

## FUZZY BASED TRUST INDEX CALCULATION SYSTEM FOR WIRELESS SENSOR NETWORKS

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**ABSTRACT.** The Wireless Sensor Networks (WSN) comprises of countless transfer hubs that gather the ecological data from the sensor hub and send them to a sink or (cluster head) CH. The improvement of communication advancements has propelled the utilization of WSNs and the remote communication. Since WSNs turned out to be progressively main stream, the nature of service extend by the WSN in the part of information collection, maintaining accuracy and transmission in a convenient way has caused more to notice the research framework of network system designers. However, the hubs are inclined to failure because of the vitality limitation, device failure, communication link error and malicious attack. The node insufficiency is the one of the most vital issue in the WSN. The proposed TIC calculation using fuzzy logic discovers the trust score for reinforcement hand-off hub task to defeat the issue in establishing the network.

### 1. INTRODUCTION

Trust index computation models are significant in wireless sensor systems to guarantee the security and genuineness. The trust model structured using non-linear estimator is versatile and fault tolerant against information loss [1]-[5]. A hand-off hub is more dominant than a sensor hub as far as energy storage, computing and communication ability. It can extract valuable data

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and expel repetition in information in data packets assembled from sensor hubs in its cluster. As of late the few calculations are proposed for hand-off hub placement [6]- [9]. The fundamental aim is to amplify the system lifetime [10]- [14]. The target of this proposed work is to foresee the failure and to establish the reinforced backup relay node. The proposed Fuzzy based Trust Index Calculation (FTIC) algorithm is used for achieving high accuracy in decision making. The proposed fault tolerance fuzzy based relay node placement algorithm, meeting the design goal such as cost effectiveness, fault tolerance, coverage, connectivity and prolonged lifetime. The contribution of proposed work is summarized as the follows:

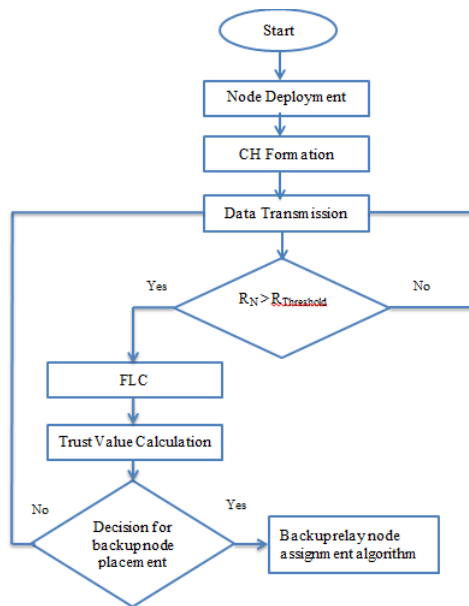
- The proposed work has been designed to implement a novel mechanism called backup relay node assignment or placement for which the decision is derived from Fuzzy Logic Controller (FLC).
- The fuzzy logic rule base is designed from the given input parameters to predict the failures and to assign a backup relay node in beforehand.
- The proposed algorithm calculates the trust score or value for the nodes using FLC.

## 2. THE PROPOSED SYSTEM

The proposed algorithm is distributed fuzzy based algorithm. Every CH has the fuzzy logic controller engine to decide on backup relay node placement. Since every CHs are involved in decision making it is a distributed algorithm.

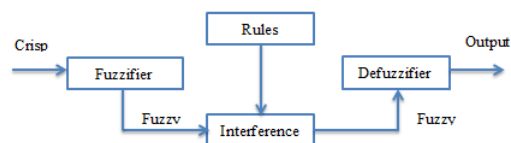
- A. Fuzzy Logic System The proposed FTIC algorithm calculates the trust value of each node based on four input parameters like Frequent Path (FP), Data Aggregation Rate (Dr), Connectivity (C), Residual Energy(Er). The trust index is calculated for each node on regular intervals. First time on threshold round  $R_n$  which is calculated as mean lifetime of the network. Each node is monitored for this four parameters which is denoted by  $N(FP, Dr, C, Er)$ . The architecture of the general FLC is shown in the Figure 1. The proposed algorithm is given in Figure 3. The main aspect of Fuzzification step is to find the crisp inputs to fuzzy sets through the membership function. The inputs are given into the fuzzy logic engine. The Figure 2 depicts the general architecture of

