

A-OLSR: ANFIS based OLSR to select multipoint relay

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ABSTRACT

The characteristics like dynamic topology, power consumption, mobility etc. may leads to affect the routing process of packet as it progresses from one node to another node. The energy of each node is very limited in MANET's due to which it becomes an important parameter to be considered while selecting the route. The 'Optimized Link State Routing Protocol' (OLSR) does not consider node energy during Multipoint relay (MPR) selection process. This paper proposes an improvement of OLSR routing protocol named as A-OLSR protocol using node energy during its MPR process. The improvement is based on adaptive neuro fuzzy inference system (ANFIS). The network simulator NS2.35 is used for the simulation, random way point model for mobility and constant bit rate (CBR) for traffic process. The performance of proposed A-OLSR protocol is evaluated using the packet delivery ratio (PDR) and end to end delay metrices. The simulation results prove the superiority of the proposed protocol in terms of PDR.

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1. INTRODUCTION

The mobile ad hoc networks (MANETs) draw attention of researchers due to its characteristics like mobility, ease of its deployment. The communication among mobile nodes takes place without infrastructure. There are lots of routing protocol which are designed for various applications. Based on table update mechanism [1], [2] these protocols are classified into three categories: 1) Table driven: these routing protocol update their routing table periodically 2) On demand: these routing protocol update their routing table when there is demand 3) Hybrid: these are the combinations of table driven and on demand categories. OLSR is a table-driven routing protocol which chooses the MPR nodes to forward the message to its neighbor. MPR nodes are chosen based on two hop communication range. Other important network affecting factors like energy of node, distance, stability parameters are not considered while selecting MPR node. The OLSR routing protocol should consider these parameters while selection of MPR node.

Many researchers proposed a lot of routing protocol for different applications in mobile ad hoc networks [3]. The details about OLSR routing protocol are presented in [1], [4]-[6]. Authors in [7] has proposed the multi metric based routing algorithm that finds cost of each link and select the path with minimum cost. To reduce the topological control traffic, authors in [8] proposed MPR selection-based strategies. To reduce the number of MPR selection in routing, author in [9] has presented the 'necessity first algorithm'. To provide security, author in [10] has proposed a trust based secured algorithm which is based on calculated trust value and behavior of the node is also analyzed. Author in [11] has done comparative analysis of on demand and table-driven mechanism considering energetic point as key factor.

In OLSR routing protocol, MPR nodes are used for spreading network data and to update route information. The OLSR routing protocol performance can be enhanced by selecting an optimum MPR. In this paper, A-OLSR routing protocol is proposed which selects MPR nodes along with energy of node.

It uses ANFIS technique to select the MPR nodes. It is also capable of processing multimeric information. The proposed protocol selects the stable route. Sometimes it can also choose the longer route.

The structure of remaining paper is as follows. Section 2, presents adaptive neuro fuzzy inference system. Section 3 contains the proposed protocol A-OLSR. In Section 4, its Simulation model is presented further its results are presented and analyzed in section 5. Finally, in Section 6, conclusions are discussed.

2. ADAPTIVE NEURO FUZZY INFERENCE SYSTEM (ANFIS)

ANFIS system is presented by J.S.R. Jang [12]. The five layers are depicted as show in Figure 1 [13], [14] and functioning of each layer is explained as:

- a. Layer 1: This layer generates the membership function for input variables hop count and energy, the linguistic variables for input are low, medium, and high and for output, the linguistic variables used are low, very low, medium, high, and very high.
- b. Layer 2: In this layer the rules for ANFIS system are framed. Since the low energy of a node will affect its route path which results in high cost and if the node energy is high (or full) it can participate for longer time, thus the cost is low. On the similar basis, the framed rules used in the ANFIS system are shown in Table1.
- c. Layer 3: The normalization of rules from preceding is executed in this layer.
- d. Layer 4: The weighted output of rules is processed in this layer.
- e. Layer 5: The final layer computes the output based on all incoming signals.

