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Fuzzy Based Amalgamated Technique for Optimal Service Time in Distributed Computing System

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Abstract: ***Due to the continuous progress of microprocessor technology and computer network, the distributed computing system (DCS) is currently one of the key areas of interest. The distributed computing system [DCS] provides the ability to share better performance and resources. There are a few registering nodes that communicate with one another through the message transient system. The advancement of new technologies in communication and information leads to the development of distributed systems.***

Task assignment is a critical step in the distributed computing system. For the proper utilization of available enumeration strength, it is necessary to allocate tasks to the processors, whose features are vastly suitable for execution. In this research paper, we have examined a task allocation problem with fuzzy performance time and fuzzy communication time, which is more realistic and general in nature. The problem of fuzzy task allocation is impure and it has been converted into a single number (i.e crisp one) using the fuzzy magnitude ranking method. Here, a serviceable model has been evolved to establish the system's optimum impedance time by optimal assignment of tasks based on triangular fuzzy execution time and triangular fuzzy communication time processor speed.

Keywords : Fuzzy Assignment, Crisp Value, Magnitude Ranking Method, Task Allocation, Fuzzy Execution Time, Fuzzy Communication Time, Task Response Time.

I. INTRODUCTION

Due to widespread applicability in industry, commerce, technology, management science, etc, there are various applications available in the real world of assignment problem. Traditional excellent assignment problems cannot be used successfully for real-life problems; Therefore, the use of fuzzy assignment problem is more appropriate. Fuzzy sets were introduced by Lofti A. Zadeh in 1965 as an extension of representing impurity or ambiguities in day to day life. Although the speed of computer has increased manifold in recent decades, the demand for capacities in technology is increasing even faster. The handling effectiveness required for some ongoing applications can't be acquired with a solitary processor framework. To tackle this issue, a methodology is to utilize Distributed Processing Systems (DPS) so an assignment program can process a few procedures to get actual time calculation. Partitioning and allocation of task are two noteworthy strides in the structure of DPS. If these steps are not executed appropriately and quantity of processors in the framework increases, then the overall flow of the framework may diminish.

With the fast advancement of Distributed System (DS) innovation, the assignment planning has turned into a significant issue. So as to compute task scheduling work in the disseminated framework, there is a need to improve productivity in the field of utilizations. The most significant issue when structuring the algorithm of any task scheduling time ledge is to diminish as far as possible and standby time. **S. Yadav et. al.** [1] consider a fuzzy based task allocation algorithm. This calculation can dispense task efficiently over various processors by adjusting the heap among processors with the goal of lessening execution and reaction time. Also **R. Q. Mary et. al.** [2] and **A. Hadi -Vencheh et. al.** [19] solved Triangular Fuzzy Assignment Problem by taken crisp values using Centroid Ranking method to find an optimal solution. The strategy uses the Euclidean separations from the source to the centroid point of each fuzzy unit to analyse and rank the fuzzy unit . **S. Muruganandam et. al.** [3] present a genetic algorithmic approach to a fuzzy assignment problem with cost(time) as imprecise number by assigning each job to exactly one person. They uses Yager's ranking method to convert fuzzy assignment problem into crisp ones and then Genetic algorithm approach is used to find the optimum solution. **A. Sharma** [4] **, Harendra Kumar et. al.** [13] **, A. Nagoor Gani et. al.** [14] **, S. Manimaran et. al.** [15] **and P. K. Yadav et. al.** [17] presents concept of defuzzification by using Robust's ranking method to convert the fuzzy value into the crisp indices of time. They created numerical model to decide the ideal reaction time of the framework with Triangular/Trapezoidal fuzzy ET and Triangular/Trapezoidal fuzzy IT correspondence time. The fuzzy task issue has been changed into crisp task issue in the LPP structure and understood by utilizing LINGO 9.0[14],[15]. **Trupti A Thakre et. al.** [5]**, D. Selvi** [6] solved FAP for the placement of four by four candidates/ designations in Life Insurance Corporation (LIC).

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They uses magnitude ranking method for transformation of fuzzy triangular into crisp ones and then solved it by Hungarian, MOA and Direct method.

