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## “Multi-Criteria Group Decision Making Approach for Scheduling Algorithms Selection by Short Term Scheduler using Fuzzy TOPSIS”.



**Abstract:** - The fundamental objective of the CPU scheduler is to equitably and effectively allocate CPU time among competing processes. Within the realm of schedulers, the short-term scheduler specifically addresses this objective by selecting processes from the ready queue for execution on the CPU, guided by various scheduling algorithms. The critical challenge faced by the short-term scheduler lies in the prudent selection of the most suitable algorithm, as an erroneous choice can detrimentally impact system performance, leading to increased waiting and response times for processes. To surmount this challenge, we employ the Fuzzy TOPSIS method within the framework of Multi-Criteria Decision Making (MCDM) to rank scheduling algorithms, taking into account both quantitative and qualitative factors. The proposed approach involves two steps: firstly, defining criteria for algorithm selection, and secondly, obtaining linguistic ratings from experts for potential alternatives based on the specified criteria. The principal aim of this investigation is to utilize the Fuzzy TOPSIS method, integrating fuzzy sets, to produce comprehensive scores that assist in selecting the optimal alternative.

**Keywords:** CPU scheduling, Decision-making, Fuzzy logic, Process optimization.

### I. INTRODUCTION

Schedulers play a crucial role in multitasking environments, where multiple processes vie for CPU time. The scheduler [1] is tasked with ensuring each process receives an equitable share of processing time, effectively managing CPU and memory resources. The primary objective of the scheduler is to optimize system resources and facilitate the fair and timely execution of tasks. Three types of schedulers are deployed based on the system's scope and scheduling algorithms [2]. The long-term scheduler is utilized for loading processes from disk to memory and determining the selection of processes from the pool of new processes for execution [1]. The medium-term scheduler is responsible for deciding to temporarily transfer processes from main memory to disk, a process known as swapping out, aimed at freeing up memory space.[1]. The short-term scheduler [1], also known as the CPU scheduler, is a commonly used scheduler for processing tasks or processes. It selects processes from the available list of processes waiting to execute on the CPU in the ready queue.

The determination of process selection from the ready queue relies on scheduling algorithms. Several scheduling algorithms exist, such as 'First-Come First-Served (FCFS),' 'Shortest Job First (SJF),' 'Priority Scheduling,' 'Multi-level feedback queue (MLFQ),' and 'Round Robin (RR),' which are commonly employed for decision-making. Each algorithm possesses its own strengths and weaknesses. In FCFS, processes are executed in the order they enter the ready queue (RQ), meaning the first-arrived process gets the CPU first [3]. It operates in a non-preemptive manner. SJF [4] selects the procedure with the shortest burst time (implementation of time) for the next run. Priority scheduling assigns a priority to each process [5], and the CPU is given to the process with the highest priority. The

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priority can be either static or dynamic (changing during process execution). MLFQ extends the concept of a multi-level queue [6]. Processes in MLFQ can switch between various queues based on their behavior. In Round Robin [7], a time quantum (TQ) or time segment is allocated to each process for CPU execution. Process execution follows a circular order, and if a process does not complete within its TQ, it is proposed to the delaying line, and the CPU switches to the next process in line. RR ensures fair distribution of CPU time among processes.

Hence, the accurate selection of scheduling algorithms has a profound impact on the system timeline, performance, and fairness. However, choosing a suitable algorithm among various scheduling algorithms poses a critical challenge for the short-term scheduler. To address this challenge, we employed the fuzzy TOPSIS method in Multi-Criteria Decision Making (MCDM) [8] to make the optimal algorithmic choice. In the Fuzzy TOPSIS method, five alternatives (FCFS, SJF, Priority Scheduling, MLFQ, and RR) are taken into account, along with four conditions: average reaction time (ART), average improvement time (ATAT), average waiting time (AWT), and output. The Fuzzy TOPSIS approach [9] is applied to rank scheduling algorithms in the context of MCDM. The uniqueness of the proposed work is as follows: Hence, the accurate selection of scheduling algorithms has a profound impact on the system timeline, performance, and fairness. However, choosing a suitable algorithm among various scheduling algorithms poses a critical challenge for the short-term scheduler. To address this challenge, we employed the fuzzy TOPSIS method in Multi-Criteria Decision Making (MCDM) [8] to make the optimal algorithmic choice. In the fuzzy TOPSIS method, five alternatives (FCFS, SJF, Priority Scheduling, MLFQ, and RR) are considered along with four criteria: average response time (ART), average turnaround time (ATAT), average waiting time (AWT), and throughput. The Fuzzy TOPSIS approach [9] is applied to rank scheduling algorithms in the context of MCDM. The uniqueness of the proposed work is as follows:

