 = [0.012,\ 0.014,\ 0.016,\ 0.018,\ 0.08,\ 0.06,\ 0.04\ ; 4]$

$\tilde{\lambda}_2 = [0.02,\ 0.04,\ 0.08,\ 0.12,\ 0.14,\ 0.16,\ 0.18\ ; 4]$

$\tilde{\mu} = [0.5,\ 0.6,\ 0.7,\ 0.8,\ 0.4,\ 1.6,\ 1.9\ ; 4]$

$R(\tilde{\lambda}_1) = 0.125$

$R(\tilde{\lambda}_2) = 0.443$

$R(\tilde{\mu}) = 3.215$

The performance measures for heptagonal fuzzy numbers are

$L_q{}^{(1)} = 0.008, W_q{}^{(1)} = 0.067,\ W_s{}^{(1)} = 0.378, L_s{}^{(1)} = 0.047$

$L_q{}^{(2)} = 0.03, w_q{}^{(2)} = 0.067, W_s{}^{(2)} = 0.378, L_s{}^{(2)} = 0.167$

Example 2

Accept that the two classes of arrivals and single server are octagonal fuzzy numbers in a first come first serve (FCFS) way, with infinite framework limit on the population size, characterized as

$\tilde{\lambda}_1 = [0.012,0.014,0.016,0.018,0.08,0.06,0.04,0.17; 1]$

$\tilde{\lambda}_2 = [0.02,0.04,0.08,0.12,0.14,0.16,0.18,0.19; 1]$

$\tilde{\mu} = [0.5,0.6,0.7,0.8,0.4,0.3,1.6,1.9; 1]$

According to the above Eq.(12) the ranking index of $\tilde{\lambda}$ is

$R(\tilde{\lambda}_1) = 0.046$

$R(\tilde{\lambda}_2) = 0.117$

$R(\tilde{\mu}) = 0.844$

The performance measures for octagonal fuzzy numbers are

$L_q{}^{(1)} = 0.013, W_q{}^{(1)} = 0.276,\ W_s{}^{(1)} = 1.46, L_s{}^{(1)} = 0.067$

$L_q{}^{(2)} = 0.032, w_q{}^{(2)} = 0.276, W_s{}^{(2)} = 1.46, L_s{}^{(2)} = 0.171$

Considering octagonal fuzzy in M/M/C queuing system

$\tilde{\lambda}_1 = [0.012,0.014,0.016,0.018,0.08,0.06,0.04,0.17; 1]$

$\tilde{\lambda}_2 = [0.02,0.04,0.08,0.12,0.14,0.16,0.18,0.19; 1]$

$\tilde{\mu} = [0.5,0.6,0.7,0.8,0.4,0.3,1.6,1.9; 1]$

$R(\tilde{\lambda}_1) = 0.185$

$R(\tilde{\lambda}_2) = 0.468$

$R(\tilde{\mu}) = 3.378$

The performance measures for octagonal fuzzy numbers are

$L_q{}^{(1)} = 0.013, W_q{}^{(1)} = 0.071,\ W_s{}^{(1)} = 0.367, L_s{}^{(1)} = 0.068$

$L_q{}^{(2)} = 0.033, w_q{}^{(2)} = 0.071, W_s{}^{(2)} = 0.367, L_s{}^{(2)} = 0.172$

Results and Discussion

Table 1

Membership function	$L_s^{(1)}$	$L_s^{(2)}$	$W_s^{(1)}$	$W_s^{(2)}$
Heptagonal	0.046	0.159	1.434	1.427
Octagonal	0.067	0.171	1.43	1.42

Table 2

Membership Function	$L_q^{(1)}$	$L_q^{(2)}$	$W_q^{(1)}$	$W_q^{(2)}$
Heptagonal	0.010	0.027	0.309	0.241
Octagonal	0.013	0.032	0.276	0.276

Table 3

Membership Function	$L_s^{(1)}$	$L_s^{(2)}$	$W_s^{(1)}$	$W_s^{(2)}$
Heptagonal	0.047	0.167	0.378	0.378
Octagonal	0.068	0.172	0.367	0.367

Table 4

Membership Function	$L_q^{(1)}$	$L_q^{(2)}$	$W_q^{(1)}$	$W^{(2)}$
Heptagonal	0.008	0.033	0.067	0.067
Octagonal	0.013	0.033	0.071	0.071

The graphical representations of Tables (1), (2), (3) and (4) are demonstrated in Figs. (1),(2),(3) and (4) respectively.

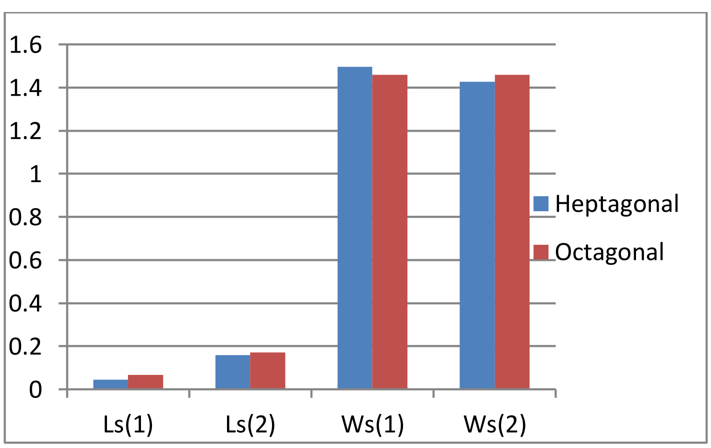

Fig. 1. Graphical representation of Table 1.