Md. Rashedul Islam et. al. [7] proposed a fuzzy rule procedure for allocating the task among the parts of an ant colony under grid computing and try to reduce the time utilization of task between them. Transportation and assignment models assume critical job in logistics and supply chain management diminishing expense and time, for better service. **Y. L. P. Thorani et. al.** [8] presents a fuzzy Multi-objective Assignment Model with three parameters as fuzzy cost, fuzzy time and fuzzy quality with generalized LR trapezoidal fuzzy numbers. **P. Neelakantan et. al.** [9] **proposes** the diffusion strategy for adjusting the tasks between the PCs in a conveyed framework. Here reaction time of the assignments is limited by moving the undertakings from the over-burden PCs to the under burden PCs utilizing a load adjusting system. To assess the execution of the framework, the load on the framework is fluctuated with the mean IAT of the tasks at every PC. **A. Rahmani et. al.** [10] proposes a new method of defuzzification based on the midst value of statistical Beta distribution and an rule for ranking fuzzy units based on the crisp unit ranking framework on R. **Sujit Kumar De et. al.** [11] **proposed** the dense fuzzy set for triangular fuzzy numbers. Then novel defuzzification method have been designed using crisp convergence rule.

The Solid Assignment Problem (SAP) is an essential enhancement of the Assignment Problem. SAP has wide applications in multi-detached sensor, capital speculation, dynamic office area, satellite propelling, time postponing problems and so on. **D. Anuradha** [12] presents strong task issue with uncertain expenses. Robust's positioning strategy is received for positioning the uncertain information. The fuzzy solid assignment problem has been changed into crisp one and fathomed via plane point technique. **P. Pandian et. al.** [16] proved two theorems; one is concerned to the optimum solution and next is belonging to obtain an rectified solution from the actual one to the FAP. The parallel moving method gives an optimal solution to the FAP in less number of iterations than the labelling algorithm. The concept of fuzzy sets is broadly used in different fields as Science, Engineering, Technology, Management, Medical Science, Bio-Science etc. today. Most of these applications can be considered as frame work with numerical input and numerical output. Basically these frame work with fuzzy values, which have to be transformed to crisp values after processing. This transformation is called defuzzification. **R. Saneifard et. al.** [18] proposed a method based on probability density function of a fuzzy number, so as to find the order of fuzzy numbers.

II. PROBLEM STATEMENT AND BASIC DEFINITIONS

Assignment problem has various applications in the real world because of their wide applicability in industry, commerce, management science, etc. Traditional classical assignment problems cannot be successfully used for real life problem; hence the use of fuzzy assignment problem is more appropriate. The objective of this fuzzy assignment problem is to find an allocation for a set of tasks $F_z\{t_i\}$ to a set of processors $F_z\{p_j\}$ in such a ways that the overall response time is minimized in the system. Since we have a Fuzzy Assignment Problem, where the time are fuzzy units, then the whole time also becomes a fuzzy unit. Consequently it can't be restricted authentically. For this purpose we defuzzify the fuzzy time coefficients into crisp ones by using the Magnitude Ranking method.

1.1 Fuzzy Execution Time: The Fuzzy Execution Time $F_z\{ET(et_{ij})\}$, where $1 \le i \le m$, $1 \le j \le n$ is the unit of time taken by different task $\{t_i\}$ that must be executed on the different processors $\{p_j\}$. During the process if the task $\{t_i\}$ isn't executed because of absence of assets, at that point $ET(et_{ij})$ on that processor is chossen to be zero [13].

$$F_z\{ET(\tilde{c})\} = \sum_{1\le i\le m} \tilde{e}t_{i,c(i)} \qquad \text{.........(1)}$$

1.2 Fuzzy Communication Time: The Fuzzy Communication Time $F_z\{CT(ct_{ik})\}$ is a unit of time between data units when executed on different processors between the two different tasks. when the tasks are allocated on the common processor, then $\{\tilde{c}t_{ik}\} = 0$. The Fuzzy Communication Time $F_z\{CT(ct_{ik})\}$ for processor $\{p_j\}$ is calculated as follows:

$$F_z\{CT(\tilde{c})\} = \sum_{\substack{1\le i\le m \\ i+1\le j\le m \\ i=j\ne k}} \{\tilde{c}t_{ik}\}, \; k = 1,2,3,\ldots,m \; ; \; 1\le j\le n \qquad \text{.........(2)}$$