1. The proposed initiative has significantly improved system performance and fairness.
2. Fuzzy logic is employed to handle uncertain or imprecise data related to scheduling algorithms' criteria.
3. Weights in the evaluation process are represented using linguistic terms or fuzzy numbers.
4. The Fuzzy TOPSIS method plays a crucial role in determining the ranking of scheduling algorithms.
5. The approach successfully addresses concerns such as avoiding starvation, minimizing context switching, and improving response time.

Chen, C. T. (2001) employed an innovative MCDM technique to address the distribution center location selection problem within a fuzzy environment [10]. He assigned ratings to each alternative and weights for criteria, employing linguistic variables and transforming them into fuzzy numbers. The evaluation value for each alternative with respect to criteria is expressed using a triangular fuzzy number. Fasanghari M. et al (2008) [11] They proposed the application of fuzzy TOPSIS in MCDM for addressing the customer satisfaction evaluation method. The study introduced a customer happiness satisfaction index for a business-to-consumer e-commerce company, utilizing fuzzy TOPSIS and fuzzy triangular numbers for linguistic variables in the assessment of customer satisfaction. Jadhav V. S. et al (2012) [12] presented a technique for creating a schedule of finite jobs on a finite number of machines with unequal efficiencies, employing the TOPSIS Method in a fuzzy environment. Ashrafzadeh M. et al (2012) [13] applied the MCDM approach for selecting a warehouse location in the presence of partial information. The proposed strategy involves two key steps: (1) Defining criteria for the selection of a warehouse location involves two key steps: (1) establishing the criteria, and (2) collecting linguistic ratings from experts for various options based on the defined criteria. This study demonstrates the application of fuzzy TOPSIS in addressing a real-world problem, specifically in choosing the optimal warehouse location for a large Iranian company. Ashrafzadeh M. et al (2012) [13] applied the MCDM approach for selecting a warehouse location in the presence of partial information. The proposed strategy involves two key steps: (1) defining criteria for warehouse location selection, and (2) obtaining linguistic ratings from experts for different options based on the specified criteria. This study demonstrates the application of fuzzy TOPSIS in addressing a real-world problem, specifically in choosing the optimal warehouse location for a large Iranian company. Junior F. R. L. et al (2014) [14] conducted a study comparing the fuzzy AHP and fuzzy TOPSIS methods, focusing on seven variables relevant to the supplier selection issue. In the context of fuzzy MCDM, the fuzzy TOPSIS method is employed to address the supplier selection problem. Büyüközkan G. et al (2016) [15] tackled the smartphone selection problem using MCDM. Intuitionistic fuzzy sets with TOPSIS (IF-TOPSIS) are utilized to remove uncertainty and more accurately capture decision makers' preferences. The proposed approach includes a real case study with Intuitionistic fuzzy TOPSIS. Shirvani

M. H. et al (2017) [16] utilized the fuzzy TOPSIS procedure to address (HPC) and cloud data center selection in MCDM. Kore N. B. et al. (2017) [17] offered a comprehensible explanation of the fuzzy TOPSIS technique for Multi-Criteria Decision Making, demonstrating its application with a real-world example. The approach can automate the procedure and eliminate uncertainty in the selection process. Irvanizam I. (2018) [18] introduced the concept of fuzzy TOPSIS to determine scholarship recipients, showcasing its use as a MADM technique through a numerical example constructing a triangular fuzzy number for fuzzy data onto a regulated weight. Regularized values are utilized in the construction of the fuzzy decision matrix. In addressing supplier selection concerns, Modibbo U. M. et al (2022) [19] examined the multi-criteria multi-supplier decision-making process and proposed a mixed-integer linear programming model. A numerical example illustrates the utility of the suggested model, showing how it aids pharmaceutical companies in making informed decisions in the real world. The Fuzzy TOPSIS method played a crucial role in assigning ranks to alternatives based on criteria.

