

# Comparison in Quality of service Performance For Wireless Sensor Network Routing between Fuzzy Topsis and SAW Algorithm

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**Abstract** – one of the advantages of Wireless Sensor Network would be its ability to reduce cost of communication system using node to node communication. Because of many things data transfer is Wireless Sensor Network operation sometimes has disturbance. A routing algorithm is a network coding that intends to enhance network performance for better operation with or without any disturbance. Fuzzy TOPSIS and SAW as MCDM algorithm is proposed for routing algorithm in Wireless Sensor Network operation. From our simulation both SAW and Fuzzy Topsis algorithm can be used in network coding (routing) to provide better QOS for Wireless Sensor Network compare with shortest path routing. For delay it perform better at about 2/3 (shortest path routing 50 millisecond, both SAW and Fuzzy Topsis algorithm 33 millisecond), and for packet loss at about 3/4 (shortest path routing 21 bit loss, both SAW and Fuzzy Topsis algorithm 16 bit loss). From our simulation both SAW and Fuzzy Topsis algorithm has benefit which is lower delay and packet loss but at higher cost which is more hopping for communication channel (shortest path routing 3 hopping, both SAW and Fuzzy Topsis algorithm 5 hopping)..

**Kata Kunci** – Wireless Sensor Network, routing, Fuzzy TOPSIS, SAW, MCDM, algorithm.

## I. INTRODUCTION

According to ITU-T WSN (Wireless Sensor Network) is classified as a next generation network in 2010 [1]. WSN is a network that contain interconnected sensor nodes that exchanging sensed data using wireless technologies such as LoRa [2], zigbee [3], and others [4]. WSN can reduce the infrastructure cost by using node to node communication, therefore it can be used whether in the forest or in the cities. Even though WSN advantages has proved to be cost saving in terms of wireless infrastructure[5], WSN also has disadvantage. One of WSN disadvantages such as limited energy [6] and data transmission disturbance (interference [5], delay [7], packet loss[8], and other [9]).

In order to minimize drop in quality of service in WSN a routing algorithm is employ. Those routing algorithms has been specified to manage the wireless sensor network routing with their unique problem such as energy node in WSN [10], [11], Location based routing [12], shortest path [13], clustering [14]and QOS [15]. Routing algorithms is behavior of a network, that show how nodes should be communicate

between each other's. Routing algorithms also has purposes to delivers observation data using point to point node communication, from the farthest node to the closer node with base station with minimize error.

Even though the simple way to deliver observation data is using a shortest path routing, however this shouldn't enough to prevent packet loss and others problem. Even though sometime this shortest path also using algorithm such as Dijkstra's algorithm or Bellman-Ford algorithm [13] but still it's not enough. we also need to maintain the quality of service of the wireless data communication in wireless sensor network. in this paper we investigate comparison performance in dynamic routing for WSN operation using MCDM (multi criteria decision making) algorithm based. using this algorithm our purposes to enhance quality of service wireless data communication in WSN network.

## II. METHODS

In this paper we presented 2 MCDM based algorithm for routing problem in WSN network. The first algorithm would be Fuzzy TOPSIS and the second algorithm would be SAW.

### A. SAW Algorithm

Simple Additive Weighting (SAW) is also known as the addition weighted method. The concept of the SAW algorithm is seeing for all weighted sum on each alternative on all attributes. SAW method was developed by Fishburn to show arranged product sets using priority orderings and assignments [16]. The SAW algorithm steps were shown from Equation 1 to 3 and flowchart on figure 1.

### Normalize Criteria Matrix

The weighted Criteria Matrix of every alternative of all attributes which is  $N_{ij}$ . Normalization needs to be done so that it can be compared all criteria.

$$r_{ij} = \begin{cases} \left( \frac{N_{ij}}{\max N_{ij}} \right) | \in \text{Benefit} \\ \left( \frac{N_{ij}}{\max N_{ij}} \right) | \in \text{Cost} \end{cases} \quad (1)$$

Where  $r$  = Normalize weighted number of alternatives,  $i=1,2,\dots,m$ , and  $j=1,2,\dots,n$

### Preference Criteria Matrix

Preference for each alternative was given by:

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$$\sum_{j=1}^n w_j a_{ij} \tag{2}$$

Where W = Preference of alternatives,  $\alpha$  = criteria Preference alternatives of  $i=1,2,\dots,m$  and  $j=1,2,\dots,n$