fuzzy logic controller and various modules in it. The fuzzy rules are expressing the knowledge of the system or propositions containing linguistic variables. It is applied to the fuzzified input and then the output is determined by how much degree of belongingness to the rule. From the fuzzy rule the probability value of the output variable is derived. The higher probability value then the node has more chance to place the backup relay node. The probabilities of fuzzy output variable are converted in to a single crisp output. It is the way toward creating a quantifiable outcome in fuzzy logic by its corresponding membership degrees.



1.png

Figure 1. Flow chart of the proposed Fuzzy based Trust Index Calculation (FTIC) method.



2.png

Figure 2. Architecture of Fuzzy Framework.

### 3. FUZZY BASED TRUST INDEX CALCULATION

In a system, a hub is an association point, either a redistribution point or an end point for information transmissions. In general, a hub has modified process or advance transmissions to different hubs. The hubs are deployed randomly in a network.

#### A. Broadcast message

Broadcasting refers to a technique of moving a message to all beneficiaries all the while. Broadcasting can be preceded as a significance level activity in a program, such as broadcasting utilizing Message Passing Interface, or it might be a low level networking activity, such as communication on Ethernet. The neighbour hubs inside the transmission range can get the message.

#### B. Cluster Head Selection and Cluster Information

The cluster-based remote sensor network can upgrade the entire network system's life time. In each cluster, the CH assumes the significant job in collecting and sending information detected by other common hubs. A significant test is the WSN to find the appropriate CH selection. In the first cycle the CH can be randomly selected. Next cycle onwards the CH can be selected based upon their residual energy value. After that inform their cluster members I am the CH. Then the cluster information forwarded to BS. Figure 3 shows the steps involved in the CH selection, initially it randomly selects the CH called T1, the T1 sends broad cast message to other nodes I am CH. On second round onwards it checks the residual energy for each node. If the node having high residual energy, that node has more chance to become CH called T2. Otherwise, it act as dummy.

#### C. Input Parameters

After initializing the CH find the frequent item set. Each data collection round is considered as the transaction. The node participating in each round is denoted as 1 and if it is not participating in the round it will denoted as 0. The CH has the information about frequent item set (discussed in chapter 3), through which node has frequently participated in each transaction can be identified.

#### D. Proposed FTIC Architecture

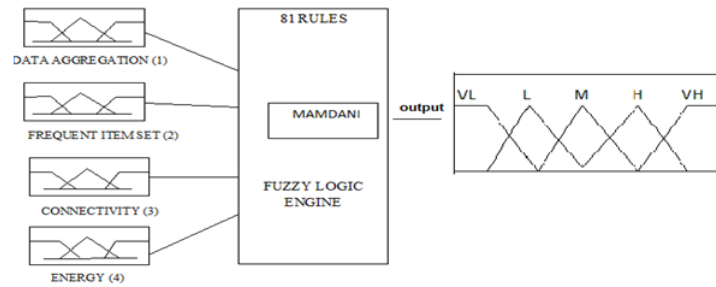
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STEP1: start T1, expires in rand(0,τ ) //timer, expires in
round 1
start T2, expires in rand(τ,2τ ) //timer, expires in round 2
announFirst = (rand(0,1) ≤ γ) CHID = -1 // ID of the cluster
head of the node
while T1 NOT expired do
if receive ENC(announcement) AND (CHID = -1) then
CHID = ID of sender of announcement
end if
end while
// T1 expired
STEP 2 : CHs checks the threshold energy for each round
If (EResidual < EThreshold)
while T2 if receive ENC(announcement) AND (CHID = -1)
then
CHID = ID of sender of announcement
end if
end while
// T2 expired if (NOT announce First) AND (CHID = -1)
then
broadcast ENC(announcement);
CHID = ID of node itself;
else broadcast ENC(dummy);
end
end

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3.png

Figure 3. Cluster Head Selection Algorithm.