The current research is organized into six sections. The initial section introduces and highlights the uniqueness of the proposed policy. The second section delves into the fundamentals of Multi-Criteria Decision-Making Systems (MCDMS), the fuzzy TOPSIS method, and fuzzy sets. The third segment outlines the mathematical approach employed in the proposed work. The fourth section outlines the foundational structure of the planned work. In the fifth segment, we discuss numerical computation and performance evaluation. The concluding remarks of the entire study and future considerations constitute the sixth and final segment.

## II. BASIC CONCEPTS

### 2.1 Multi criteria decision making system

A (MCDMS), recognized as a decision support system, aids individuals or entities in navigating intricate decisions encompassing multiple criteria or objectives [20]. Decision-making in numerous real-world scenarios demands consideration of diverse factors or criteria, some of which may conflict or align. In handling such situations, MCDMS provides a systematic and unbiased approach to evaluate, analyze, and assess different selections based on a variety of apparent conditions.

Let  $\alpha$  be a set of judgement replacements, and  $\beta$  be a set of valuation principles. Each decision alternative  $x \in \alpha$  undergoes assessment based on its performance concerning each criterion  $y \in \beta$ .

Consider  $Q$  as the  $n \times m$  decision matrix, where  $ij$  signifies the evaluation score of alternatives  $I$  concerning condition  $J$ . The matrix  $Q$  is defined as:

$$Q = \{\bar{\omega}_{12} \quad \bar{\omega}_{21} \dots \bar{\omega}_n \quad \bar{\omega}_{12} \quad \bar{\omega}_{22} \dots \bar{\omega}_{n_2} \quad \bar{\omega}_{13} \dots$$

The aim of the Multi-Criteria Decision Making (MCDM) system is to discern a decision rule or methodology proficient in ranking or choosing the optimal options from  $\alpha$  based on the criteria in  $\beta$ . Diverse MCDM approaches utilize an array of mathematical tools and models to accomplish this objective.

### 2.2 Fuzzy Technique for Order Preference by Similarity to Ideal Solution (FTOPSIS)

FTOPSIS [21] serves as an extension of the traditional TOPSIS approach, incorporating fuzzy set theory. Fuzzy TOPSIS is a Multi-Criteria Decision Making (MCDM) procedure that ranks options based on their proximity to ideal and undesirable solutions, initially developed by Yoon and Hwang in 1981. FTOPSIS proves to be particularly advantageous when seeking a compromise option that optimally diverges from the anti-idyllic complementary while sufficient all obligations. It relies on two fundamental models: Positive Ideal Solution (PIS) and Negative Ideal Solution (NIS). The primary goal of PIS is to maximize throughput while minimizing waiting time, while NIS aims to maximize waiting time while minimizing throughput. In FTOPSIS, the alternative that is closest to PIS and farthest from NIS is identified. The widespread popularity of FTOPSIS is attributed to its effectiveness and reliability in various Multiple Criteria Decision Making (MCDM) applications.

Unlike the conventional TOPSIS approach [22], which utilizes crisp data represented by single values for criteria, FTOPSIS deals with real-world decision-making scenarios where data may be ambiguous, inaccurate, or confusing. The FTOPSIS method addresses such situations by treating criteria as fuzzy sets, assigning each value a point of inclusion between 0 to 1 to denote the level of assurance.

