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EVALUATING SYSTEM PERFORMANCE MEASURE FOR BULK ARRIVAL QUEUEING MODEL BY LR METHOD

S. VIJAYA, Research Scholar,
Mathematics Department
St. Peter's Institute of Higher Education and Research
Avadi, Chennai – 54.
18svijaya@gmail.com

Dr. N. SRINIVASAN, Professor,
Mathematics Department
St. Peter's Institute of Higher Education and Research
Avadi, Chennai – 54.
sri24455@yahoo.com

D.JAYASRI, Assistant Professor,
Mathematics Department
St. Peter's college of engineering and technology
Avadi, Chennai – 54.
jayasridhanajahan@gmail.com

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Abstract— **LR method is studied in this paper to analyse the system of a bulk arrival queueing model that directs for evaluation of system performance measure. LR method is used to calculate the performance measure in bulk arrival queueing model using trapezoidal fuzzy numbers of LR type. LR method is easy and time convenient compared to alpha-cut method. The applicability of this method is illustrated by a numerical example.**

Keywords— Fuzzy queueing, System performance, Bulk arrival queueing model, alpha cut method, LR method, Trapezoidal fuzzy number.

I. INTRODUCTION

Bulk arrival queueing models are examined by many authors like SP Chen [9], Bailey [11], Bhat [1], Borthakur [2], Chaudhary and Templeton [3], Kao [4]. Fuzzy queueing system with arrival in bulk numbers have been accessed and examined in the researchers paper.

In this paper, $FM^{[k]}/FM/1$ queueing system is considered where $FM^{[k]}$is the Fuzzified Poisson arrival rate of batch size k, FM is the Fuzzified exponential service rate with single server under FCFS pattern. Mixed Integer non linear programs have been developed for construction of performance measure in bulk arrival queueing model problems. Bulk arrival queueing model have its applications in telecommunication,

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transportation, Industrial engineering, finance, emergency services and computing. By using LR method, bulk arrival queueing model will have much more applications.

The objective of this paper is to emphasize LR method which gives a platform for other Queueing model problems since LR method takes less time in solving problems.

II. PRELIMINARIES

A. Fuzzy set:

A fuzzy set $\widetilde{P}$ defined on R is categorized by a membership function having the components of a specified space 'X' in the interval [0, 1]. It is represented as

$$\widetilde{P} = \{ (Z, \mu_{\widetilde{P}}(z)) ; z \in Z \}$$

B. Trapezoidal fuzzy number by LR – type :

A fuzzy number $\widetilde{P} = (p, q, r, s)_{LR}$ is said to be trapezoidal fuzzy numbers of LR type if its membership function is given by

$$\mu_{\widetilde{P}}(x) = \begin{cases} L\left(\frac{p-x}{r}\right); & \text{if } x \leq p ; r > 0 \\ R\left(\frac{x-q}{s}\right); & \text{if } x \geq q ; s > 0 \\ 1 & ; \text{otherwise} \end{cases}$$

C. Representation of trapezoidal fuzzy number by LR – type:

Trapezoidal fuzzy numbers are noted as $\widetilde{P}$(v,i,j,a). In LR representation, it can be written as $\widetilde{P}$(v,i,j,a) = < i, j, i-v, a-j >Where i,j are left and right spreads.

III. FUZZY BATCH SIZES VARYING WITH BULK ARRIVAL QUEUES:

We assume a $FM^{[k]}/FM/1$ queueing model of a Poisson problem for a single server facility in batches as a arrival rate $\widetilde{\lambda}$, Where $\widetilde{\lambda}$ is a fuzzy number and exponentially distributed for all service time that are identical with fuzzy service rate $\widetilde{\mu}$. The trapezoidal fuzzy batch size number is represented by J.

The system performance measures such as L_q, L_s, W_s, W_q with bulk arrival is given by

- $L_q = \left[\frac{V\{IE[J^2]+2V(E[J])^2-IE[J]\}}{2I(I-VE[J])}\right]$
- $L_s = \left[\frac{V\{E[J]+(E[J^2])\}}{2(I-VE[J])}\right]$
- $W_s = \left[\frac{E[J]+E[J^2]}{2(I-VE[J])}\right]$
- $W_q = \left[\frac{IE[J^2]+2V(E[J])^2-IE[J]}{2I(I-VE[J])}\right]$

IV. NUMERICAL EXAMPLE:

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Raw materials arrive in batches for a car manufacturing factory. The trapezoidal arrival size is a trapezoidal fuzzy number $[1,2,3,4]$ and E [J] = 2.5, E [J^2] = 6.25. The group arrival rate and service rate are trapezoidal fuzzy numbers represented by $\tilde{\lambda} = [2,3,4,5]$ and $\tilde{\mu} = [13,14,15,16]$per minute respectively. Evaluate the performance measures of the system such as L_q, L_s, W_s, W_q using LR method.