4.png

Figure 4. Proposed Fuzzy Logic Controller.

The Figure 4 shows proposed fuzzy logic controller, input variable of the fuzzy set such as, data aggregation, frequency item set, and residual energy and node connectivity degree, the number of nodes connected or the in degree of the nodes. Since there are 4 input parameters with three linguistic variables for all the four parameters ( $3 \times 3 \times 3 \times 3$ ) is 81 rules. The input parameters are given in the Table 1 .Frequently used nodes are determined using Apriori algorithm.The Input membership functions can be triangular, trapezoidal, bell shaped, only increasing, only decreasing. In our fuzzy logic controller trapezoidal and triangular membership function is used. The input membership function

ranges and values are determined from curves. The output is formed based on the input parameters and the rules of the FLC. Table 1 shows, input variable of the fuzzy set such as, data aggregation, frequency item set, and energy is the linguistic factors of the fuzzy set. The high and low linguistic factors have trapezoidal association with the triangular membership activity.

#### E. Trust value calculation

The normalization of the input parameters is done through multiplying the input with weights. Consider nodes = 1000, and their Initial Range Energy is 1, Frequent item set  $\Rightarrow$  support  $(x \cup y) / \text{support}(X)$ ,  $n_1, n_2 = 99/150 = 0.66$ . Data aggregation rate  $\Rightarrow \text{AVG}_{\text{sink}}() = N_1(\text{DATA}) \Rightarrow 99/1000 = 0.99$ . The weighted average for the individual parameters of entire dataset are considered for calculating the weight for the following input parameters  $W_1 = 0.492209$ ,  $W_2 = 0.38880$ ,  $W_3 = 0.27881$  and  $W_4 = 0.453480$  are given for frequent node set, data aggregation, connectivity, residual energy respectively. The fuzzy calculation for each node based on the input parameters values is given by a formula by O Pavlacka and J Talasova (2007).

$$(3.1) \quad u = \frac{u_1 w_1 + u_2 w_2 + \cdots + u_m w_m}{w_1 + w_2 + \cdots + w_m}, \quad \sum_{i=1}^m w_m > 0.$$

In eqn (3.1), different parameters are input. According to equation 3.1 the value Trust value of the first row of input is calculated as,

$$(3.2) \quad \text{TrustValue} = \frac{W_1 Y_1 + W_2 V_1 + W_3 X_1 + W_4 U_1}{W_1 + W_2 + W_3 + W_4}.$$

Based on the trust value calculated using equation (3.2) the decision for the relay node placement is determined. Table 2 shows the some sample trust values. The trust value is calculated the using fuzzy inputs namely data aggregation, frequent item set, connectivity and energy. In specified interval it calculates the trust value for the inputs. If the trust value is obtained high, there is possibility to partition the network due to node failure of the particular node. For such position, we place

the backup relay node in prior to overcome the data loss and network connectivity.

Table 1. Input parameters for Fuzzy Logic Controller.

INPUT PARAMETERS	TERM SET	MEMBER SHIP FUNCTION	LIMITS
Frequent Item Set	Low(L), Medium (M), High (H)	Trapezoidal & Triangular	0 to 0.9
Data Aggregation	Low, Medium, High	Trapezoidal & Triangular	0 to 0.5
Connectivity	Low, Medium, High	Trapezoidal & Triangular	0 to 0.5
Energy	Low, Medium, High	Trapezoidal & Triangular	0 to 1

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Table 2. Sample Trust Value calculation.

Frequent Node set	Data aggregation	Connectivity	Residual Energy	Trust Value
0.195	0.9597	0.2332	0.2798	0.3085
0.8223	0.1875	0.3345	0.375	0.4054
0.895	0.860	0.3567	0.430	0.729
0.9141	0.490	0.4897	0.245	0.5872
0.8467	0.580	0.1988	0.290	0.4061
0.9518	0.790	0.2344	0.395	0.5552
0.9013	0.685	0.3768	0.342	0.4095

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Table 3. Fuzzy Rule Base.