Widely applied across diverse domains such as 'supply chain management,' 'manufacturing systems,' 'business and marketing management,' 'health,' and 'human resources management,' the FTOPSIS approach proves versatile in numerous subject areas. In essence, FTOPSIS facilitates the ranking of decision alternatives by evaluating their overall performance across multiple criteria, incorporating both ideal and anti-ideal solutions. It provides a systematic and objective methodology for addressing multi-criteria decision-making problems.

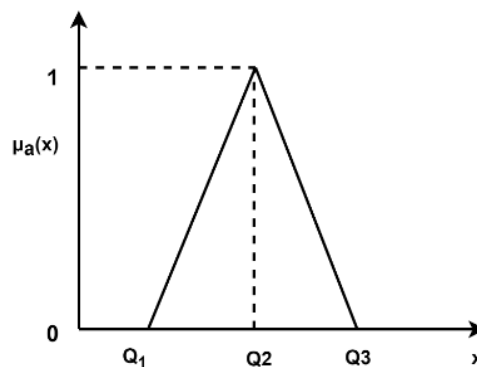
**2.3 Fuzzy Set**

Understanding fuzzy set concepts necessitates grasping the fundamental principles of conventional set theory [23]. In mathematics, the notion of a conventional set is straightforward—an assemblage of objects with well-defined boundaries. In contrast, elements in fuzzy set theory possess degrees of belonging to the set ranging from 0 to 1, unlike the elements in classical/crisp set theory, which are either members or non-members. The imprecision or vagueness of fuzzy set boundaries introduces a different perspective. Mathematically, ambiguity and fuzziness in the association of constituents to a usual find representation through fuzzy sets.

Consider K as the space of discussion, where k belongs to K. A fuzzy set A, classified on K, can be expressed as a compilation of structured pairs.

$$\tilde{A} = \{(k, \mu_{\tilde{A}}(k)): k \in K\}$$

Where  $\mu_{\tilde{A}}(k)$  is called the membership function. Membership is essentially a measure of belongingness, ranging from 0 to 1. Each pair of values is termed a singleton. Various membership functions, such as three-sided, trapezoidal, Gaussian, sigmoidal, etc. [23], can be employed to express the degree of membership. In figure 1, we opted for the triangular function to depict the association function. A three-sided fuzzy number is indicated  $\rho = (a_1, a_2, a_3)$ .



**Figure 1: Triangular membership function**

So, the triangular membership function

$$\mu_{\rho}(x) = \begin{cases} \frac{x - Q_1}{Q_2 - Q_1} & \text{if } Q_1 \leq x < Q_2 \\ \frac{Q_2 - x}{Q_3 - Q_2} & \text{if } Q_2 \leq x \leq Q_3 \end{cases}$$

**III. A MATHEMATICAL APPROACH FOR RANKING THE SCHEDULING ALGORITHMS USING FTOPSIS APPROACH.**

**Step 1:** Formulate the fuzzy decision matrix (FDM) P with  $\alpha$  number of alternative ( $\alpha_1, \alpha_2, \alpha_3, \dots \dots \alpha_n$ ) and  $\delta$  number of criteria ( $\delta_1, \delta_2, \delta_3, \dots \dots \delta_n$ ) and assign the fuzzy rating to alternatives with relation of criteria.

$$P = \alpha_1 \alpha_2 \alpha_3 \vdots \vdots \alpha_n \{ \delta_1 P_{11} P_{21} \vdots \vdots P_{b1} \delta_2 P_{12} P_{22} \vdots$$

Where  $p_{ij}$  represents the performance or evaluation score of alternatives with respect to criteria. Table 1 displays the assigned ratings of alternatives and weights, represented in linguistics terms.

**Table 1: Rating of alternatives and weights**

Fuzzy Number	Alternative Assessment	Weights
(1,2,3)	Very low (VL)	Very poor (VP)
(1,3,5)	Low (L)	Poor (P)
(3,5,7)	Average (AV)	Fair (F)
(5,7,9)	High (H)	Good (G)
(7,8,9)	Very high (VH)	Very good (VG)

**Step 2:** Utilizing ideal linguistics terms, we represent the evaluation score and convert it into triangular fuzzy numbers (TFN). The application of TFN is then implemented for the alternatives in the FDM.