V = $\tilde{\lambda} = [2,3,4,5]$ and I = $\tilde{\mu} = [13,14,15,16]$

In LR method, this can be written as V = $< 3,4,1,1 >$and I = $< 14,15,1,1 >$

A. *To find L_q:*

$$L_q = \left[\frac{V\{IE[J^2] + 2V(E[J])^2 - IE[J]\}}{2I(I - VE[J])}\right]$$

$$= \left[\frac{\langle 3,4,1,1\rangle\langle 14,15,1,1\rangle(6.25) + 2\langle 3,4,1,1\rangle^2(2.5)^2 - \langle 3,4,1,1\rangle\langle 14,15,1,1\rangle(2.5)}{2(\langle 14,15,1,1\rangle^2) - 2\langle 3,4,1,1\rangle\langle 14,15,1,1\rangle(2.5)}\right]$$

$$= \left[\frac{\langle 42,60,17,19\rangle(6.25) + 2(\langle 9,16,1,1\rangle)(6.25) - \langle 42,60,17,19\rangle(2.5)}{2\langle 196,225,1,1\rangle - 2\langle 42,60,17,19\rangle(2.5)}\right]$$

$$= \left[\frac{\langle 262.5,375,106.25,118.75\rangle + \langle 112.5,200,12.5,12.5\rangle - \langle 105,150,42.5,47.5\rangle}{\langle 392,450,2,2\rangle - \langle 210,300,85,95\rangle}\right]$$

$$= \left[\frac{\langle 225,470,166.25,173.75\rangle}{\langle 92,240,97,87\rangle}\right]$$

$$L_q = \langle 0.9375,5.1086,1.9109,1.7912\rangle$$

B. To find L_s:

$$L_s = \left[\frac{V\{E[J] + (E[J^2])\}}{2(I - VE[J])}\right]$$

$$= \left[\frac{\langle 3,4,1,1\rangle(2.5) + \langle 3,4,1,1\rangle(6.25)}{2\langle 14,15,1,1\rangle - 2\langle 3,4,1,1\rangle(2.5)}\right]$$

$$= \left[\frac{\langle 7.5,10,2.5,2.5\rangle + \langle 18.75,25,6.25,6.25\rangle}{\langle 28,30,2,2\rangle - \langle 6,8,2,2\rangle(2.5)}\right]$$

$$= \left[\frac{\langle 26.25,35,8.75,8.75\rangle}{\langle 28,30,2,2\rangle - \langle 15,20,5,5\rangle}\right]$$

$$= \left[\frac{\langle 26.25,35,8.75,8.75\rangle}{\langle 8,15,7,7\rangle}\right]$$

$$L_s = \langle 1.75,4.375,1.25,1.25\rangle$$

C. To find W_s:

$$W_s = \left[\frac{E[J] + E[J^2]}{2(I - VE[J])}\right]$$

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$$= \left[\frac{25 + 6.25}{2\langle 14,15,1,1\rangle - 2\langle 3,4,1,1\rangle(2.5)}\right]$$

$$= \left[\frac{8.75}{\langle 28,30,2,2\rangle - \langle 15,20,5,5\rangle}\right]$$

Taking 8.75 as trapezoidal fuzzy number,

$$8.75 = \langle 8.8335,8.8336,8.8337,8.8338\rangle$$

$$W_s = \left[\frac{\langle 8.8335,8.8336,8.8337,8.8338\rangle}{\langle 8,15,7,7\rangle}\right]$$

$$= \langle 0.5889,1.1042,1.2619,1.2619\rangle$$

D. To find W_q:

$$W_q = \left[\frac{IE[J^2\ ] + 2V(E[J])^2 - IE[J]}{2I(I - VE[J])}\right]$$

$$= \left[\frac{\langle 14,15,1,1\rangle(6.25) + 2\langle 3,4,1,1\rangle(2.5)^2 - \langle 14,15,1,1\rangle(\mathbf{2.5})}{2(\langle 14,15,1,1\rangle^2) - 2\langle 3,4,1,1\rangle\langle 14,15,1,1\rangle(2.5)}\right]$$

$$= \left[\frac{\langle 87.5,93.75,6.25,6.25\rangle + \langle 6,8,2,2\rangle(6.25) - \langle 35,37.5,2.5,2.5\rangle}{2\langle 196,225,1,1\rangle - 2\langle 42,60,17,19\rangle(2.5)}\right]$$

$$= \left[\frac{\langle 87.5,93.75,6.25,6.25\rangle + \langle 37.5,50,12.5,12.5\rangle - \langle 35,37.5,2.5,2.5\rangle}{\langle 392,450,2,2\rangle - \langle 210,300,85,95\rangle}\right]$$

$$= \left[\frac{\langle 125,143.75,18.75,18.75\rangle - \langle 35,37.5,2.5,2.5\rangle}{\langle 92,240,97,87\rangle}\right]$$

$$= \left[\frac{\langle 87.5,108.75,21.25,21.25\rangle}{\langle 92,240,97,87\rangle}\right]$$

$$= \langle 0.3645,1.1820,0.2442,0.2190\rangle$$

Note:

For the above problem, results are compared with α cut method.

	α cut	**LR**
	MATLAB software is used for system performance	Manual calculation is done for system performance
L_q	Falls between 1.2667 and 3.7024 and does not fall outside 0.5511-46.5385	Falls between 0.9375-5.1086
L_s	Falls between 1.7667 and 4.4167 and does not fall outside0.8636-47.5000	Falls between 1.7500-4.3750
W_s	Falls between 0.5889 and1.1042 and does not fall outside0.4318-9.5000	Falls between 0.5889-1.1042
W_q	Falls between 0.4222 and 0.9256 and does not fall outside0.2756-9.3077	Falls between 0.3645-1.1820

V. CONCLUSION:

In this paper, the performance measure in bulk arrival queueing system is calculated using trapezoidal fuzzy numbers of LR type. The left and right spreads are calculated using trapezoidal fuzzy numbers of LR type using LR method.

L_q lie between 0.9375 and 5.1086
L_s lie between 1.7500 and 4.3750
W_s lie between 0.5889 and 1.1042 and
W_q lie between 0.3645 and 1.1820.

Therefore LR method is simple and convenient in calculating the system performance measure of a queueing system.

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