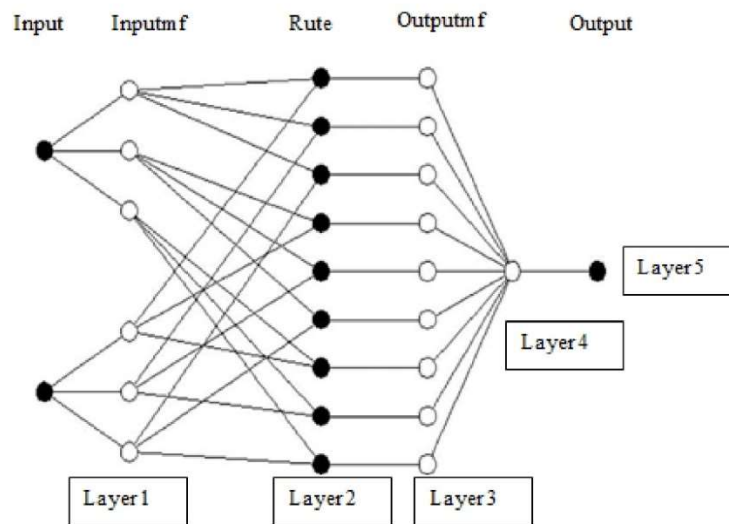
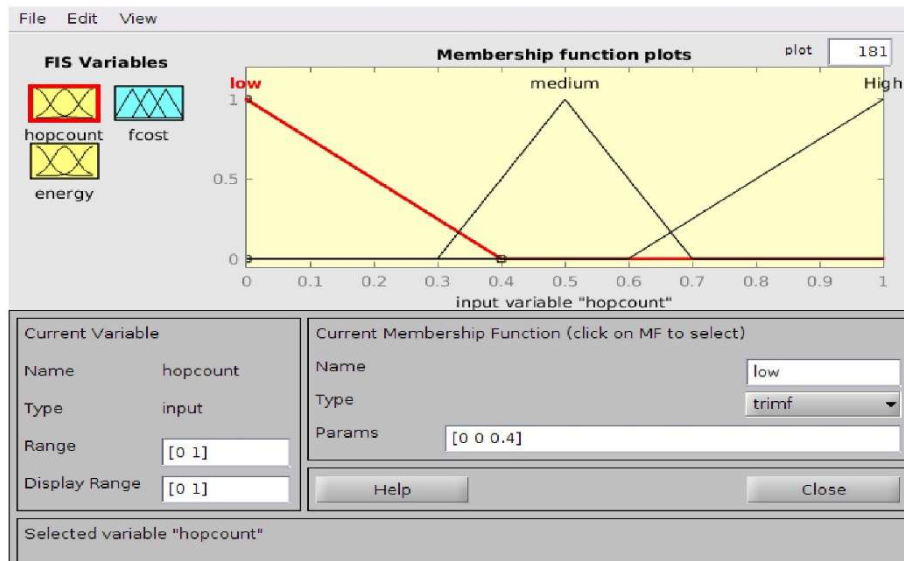


Figure 1. Architecture of ANFIS

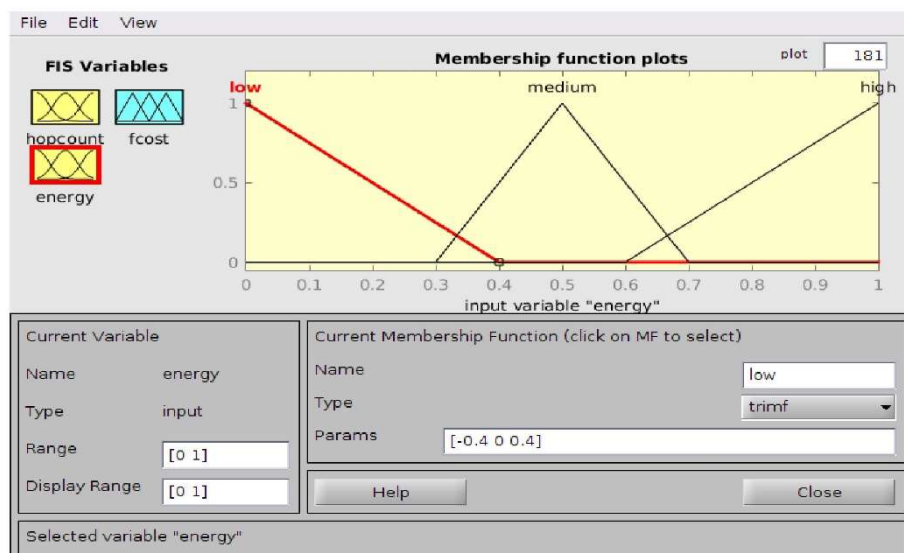
Table 1. Rule Value for ANFIS

Rule	Hop count	Energy	Output Value
1.	L	L	VH
2.	L	M	H
3.	L	H	L
4.	M	L	H
5.	M	M	M
6.	M	H	L
7.	H	L	M
8.	H	M	L
9.	H	H	VL

Here L, M, H, VL, VH denotes Low, Medium, High, Very Low, Very High respectively. Membership functions of A-OLSR (hop count) and Membership functions of A-OLSR (energy) as shown in Figure 2.