**Table-2 evaluation score in triangular fuzzy numbers**

	$\delta_1$	$\delta_2$	$\delta_3$	$\delta_4$
$\alpha_1$	7,8,9	3,5,7	1,3,5	7,8,9
$\alpha_2$	1,3,5	1,2,3	9,7,5	1,2,3
$\alpha_3$	1,3,5	7,8,9	5,7,9	1,3,5
$\alpha_4$	3,5,7	1,3,5	1,3,5	3,5,7
$\alpha_5$	5,7,9	1,2,3	7,8,9	3,5,7

The conversion of linguistic terms into Triangular Fuzzy Numbers (TFN) is illustrated in Table 2.

**Step 3:** Normalize the fuzzy decision matrix P to eliminate the impact of varying units of measurements using the normalization process.

$$\tilde{m}_{ij} = \left[ \frac{p_{ij}}{\partial_j^*}, \frac{q_{ij}}{\partial_j^*}, \frac{r_{ij}}{\partial_j^*} \right] \text{ and } \partial_j^* = \max_i \{r_{ij}\} \text{ (benefit criteria)}$$

$$\tilde{m}_{ij} = \left[ \frac{\bar{p}_j}{r_{ij}}, \frac{\bar{p}_j}{q_{ij}}, \frac{\bar{p}_j}{p_{ij}} \right] \text{ and } \bar{p}_j = \min\{p_{ij}\} \text{ (cost criteria)}$$

Where  $i = 1,2 \dots \dots m$  and  $j = 1,2 \dots \dots n$ .

**Step 4:** Assign weights ( $w$ ) to each criterion to denote their relative importance and calculate the weighted normalize FDM by multiplying with the assigned weights.

$$\omega' = (\omega'_{ij}) \text{ where } \omega'_{ij} = \tilde{m}_{ij} \times \bar{w}_j$$

$$\zeta_1 \otimes \zeta_2 = (\eta_1, \vartheta_1, \kappa_1) \otimes (\eta_2, \vartheta_2, \kappa_2) = (\eta_1 * \eta_2, \vartheta_1 * \vartheta_2, \kappa_1 * \kappa_2)$$

**Step 5:** Compute the 'fuzzy positive ideal solution (FPIS)' and the 'fuzzy negative ideal solution (FNIS).'

$$A^+ = \{\omega_1^+, \omega_2^+, \omega_3^+ \dots \dots, \omega_n^+\}$$

Where  $\omega_j^+ = \max_i (\omega_{ij3})$  for benefit type

$$A^- = \{\omega_1^-, \omega_2^-, \omega_3^- \dots \dots, \omega_n^-\}$$

Where  $\omega_j^- = \min_i (\omega_{ij1})$  for cost type

**Step 6:** Assess the distance from each individual alternative to both the FPIS and FNIS by applying the appropriate method.

$$D(\tilde{x}, \tilde{y}) = \sqrt{1/3 \{ (\tilde{a}_1 - \tilde{a}_2)^2 + (\tilde{b}_1 - \tilde{b}_2)^2 + (\tilde{c}_1 - \tilde{c}_2)^2 \}}$$