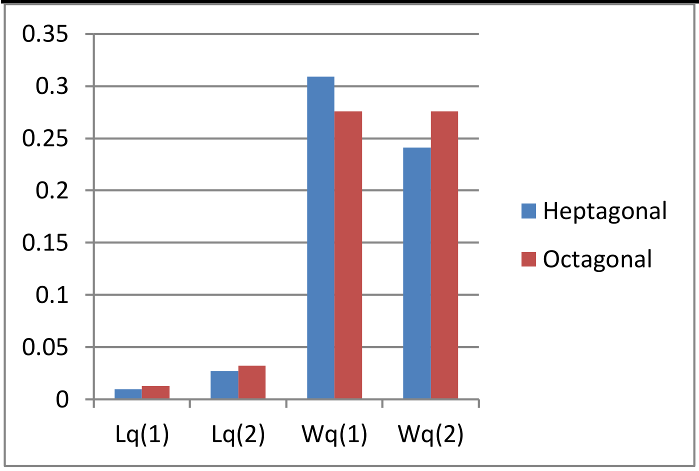

Fig. 2. Graphical representation of Table 2.

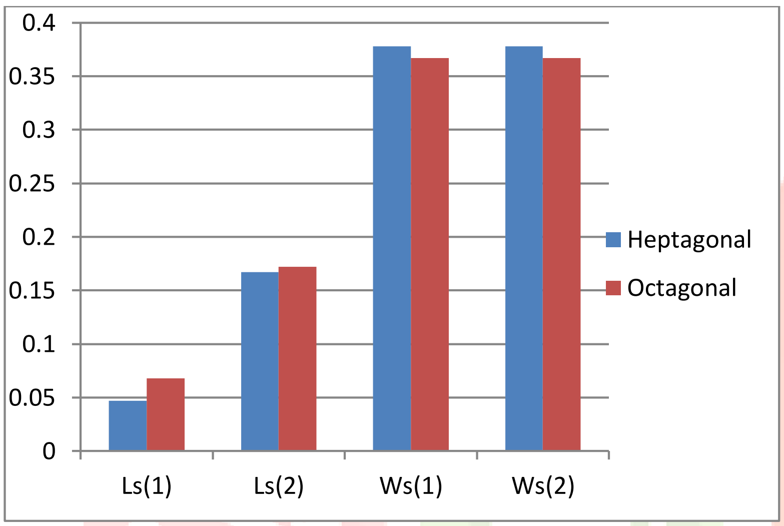

Fig. 3. Graphical representation of Table 3.

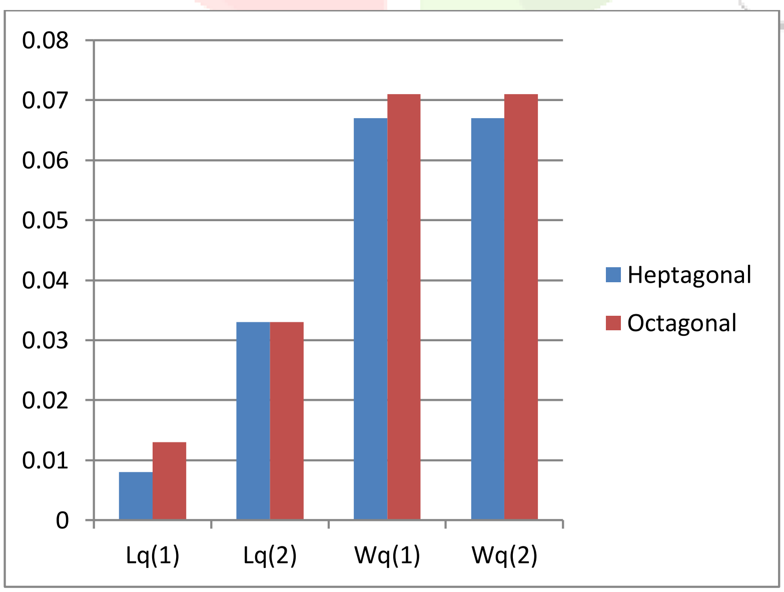

Fig. 4. Graphical representation of Table 4.

From the outcomes shown in tables and its graphical representation demonstrated in figure (1),(2,),(3) and (4), the positioning technique gives different arrangements of real values, for examples, the arrival and service rates for each class. It is likewise observed from tables that all execution proportions of class two in the framework for all the two sorts of fuzzy numbers.

CONCLUSION

In this paper, the fuzzy set theory is shown to be strong tool when dealing with real applications in queuing models with two classes of arrivals and single server. The ranking approach adopted is also seen to be effective when transforming fuzzy queues into crisp queues, thus evaluating the system by conventional performance measurements such as the expected queue length of customers in the queues and system for both classes of arrivals. Also the computation of the expected waiting time of customers in the queue and in the whole system is obtained too. Therefore the manager can take the best values and make optimal decisions. Another advantage of using the ranking method index is obtaining exact values inside the closed crisp interval, while also providing more than one solution of values in the queuing system with different types of membership functions.

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