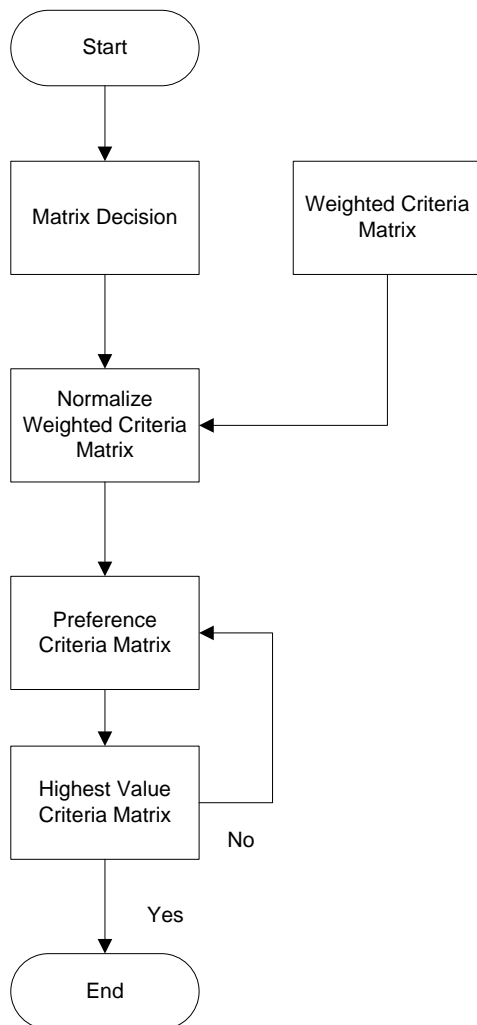


Fig. 1. SAW flowchart algorithm

**B. Fuzzy TOPSIS Algorithm**

A fuzzy concept was developed by Zadeh in 1965 [11], [12]. It was invented to solve real-world problems using approximate reasoning from precise and not precise like human thought. In modern day more complex and new problems arise, and so is the fuzzy. Until now a new fuzzy algorithm is born to model real-world problems and solve it. To solve routing problems which are very MCDM problems, Fuzzy Topsis is employed because it can choose the best ideal node alternative and worst node alternative. The chosen node would be one of the nodes that has the best score. The fuzzy algorithm steps were shown in a flowchart on figure 2 and from Equation 4 to 10.

**Normalize Matrix Decision**

For every criterion, the normalization needs to be done. This step was to limit the criterion between 0 and to 1 [21].

$$r_{ij} = \frac{x_{ij}}{\sqrt{\sum_{i=1}^m x_{ij}^2}} \tag{3}$$

Where r = Normalize number of alternatives, x = number of alternatives,  $i=1,2,\dots,m$  and  $j=1,2,\dots,n$

**Weighted Normalize Matrix Decision**

The normalized matrix needs to be weighted. This weight was to show the criteria that had the most impact value for the system. The weighted Criteria Matrix can be expressed below.

$$N_{ij} = r_{ij} \cdot w_{ij} \tag{4}$$

Where N = Weighted Normalize number of alternatives, r = Normalize number of alternatives,  $i=1,2,\dots,m$  and  $j=1,2,\dots,n$

**For Positive Ideal Solution**

The Weight of the normalized matrix decision can be shown as a positive ideal solution as shown in Equation (5).

$$A_b = \left\{ \begin{matrix} (\min(t_{ij} | i = 1, 2, \dots, m) | j \in J^-) \\ (\max(t_{ij} | i = 1, 2, \dots, m) | j \in J^+) \end{matrix} \right\} \{t_{bj} | j = 1, 2, \dots, n\} \tag{5}$$

Where  $A_b$  = best Ideal Solution alternatives,  $J^+ = \{j=1,2,\dots,n | j\}$  criteria that having a positive impact.

**For Negative Ideal Solution**

The Weight of the normalized matrix decision can be shown as a negative ideal solution as shown in Equation (6).

$$A_w = \left\{ \begin{matrix} (\max(t_{ij} | i = 1, 2, \dots, m) | j \in J^-) \\ (\min(t_{ij} | i = 1, 2, \dots, m) | j \in J^+) \end{matrix} \right\} \{t_{wj} | j = 1, 2, \dots, n\} \tag{6}$$

Where  $A_w$  = Worst Ideal Solution alternatives,  $J^- = \{j=1,2,\dots,n | j\}$  criteria that having a negative impact

**Distance for Positive Ideal Solution**

The alternative was the nearest with the best is:

$$d_{ib} = \sqrt{\sum_{j=1}^n (t_{ij} - t_{bj})^2} \tag{7}$$

Where,  $d_{ib}$  = distance to the best Ideal Solution alternatives,  $i = 1,2,\dots,m$

**Distance for Negative Ideal Solution**

The alternative was the nearest with the best

$$d_{iw} = \sqrt{\sum_{j=1}^n (t_{ij} - t_{wj})^2} \tag{8}$$

Where,  $d_{iw}$  = distance to the worst Ideal Solution alternatives,  $i = 1,2,\dots,m$