$$D(x, y) = \sqrt{1/3 \{ (a_1 - a_2)^2 + (b_1 - b_2)^2 + (c_1 - c_2)^2 \}}$$

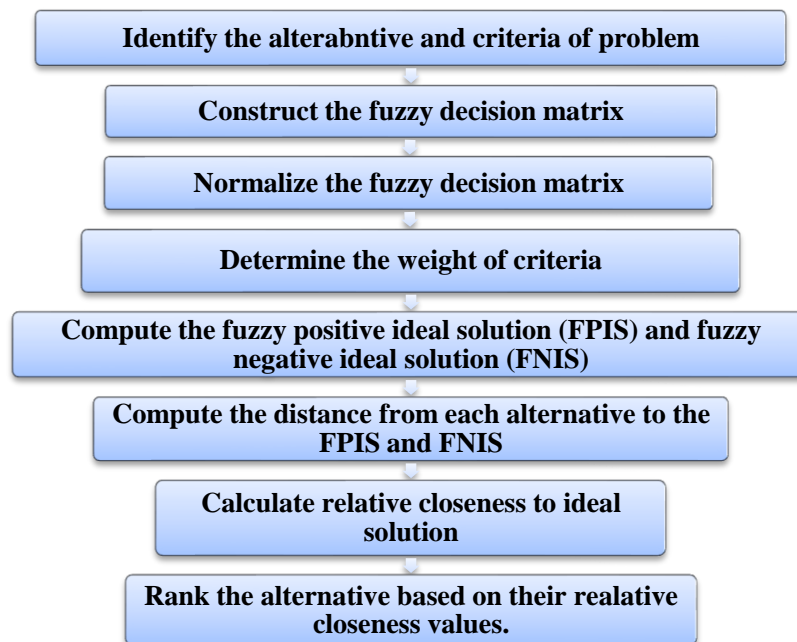
**Step 7:** Compute the proximity of each alternative to the ideal solution using the appropriate method.

$$R_i = \frac{d_i^-}{d_i^+ + d_i^-}$$

**Step 8:** Assign ranks to the alternatives based on their relative closeness values.

#### IV. ARCHITECTURAL DIAGRAM FOR SCHEDULING ALGORITHM SELECTION USING FUZZY TOPSIS

The operational design of the proposed method is depicted in Figure 2.



**Figure. 2** Architectural diagram of planned approach

### 5.0 Numerical computation

Consider the scenario of the short-term scheduler faced with the challenge of selecting a scheduling algorithm from numerous options available for the process scheduling task. Despite the variety of scheduling algorithms, making the right choice becomes a complex task for the short-term scheduler. To overcome this challenge, we employ the fuzzy TOPSIS method within the realm of Multi-Criteria Decision Making (MCDM). The fuzzy TOPSIS approach involves evaluating algorithms based on predefined principles for the substitutes. Semantic terms such as VL, L, AV, H, and VH are utilized within the FDM, accompanied by a rating scale of 1 to 9 for assessing the criteria. The fuzzy TOPSIS method adeptly addresses this problem through a systematic series of steps.

**Step 1:** Identify the alternatives, including FCFS, SJF, Priority Scheduling, RR, and MLFQ, along with the criteria ART, ATAT, AWT, and Throughput for the scheduling algorithm selection problem. Formulate the decision matrix

based on these alternatives and criteria. Assign ratings to the alternatives according to the specified criteria. Table 3 illustrates the FDM after incorporating the assigned ratings.

**Table 3: FDM in linguistic term**

	ART	ATAT	AWT	Throughput
<b>FCFS</b>	VH	AV	L	VH
<b>SJF</b>	L	VL	H	VL
<b>Priority Scheduling</b>	L	VH	H	L
<b>RR</b>	AV	L	L	AV
<b>MLFQ</b>	H	VL	VH	AV

**Step 2:** Fuzzify the five-point scale using a triangular membership function, transforming each linguistic term into a fuzzy number. Table 4 illustrates the fuzzy decision matrix with fuzzy numbers.

**Table 4: Fuzzy decision matrix in term of fuzzy number**

	ART	ATAT	AWT	Throughput
<b>FCFS</b>	7,8,9(VH)	3,5,7(AV)	1,3,5( L)	7,8,9(VH)
<b>SJF</b>	1,3,5( L)	1,2,3(VL)	5,7,9(H)	1,2,3(VL)
<b>Priority scheduling</b>	1,3,5( L)	7,8,9(VH)	5,7,9(H)	1,3,5( L)
<b>RR</b>	3,5,7(AV)	1,3,5( L)	1,3,5( L)	3,5,7(AV)
<b>MLFQ</b>	5,7,9(H)	1,2,3(VL)	7,8,9(VH)	3,5,7(AV)

**Step 3:** Our objective is to minimize the criteria ART, ATAT, and AWT (considered as cost criteria) while maximizing the criterion Throughput (viewed as a benefit criterion) through the normalization of the choice table. All decisive factors contribute to the identical overarching goal. Table 5 depicts the fuzzy normalized verdict format.