1.3 Fuzzy Task Response Time: The Fuzzy Task Response Time $F_z TRT(\tilde{c})$ is a function of the unit of computation to be executed by each task on different processor and the communication between them. It is defined as:

$$F_z\{TRT(\tilde{c})\} = \max_{1\le j\le n}\left(F_z\{ET(\tilde{c})\} + F_z\{CT(\tilde{c})\}\right) \qquad \text{.........(3)}$$

1.4 Defuzzification: Defuzzification is the process of finding exclusive time (crisp value) which represents the moderate time of the Triangular Fuzzy Numbers. There are different methods for defuzzification of triangular fuzzy number such as Robust Ranking , Magnitude Ranking and Centroid Ranking Method. Here we used Magnitude Ranking Method.

- ➢ The magnitude of triangular fuzzy numbers $(\tilde{c})$ shows information on every membership degree, and this magnitude is visual and natural. Also it satisfies the linearity and additive property. For an arbitary triangular fuzzy number $\tilde{c} = (a_0, \underline{a}, \overline{a})$ the magnitude is given by

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$$Mag(\tilde{c}) = \frac{1}{2}\int_{0}^{1} (\bar{a} + 3a_0 - \underline{a}) f(k) dk \qquad \text{..........(4)}$$

Where $f(k)$ is a non-unassertive and increasing function on [0,1] with f(0)=0, f(1)=1. The function $f(k)$ assumed to be weighting function. In general $f(k)$ can be taken by the decision maker as per circumtances of the application. Here for simplicity we take it $f(k) = k$.

1.5 Fuzzy Linked Array: The Fuzzy Linked Array is calculated by using fuzzy communication time as follow:

$$F_z\{LA(i,j)\} = \sum_{i \neq k}[ct_{ik}] \ , \quad \text{for } k = 1,2,3,...,m \ ; 1 \leq j \leq n \qquad \text{..........(5)}$$

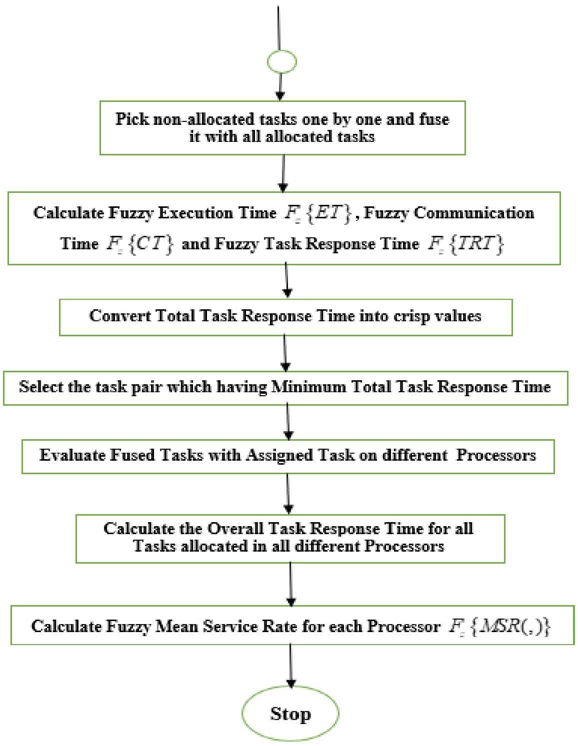
A task is to be maximally linked if it has the largest aggregate on inter task communication time of any of the tasks that are adjacent to one or more of the tasks. Since a maximally linked tasks has the maximum unit of communication with its adjacent tasks, in general it is advantages to form cluster around such tasks.