**Closeness Coefficient**

With the best alternative distance and the worst alternative distance, closeness coefficient can be calculated to show the best of the performance of the node alternative, as expressed below:

$$CC^* = \frac{d_{iw}}{d_{iw} + d_{ib}}, 0 \leq C_i^* \leq 1 \tag{9}$$

Where, CC = Closeness Coefficients of alternatives,  $i = 1,2,\dots,n$

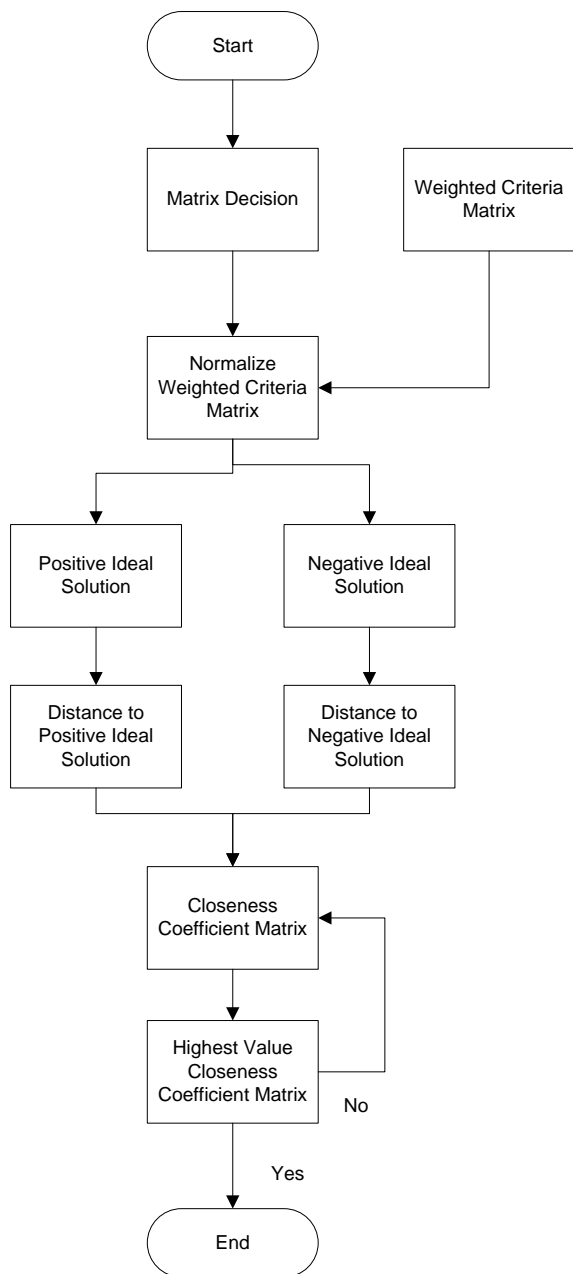


Fig. 2. Fuzzy topsis flowchart algorithm

### III. SIMULATION

In this simulation we do will do twice simulation using each respective algorithm. The simulations contain 3x4 WSN nodes, with QOS parameter such as delay (millisecond), packet loss (bit), and hop quantity. The QOS parameter value will be add randomly for a random WSN node. Figure 3 show WSN node simulation configuration.



Fig. 3. 3x4 WSN nodes, with random delay and packet loss  
Fig. 4.

For weighted value will be given at fixed value on table 1.

TABLE I  
WEIGHTED VALUE FOR EACH CRITERIA

Item	Delay	Packet Loss	Hop Quantity
Weighted Value	3	2	1

#### A. SAW Algorithm

Using SAW algorithm step by step routing from node K to node B QOS is show using table 2 to table 7:

#### Step 1

Node K has 3 neighbor nodes, and one of those nodes will be the next communication node (see figure 3), therefore the decision matrix will be:

TABLE III  
SAW ALGORITHM STEP 1

Routing Channel	Delay	Packet Loss	Hop Quantity
Node J	0.46	0.8	0.5
Node L	3	2	0.5
Node H	0.3	0.5	1

Using equation 1 until equation 2, we can find the next node automatically. Node L was selected because summation has the higher score.

TABLE IIIII  
SAW SELECTED NODAL

Routing Channel	Decision Score
Node J	1.7615385
Node L	5.5
Node H	1.8

#### Step 2

Node L has only 1 neighbor nodes which is node I, and thus it will selected automatically (no need SAW algorithm)

**Step 3**

Node I has 2 neighbor nodes, and one of those node will be the next node, therefore the decision matrix will be:

TABLE IVV  
SAW ALGORITHM STEP 3

Routing Channel	Delay	Packet Loss	Hop Quantity
Node F	2.86	1	1
Node H	3	0.75	1

Using equation 1 until equation 2, we can find the next node automatically. Node F was selected because summation has the higher score.