In Table 6, observe the ranges of normalized Triangular Fuzzy Numbers (TFN) falling within the interval (0, 1).

**Table 5: Fuzzy normalized decision matrix**

	ART	ATAT	AWT	Throughput
<b>SJF</b>	1/9,1/8,1/7	1/3,1/5,1/7	1/5,1/3,1/1	7/9,8/9,9/9
<b>Priority scheduling</b>	1/5,1/3,1/1	1/3,1/2,1/1	1/9,1/7,1/5	1/9,2/9,3/9
<b>RR</b>	1/5,1/3,1/1	1/7,1/8,1/9	1/9,1/7,1/5	1/9,3/9,5/9
<b>MLFQ</b>	1/3,1/5,1/7	1/1,1/3,1/5	1/1,1/3,1/5	3/9,5/9,7/9

**Table 6: Fuzzy normalized decision matrix**

	ART	ATAT	AWT	Throughput
<b>FCFS</b>	0.11,0.12,0.14	0.14,0.2,0.33	1,0.33,0.2	0.77,0.88,1
<b>SJF</b>	0.2,0.33,1	0.33,0.5,1	0.11,0.14,0.2	0.11,0.22,0.33
<b>Priority scheduling</b>	0.2,0.33,1	0.11,0.12,0.14	0.11,0.14,0.2	0.11,0.33,0.55
<b>RR</b>	0.14,0.2,0.33	0.2,0.33,1	0.2,0.33,1	0.33,0.55,0.77
<b>MLFQ</b>	0.11,0.14,0.2	0.33,0.5,1	0.11,0.12,0.14	0.33,0.55,0.77

**Step 4:** Linguistic terms are employed to express the evaluation scores of weights and are transformed into fuzzy numbers in Table 7. The assignment of weights is then carried out.

**Table 7: Fuzzy number for weights**

Fuzzy Number	Weights
(1,2,3)	VP
(1,3,5)	P
(3,5,7)	F
(5,7,9)	G
(7,8,9)	VG

( $w_1 = 1,2,3$   $w_2 = 3,5,7$   $w_3 = 5,7,9$  and  $w_4 = 1,3,5$ )Distribute weights to the reasons and determine the prejudiced fuzzy regulated decision conditions by multiplying it with the assigned weights. Table 8 illustrates the resulting weighted fuzzy normalized decision matrix.

**Table 8: Weighted fuzzy normalized decision matrix.**

Weights	ART $\bar{w}_4 = 1, 2, 3$	ATAT $\bar{w}_4 = 1, 2, 3$	AWT $\bar{w}_4 = 1, 2, 3$	Throughput $\bar{w}_4 = 1, 2, 3$
<b>FCFS</b>	0.11,0.24,0.42	0.42,1,2.31	5,2.31,1.8	0.77,2.64,5
<b>SJF</b>	0.2,0.66,3	0.99,2.5,7	0.55,0.98,1.8	0.11,0.66,1.65
<b>Priority scheduling</b>	0.2,0.66,3	0.33,0.6,0.98	0.55,0.98,1.8	0.11,0.99,2.75
<b>RR</b>	0.14,0.4,0.99	0.6,1.65,7	1,2.31,9	0.33,1.65,3.85
<b>MLFQ</b>	0.11,0.28,0.6	0.99,2.5,7	0.55,0.84,1.26	0.33,1.65,3.85

$$v_1^+ = 0.2,0.66,3 \quad v_2^+ = 0.99, 2.5,7$$

$$v_3^+ = 0.5,2.31,9 \quad v_4^+ = 0.77, 2.64,5$$

$$v_1^- = 0.11,0.24,0.42 \quad v_2^- = 0.33,0.6,0.98$$

$$v_3^- = 0.55,0.84,1.26 \quad v_4^- = 0.11,0.66,1.65$$

So the  $A^+ =$

**Step 5:** Compute the FPIS and FNIS.

$$\{(0.2,0.66,3), (0.99,2.5,7), (0.5,2.31,9), (0.77,2.64,5)\}$$

and

$$A^- = \{(0.11,0.24,0.42), (0.33,0.6,0.98), (0.55,0.84,1.26)$$

**Step 6:** Now calculate the distance ( $d_i^+$ ) calculate the distances from each alternative to the FPIS and FNIS, resulting in the distance matrix from the FPIS in table 9 and the distance matrix from the FNIS in table 10.