(a)



(b)

Figure 2. a) Membership functions of A-OLSR (hop count), b) Membership functions of A-OLSR (energy)

3. PROPOSED ANFIS OLSR(A-OLSR)

The routing information is updated by each node in its table after the periodic exchange of Hello messages. The information about its 1-hop neighbor (hop count, energy) in the routing table is added. On the reception of Hello message each node calculates the path cost of neighbor by using ANFIS system. During the MPR selection process, the path information variable can also affect the selection process. Therefore, to handle the uncertain information and to select the optimize MPR, ANFIS system is required. On reception of hello message, intermediate node extracts the variable information and send it to ANFIS system as input as shown in Figure 3. The intermediate node then processes these variables and sends the output. The resulted output of ANFIS system are used for selection of MPR nodes. Thus with the proper selection of optimize MPR, the proposed protocol A-OLSR chooses a more reliable path than OLSR. A-OLSR Algorithm as shown in Figure 4.

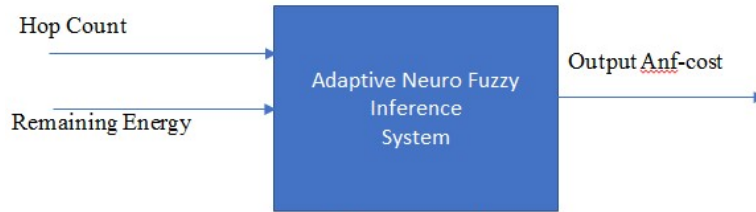


Figure 3. ANFIS for OLSR

Algorithm: -

1. Initialize the following parameter:
 - I** = **Ith node;**
 - N** = **number of nodes;**
 - S_i** = **Source node;** (The node willing to communicate by establishing a connection)
2. **For each node n**
 - Compute H1 (n)
 - Compute H2 (n)
 - {H₁ (n): 1-hop neighbour means the set of nodes which are in the range of n.
 - H₂ (n): 2-hop neighbour means the set of nodes which are neighbours of H₁(x) but not belong to H₁ (n). }
 - Compute Anf-cost (Hop count (h_i), Energy (E_i)) (Process carried by Adaptive neuro fuzzy logic)
3. Select source node(S_n) in MPR;
4. Arrange anf-cost in ascending order as ordered anf-cost.
5. Build MPR based on
 - Choose I for which Min order cost
 - Choose I for which H₂ (anf-cost) <H₁ (anf-cost)
6. Add selected ith node in MPR.
7. Remove ith node from anf-cost H₁ and H₂ queue.
8. goto step 4. until all nodes in MPR:

Figure 4. A-OLSR algorithm

4. SIMULATION MODEL

The simulation is conducted in the environment of network simulator tool NS2.35. The results are simulated with varying number of nodes 10, 15, 30, 45 and 60. To obtain the correctness of proposed A-OLSR, the area chosen for the simulation is 1200 ×500 in which for mobility model, the random way point model is used with maximum speed of 20m/s and for transmission range a node in 250-meter area is selected. The other initial settings are: the data payload of 512 bytes, the channel capacity of 54 Mbps and the traffic generator is used for CBR (Constant Bit Rate). The network is simulated for 150 s for OLSR routing protocol and proposed A-OLSR. The traffic generators is developed to simulate CBR (Constant Bit Rate). The environment variable that are used for simulation are shown in Table 2.

The data set comprising 800 data points, which is divided into two sets of 300 data points and 500 data points for training and testing purpose respectively. The first set is used to train the network and the model is validated, then with all the 800 points including the 500 points that were not used in the training process the output is obtained. Data sets are derived from fuzzy ‘if then rules’. The training data set is fed as an input to ANFIS tool under MATLAB environment. To train the FIS hybrid learning method is used.