S.no	Data aggregation	Frequent Item	Connectivity	Energy	Output
1.	High	High	High	High	Very high
2.	High	High	Medium	High	High
3.	High	Medium	High	High	High
4....	Medium	High	High	High	High
20.	Medium	Medium	Medium	Medium	Medium
21.	Medium	Medium	Low	Medium	Moderate
22...	Medium	Low	Medium	Medium	Moderate
53.	Low	Medium	Medium	Low	Low
54.	Medium	Medium	Low	Low	Low
55....	Low	Low	Medium	Medium	Low
81.	Low	Low	Low	Low	Very low

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Table 4. The Output Trust Value and Relay Node placement decision.

Output	Team Set	Member Ship	Limits
RNPD(Relay Node Placement Decision)	VERY LOW (VL), LOW (L), MODERATE (M), HIGH (H), VERY HIGH (VH).	TRAPIZOIDAL & TRIANGULAR	0 to 1

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#### F. Fuzzy Generation Rule

The data aggregation and energy morphological factors have trapezoidal association with the triangular membership activity. After that there is a need to apply the fuzzy rules and into the fuzzy logic engine. From Table 3 it is inferred that if all the input is high, obtained every high output, if the input is of the range high, medium, low output obtained is high, if the input is medium, medium, medium, the outcome is moderate, the input is low, low, low we obtain very low output. The trust value become high or very high resources it acquires more possibilities to place the backup node as relay node while the trust value is very low or low it may exit. Then the fuzzyfied value is converted in to Defuzzified value, to get the accurate value and immediately to place the backup node on the network. From the fuzzy principle the likelihood of output variable is obtained. The higher probability implies that the hub has more for reinforcement hand-off hub. Table 4 shows the possible output limits. With reference to Table 2, the output is normalized in the range of 0 and 1.

### 4. SIMULATION AND PERFORMANCE EVALUATION

The proposed network is designed using the fuzzy system and AFTC algorithm. The system is simulated in MATLAB 2010 and the performance of the proposed network is compared against the parameters such as energy consumption, system lifetime, and the number of alive hubs. Simulation parameters are given in Table 3. The implementation is done in four modules: clustering, energy module, frequent set item, data aggregation. In the first module, the hierarchical cluster information with cluster head election done. In the second module, the energy module is implemented with clustering. The third and fourth module introduces the frequency item set and data aggregation in the network.

Figure 5 shows the proposed FTIC shows 1% to 3% performance improvement when compared with TIC in number of relay node placement and 5% to 10% improvement in comparison with AFTC. The Energy utilization of the FTIC, AFTC and TIC. FTIC and TIC are similar in energy utilization initially. The energy utilization of the there is an increase 4% to 6% when compared



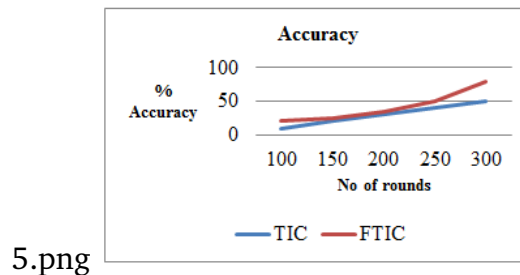


Figure 5. Comparisons of Accuracy.

with TIC and 5% to 10% comparison with AFTC in the energy utilization and the life time of the WSN is prolonged on using FTIC.

## 5. CONCLUSION

In the proposed Fuzzy Based Trust Index Calculation FTIC is novel approach to identify the fault. The proposed system uses parameter namely the data aggregation of the node, the Residual energy of nodes, degree of neighbouring nodes and frequency of the node participation to calculate the trust value. The proposed algorithm is implemented using Matlab. The simulation results show that FTIC yield maximum of 3% better results in relay node placement. The accuracy of trust value calculation is drastically improved compared to the earlier works. The proposed work can be implemented by including variable other parameters apart from above mentioned parameters.

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