TABLE V  
SAW SELECTED NODAL

Routing Channel	Decision Score
Node F	4.8571429
Node H	4.75

**Step 4**

Node F has 2 neighbor nodes which is C and E, and one of those nodes will be the next communication node, therefore the decision matrix will be:

TABLE VV  
SAW ALGORITHM STEP 4

Routing Channel	Delay	Packet Loss	Hop Quantity
Node C	3	2	1
Node E	0.35	0.2222222	1

Using equation 1 until equation 2, we can find the next node automatically. Node C was selected because summation has the higher score.

TABLE VII  
SAW SELECTED NODAL

Routing Channel	Decision Score
Node C	6
Node E	1.5683761

**Step 5**

Node C has only 1 neighbor nodes which are Node B, and thus it will select automatically (no need SAW algorithm).

*B. Fuzzy TOPSIS Algorithm*

Using Fuzzy Topsis algorithm step by step routing from node K to node B QOS is show using table 8 to table 13:

**Step 1**

Node K has 3 neighbor nodes, and one of those nodes will be the next communication node (see figure 3), therefore the decision matrix will be:

TABLE VIII  
TOPSIS ALGORITHM STEP 1

Routing Channel	Delay	Packet Loss	Hop Quantity
Node H	20	8	3
Node J	13	5	5
Node L	2	2	5

Using equation 3 until equation 9, we can find the next node automatically. Node L was selected because closeness coefficient has the higher score.

TABLE IX  
CLOSENESS COEFFICIENT STEP 1, SELECTED NODAL

Routing Channel	Closeness Coefficient
Node H	0.54388548
Node I	0.67574319
Node L	0.96505298

**Step 2**

Node L has only 1 neighbor nodes which is node I, and thus it will selected automatically (no need Fuzzy Topsis algorithm)

**Step 3**

Node I has 2 neighbor nodes which is H and F, and one of those nodes will be the next communication node, therefore the decision matrix will be:

TABLE X  
TOPSIS ALGORITHM STEP 3

Routing Channel	Delay	Packet Loss	Hop Quantity
Node H	20	8	3
Node F	21	6	3

Using equation 3 until equation 9, we can find the next node automatically. Node F was selected because closeness coefficient has the higher score.

TABLE XI  
CLOSENESS COEFFICIENT STEP 3, SELECTED NODAL

Routing Channel	Closeness Coefficient
Node H	0.43767161
Node F	0.50000000

**Step 4**

Node F has 2 neighbor nodes which is E and C, and one of those node will be the next communication node, therefore the decision matrix will be:

TABLE XII  
TOPSIS ALGORITHM STEP 4

Routing Channel	Delay	Packet Loss	Hop Quantity
Node E	26	9	1
Node C	3	1	1

Using equation 3 until equation 9, we can find the next node automatically. Node C was selected because closeness coefficient has the higher score.

TABLE XIII  
CLOSENESS COEFFICIENT STEP 4, SELECTED NODAL

Routing Channel	Closeness Coefficient
Node E	0.45089278
Node C	0.50000000

**Step 5**

For node C has only 1 neighbor nodes which are Node B, and thus it will select automatically (no need Fuzzy Topsis algorithm).

**IV. RESULT & DISCUSSION**

Using table 2 until table 7 for SAW algorithm and table 8 until table 14 we can summarize both algorithm against shortest path routing. Table 14 show SAW and fuzzy topsis algorithm versus shortest path routing.

TABLE XIV  
SHORTEST PATH, FUZZY TOPSIS, AND SAW SUMMARY

Parameter	Shortest Path	Fuzzy TOPSIS	SAW
Delay	50	33	33
Packet Loss	21	16	16
Hop Quantity	3	5	5

MCDM algorithm based such as fuzzy topsis and SAW algorithm can perform well for routing in WSN application. Both of them would take 5 hops to finish sending data from node K to node B and resulting in lower delay 33millisecond and packet loss 16 bit. This result show SAW and fuzzy topsis algorithm both of them has same identic performance in WSN routing application.

**V. CONCLUSION**

In this paper we compare performance of fuzzy TOPSIS and SAW algorithm to be used as routing algorithm in Wireless Sensor Network. From our simulation both SAW and Fuzzy Topsis algorithm can be used in network coding (routing) to provide better QOS for Wireless Sensor Network compare with shortest path routing. For delay it perform better at about 2/3 (shortest path routing 50 millisecond, both SAW and Fuzzy Topsis algorithm 33 millisecond), and for packet loss at about 3/4 (shortest path routing 21 bit loss, both SAW and Fuzzy Topsis algorithm 16 bit loss). From our simulation both SAW and Fuzzy Topsis algorithm has benefit which is lower delay and packet loss but at higher cost which is more hopping for communication channel (shortest path routing 3 hopping, both SAW and Fuzzy Topsis algorithm 5 hopping).

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