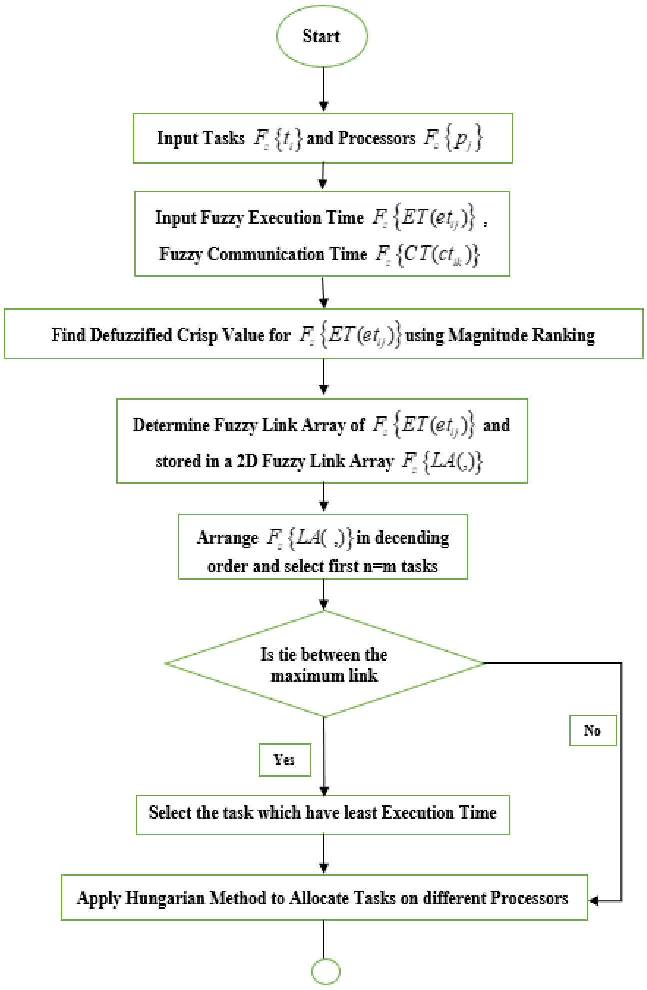
1.6 Fuzzy Mean Service Rate: The Fuzzy Mean Service Rate for each of the processors is calculated by

$$F_z\{MSR(j)\} = \frac{\{Tt_j\}}{F_z\{ET(et_j)\}} \qquad \text{..........(6)}$$

Here $\{Tt_j\}$ is the total tasks on each processor.

III. FLOW CHART REPRESENTING THE PROPOSED ALGORITHM





IV. THE ALLOCATION ALGORITHM FOR PROPOSED METHOD

The mapping between the tasks and processors is defined by $\varphi : N \rightarrow M$. A task may be a data file or code which is to be executed on different processors having different processing capabilities. Assume that number of tasks is more than the number of processors $(m \geq n)$ as normally seen in real life. Also it is assumed that the execution time of a task on each processor and inter task communication time is known. The inter task communication time between the same tasks is zero.

Step1: Set Fuzzy quantitative problem of m tasks $F_z\{t_i\}$ for $1 \leq i \leq m$ i.e. $\{t_1, t_2, t_3, t_4, t_5\}$.

Step2: Set Fuzzy quantitative problem of n processors $F_z\{p_j\}$ for $1 \leq j \leq n$ i.e. $\{p_1, p_2, p_3\}$

Step3: Set $F_z\{ET(et_{ij})\}$ and $F_z\{CT(ct_{ik})\}$ in the form of fuzzy triangular number. $F_z\{ET(et_{ij})\}$ and $F_z\{CT(ct_{ik})\}$ are taken in the form of matrices as Fuzzy Execution Time Matrix and Fuzzy Inter Task Communication Time Matrix.

Step4: Determine Defuzzified Crisp Value for $F_z\left\{ET(et_{ij})\right\}$ using **Magnitude Ranking** by using equations (4).

Step5: Determine Link Array for those 'n'tasks, which have link with other tasks by using equation (5). This link is stored in a two dimentional array, Fuzzy Link Array $F_z\left\{LA(\ ,)\right\}$, where the first column represents the task sequence and the second column represents the average maximum link between the tasks.

Step6: Select the first 'n' tasks (n=m), which have maximum link with other task using step-5 from $F_z\left\{ET(et_{ij})\right\}$ and use Hungarian rule to the "n" tasks to assign on the different processor.

a. If there is tie between the maximum link value then select the task which have least execution time.

b. If there is tie between the least execution time then select the task arbitrily.

Step7: Let tasks allocated to processors is denoted by $F_z\left\{ET(et_{ij})\right\} = T_{allocate}$ and remaining (m-n) tasks not allocated is denoted by $F_z\left\{ET(et_{ij})\right\} = T_{not-allocate}$.