**Table 9: Calculated  $d_i^+$  from FPIS.**

	ART	ATAT	AWT	Throughput	$d_i^+$ $\left\{ \sum_{j=1}^n d(v_{ij}, v_j^+) \right\}$
<b>FCFS</b>	1.52	2.7	4.5	0	8.72
<b>SJF</b>	0	0	4.9	2.2	7.1
<b>Priority scheduling</b>	0	3.6	4.9	2.8	11.3
<b>RR</b>	1.17	0.54	2.3	0.91	4.92
<b>MLFQ</b>	1.4	0	5.2	0.91	7.51



**Table 10: Calculated  $d_i^-$  from FNIS.**

	ART	ATAT	AWT	Throughput	$d_i^-$ $\left\{ \sum_{j=1}^n d(v_{ij}, v_j^-) \right\}$
<b>FCFS</b>	0	0.8	2.7	2.3	5.8
<b>SJF</b>	1.5	3.6	0.3	0	5.4
<b>Priority scheduling</b>	1.5	0	0.3	0.66	2.46
<b>RR</b>	0.35	0.17	4.5	1.4	6.42
<b>MIFQ</b>	0.1	3.6	0	1.4	5.1

**Step 7:** Determine the relative closeness ( $R_i$ ) of each alternative to the ideal solution.

Evaluate the proximity of each alternative to the ideal solution.

$$R_1 = \frac{5.8}{5.8 + 8.72} = 0.39$$

$$R_2 = \frac{5.4}{5.4 + 7.1} = 0.43$$

$$R_3 = \frac{2.46}{2.46 + 11.3} = 0.18$$

$$R_4 = \frac{6.42}{6.42 + 4.92} = \mathbf{0.56}$$

$$R_5 = \frac{5.1}{5.1 + 7.51} = 0.4$$

**Step 8:** Assign ranks to the alternatives based on their relative closeness values.

**Table 11: All alternatives with rank**

	$d_i^+$	$d_i^-$	$R_i$	Rank
<b>FCFS</b>	8.72	5.8	0.39	4
<b>SJF</b>	7.1	5.4	0.43	2
<b>Priority Scheduling</b>	11.3	2.46	0.18	5
<b>RR</b>	4.92	6.42	<b>0.56</b>	<b>1</b>
<b>MLFQ</b>	7.51	5.1	0.4	3

The rankings presented in Table 11 clearly indicate that the rank of RR is notably superior in comparison to FCFS, SJF, Priority Scheduling, and MLFQ scheduling algorithms. As a result, it is highly beneficial for the scheduler to opt for the algorithm with a superior rank, such as RR, to ensure the efficient completing of progressions/chores on the CPU.

## V. CONCLUSION AND FUTURE WORK.

"The decision of choosing a organizing procedure presents a Multi-Criteria Decision Making (MCDM) challenge, involving a combination of quantitative and qualitative considerations. In this algorithmic context, we present an MCDM approach for scheduling algorithm selection in a fuzzy environment. Utilizing a mathematical framework, we employ the Fuzzy TOPSIS method to rank scheduling algorithms, significantly reducing the effort required for short-term scheduler algorithm selection. Optimal algorithm selection by the scheduler leads to enhanced system performance and a reduction in delaying time, reaction time, and environment turning for processes. Fuzzy theory

serves as a suitable tool for addressing uncertainties and complex environments. "The utilization of the extension of fuzzy set theory in the suggested method paves the way for novel possibilities. In future research, the exploration of the neutrosophic environment [24] as an alternative to the fuzzy set environment could be considered.

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