Table 2. Simulation Environment Variables

Parameter	Values
Routing Protocol	OLSR, M-OLSR, A-OLSR
No. of Nodes	10,15,30,45,60
Area	1200 * 500
Channel Capacity	54 Mbps
Traffic type	CBR
Mobility Model	Random Way point
Simulation Time	150 S

5. SIMULATION RESULTS

The following parameters are used to calculate the performance of OLSR and A-OLSR routing protocol: Packet Delivery Ratio (PDR): It is the ratio of summation of all the packets that are received at the destination to the summation of all the packets that have been sent.

$$\text{PDR} = \frac{\sum \text{Number of packet receive}}{\sum \text{Number of packet send}} \quad (1)$$

End to End Delay: It is the measured as the average delay between the time taken by a packet from its origin to reach its destination in the network.

$$\text{End to End Delay} = \frac{\sum (\text{arrive time} - \text{send time})}{\sum \text{Number of connections}} \quad (2)$$

In Figure 5, Packet delivery ratio is shown for various number of nodes. The PDR of proposed algorithm is higher than that of OLSR and fuzzy based OLSR (M-OLSR) protocol due to efficient selection of MPR. This is due to the fact that it also considers the energy factor during MPR selection. However, it may also possible that the longer route might be selected. From Figure 5, it is observed that when the number of nodes is around 30 then the PDR is maximum, this is due to because, the number of nodes is in direct range of each other. When the number of nodes is around 45 and 60 it is observed that the PDR decreases because with the increase in number of nodes the path length might be increases therefore there is increase in path breaks which in turn leads to packet drop. Thus, basically it is trade-off between PDR, Energy and route length.

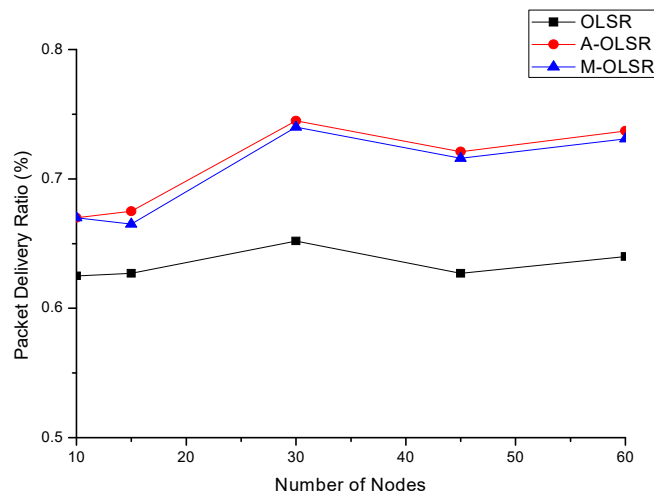


Figure 5. Packet delivery ratio vs number of nodes

In Figure 6, End to end delay is increased with higher number of nodes. The proposed protocol has slightly higher end to end delay as it selects the longer route. At higher density (here 60 nodes) the end to end delay of proposed algorithm is .06 s that can be acceptable in real time application. This can be compensated by the improvement in packet delivery ratio, it is observed that the proposed OLSR (A-OLSR) protocols have slight high value of end to end delay compared to its existing OLSR protocol. However, this high value is just nearly 2% average increase which can be considered very minimal and that too of the order of 0.02 sec maximum.

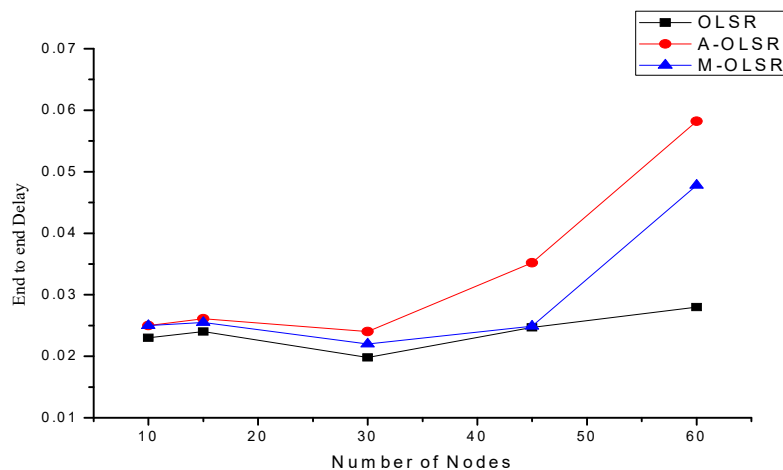


Figure 6. End to end delay vs number of nodes

6. CONCLUSION

In the process of route selection, the proposed algorithm A-OLSR employs ANFIS for the selection of MPR. ANFIS is applied to process the intermediate node energy for the computation of node cost. The improvement of MPR selection process is achieved with the inclusion of node energy during selection. The simulated results in NS2.35 shows that A-OLSR attains significantly high value of PDR than the OLSR routing protocol and the recent state of art Fuzzy OLSR (M-OLSR) protocol.

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