Step8: Pick non-allocated tasks one by one and fuse it with all allocated tasks to calculate Total Fuzzy Execution Time $F_z\left\{ET\right\}$, Total Fuzzy Communication Time $F_z\left\{CT\right\}$ and Total Fuzzy Task Response Time $F_z\left\{TRT\right\}$ using equations (1), (2), and (3).

Step9: Convert Total Task Response Time into crisp values once using step-4 because it is fuzzy quantitative number.

Step10: Select the task pair which having Minimum Total Task Response Time. This Minimum crisp value represent that the task $F_z\left\{ET(et_{ij})\right\} = T_{not-allocate}$ goes on that processor. Continue this process until all the task $F_z\left\{ET(et_{ij})\right\} = T_{not-allocate}$ are fused with the task $F_z\left\{ET(et_{ij})\right\} = T_{allocate}$.

Step11: Now calculate the Overall Task Response Time for all tasks allocated in all different processors.

Step12: Calculate Fuzzy Mean Service Rate for each Processor $F_z\left\{MSR(,)\right\}$.

Step13: Stop

V. NUMERICAL IMPLEMENTATION

Step1: Set Fuzzy quantitative problem of m tasks $F_z\left\{t_i\right\}$ for $1 \le i \le m$ i.e. $\left\{t_1, t_2, t_3, t_4, t_5\right\}$.

Step2: Set Fuzzy quantitative problem of n processors $F_z\left\{p_j\right\}$ for $1 \le j \le n$ i.e. $\left\{p_1, p_2, p_3\right\}$.

Step3: Set $F_z\left\{ET(et_{ij})\right\}$ and $F_z\left\{CT(ct_{ik})\right\}$ in the form of fuzzy triangular number. $F_z\left\{ET(et_{ij})\right\}$ and $F_z\left\{CT(ct_{ik})\right\}$ are taken in the form of matrices.

Table I: Fuzzy Execution Time Matrix

$F_z\left\{ET(et_{ij})\right\} =$

	t_1	t_2	t_3	t_4	t_5
p_1	(5,10,20)	(10,15,20)	(10,20,30)	(5,10,20)	(5,10,15)
p_2	(5,10,15)	(10,20,30)	(10,15,25)	(10,15,20)	(5,10,20)
p_3	(10,15,20)	(10,15,25)	(10,15,20)	(5,10,15)	(5,15,20)

Table II: Fuzzy Communication Time Matrix

$F_z\left\{CT(ct_{ik})\right\} =$

	t_1	t_2	t_3	t_4	t_5
t_1	$(0,0,0)$	$(20,30,40)_{17.5}$	$(10,20,30)_{10}$	$(40,45,50)_{31.25}$	$(5,10,20)_{6.25}$
t_2	$(20,30,40)_{17.5}$	$(0,0,0)$	$(40,50,60)_{32.5}$	$(10,20,30)_{10}$	$(30,40,50)_{25}$
t_3	$(10,20,30)_{10}$	$(40,50,60)_{32.5}$	$(0,0,0)$	$(10,15,25)_{10}$	$(10,20,30)_{10}$
t_4	$(40,45,50)_{31.25}$	$(10,20,30)_{10}$	$(10,15,25)_{10}$	$(0,0,0)$	$(15,25,30)_{12.5}$
t_5	$(5,10,20)_{6.25}$	$(30,40,50)_{25}$	$(10,20,30)_{10}$	$(15,25,30)_{12.5}$	$(0,0,0)$

Step4: Determine Defuzzified Crisp Value for $F_z\left\{ET(et_{ij})\right\}$ using Magnitude Ranking Method.

Table III: Defuzzified Crisp Values for Fuzzy Execution Time Matrix

	t_1	t_2	t_3	t_4	t_5
p_1	6.25	8.75	10	6.25	5
p_2	5	10	10	8.75	6.25
p_3	8.75	10	8.75	5	5

Step5: Determine Maximally Link Array for those 'n'tasks, which have maximum link with other tasks. Here we select first '3' task from Maximally Linked Task Time for which processor execution time is maximum.

Table IV: Fuzzy Linked Task Time

$F_z\left\{LA(,)\right\} =$

$Task$	$CrispValues$
t_1	106.25
t_2	140
t_3	106.25
t_4	105
t_5	95

Step 6 & 7: Select the first 'n' tasks (n=m), which have maximum link with other task and apply Hungarian method to the "n" tasks to allocate on the different processor.

Table V: Hungarian Method Implimentation

$$F_z\{ET(et_{ij})\} = T_{allocate} \Rightarrow \begin{array}{c|ccc} & t_2 & t_1 & t_3 \\ \hline p_1 & \boxed{8.75} & 6.25 & 10 \\ p_2 & 10 & \boxed{5} & 10 \\ p_3 & 10 & 8.75 & \boxed{8.75} \end{array}$$

Here $F_z\{ET(et_{ij})\} = T_{not-allocate} \Rightarrow \{t_4, t_5\}$.

Step8 & 9: Pick non-allocated tasks $\{t_4, t_5\}$ one by one and fuse it with all allocated tasks to calculate Total Fuzzy Execution Time $F_z\{ET\}$, Total Fuzzy Inter Task Communication Time $F_z\{CT\}$ and Total Process Response Time $F_z\{TRT\}$. Convert Total Process Response Time into crips once.

Table VI: Fuzzy Total Response Time with Fused Task $\{t_4\}$

$Processor$	$Task\ t_4\ Fused$	$F_z\{ET\}$	$F_z\{CT\}$	$F_z\{TRT\}$	$CrispValues$
p_1	$t_2 \oplus t_4$	(15,25,40)	(155,205,255)	(170,230,295)	143.75
p_2	$t_1 \oplus t_4$	(15,25,35)	(70,120,175)	(85,145,210)	$\boxed{80}$
p_3	$t_3 \oplus t_4$	(15,25,35)	(125,180,230)	(140,205,265)	120

TableVII: Fuzzy Total Response Time with Fused Task $\{t_5\}$

$Processor$	$Task\ t_5\ Fused$	$F_z\{ET\}$	$F_z\{CT\}$	$F_z\{TRT\}$	$CrispValues$
p_1	$t_2 \oplus t_5$	(15,25,35)	(100,155,210)	(115,180,245)	$\boxed{102}$
p_2	$t_1 \oplus t_5$	(10,20,35)	(125,180,230)	(135,200,265)	117.5
p_3	$t_3 \oplus t_5$	(15,30,40)	(110,160,215)	(125,190,255)	110

Hence task t_4 goes to processor p_2 and task t_5 goes to p_3.

Step10 & 11: Now calculate the Overall Process Response Time for all tasks allocated in all different processors and Mean Service Rate in terms of task allocated on different processors.

Table VIII: Mean Service Rate for Tasks on processor

$Processor$	$Tasks$	$F_z\{ET\}$	$F_z\{CT\}$	$F_z\{TRT\}$	$CrispValues$	$F_z\{MSR\}$
p_1	$t_2 \oplus t_5$	(15,25,35)	(100,155,210)	(115,180,245)	$\boxed{102.5}$	0.0195
p_2	$t_1 \oplus t_4$	(15,25,35)	(70,120,175)	(85,145,210)	80	0.025
p_3	t_3	(10,15,20)	(70,105,145)	(80,120,165)	71.25	0.0140

VI. CONCLUSION AND DISCUSSION

In this paper we developed a new algorithm by using Fuzzy Execution Times and Fuzzy Inter Tasks Communication Times which provide the new direction to optimize the system. In this paper, the Mean Service Rate of the tasks is minimized by migrating the tasks from the overloaded processors to the under load processors using a fusion of the tasks. To evaluate the performance of the system, the allocation on the system is varied with the Mean Service Rate of the tasks at each processor. By comparison the results of the proposed technique and existing ways, it's shown that the proposed technique has given better results than the present ways. The proposed technique has the efficient fusion of tasks for the optimal allocation to minimize the Mean Service Rate of the system.

Existing Technique			**Proposed Technique**
Harendra Kumar[13]	Abhilasha Sharma[4]	Seema Yadav[1]	**102.5**
178.33	166.66	166.66	

In this paper the proposed methodology is efficient but do not provide the completeness for the all technique which would exist. Many new ways we can also design in future work. In this work we have focused only on the Mean Service Rate of the system, but we can also consider the load balancing problem in future with fuzzy technique. This model is useful in telephone networks, cellular network, image processing etc.

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