Improving OLSR protocol of MANETs Using Fuzzy Logic

Arun Sharma
Department of CSE, KIET Group of Institutions
Delhi NCR, India
arun_tuples@hotmail.com

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Abstract- Mobile Ad-hoc Networks consists of large number of mobile nodes having limited number of resources like energy, storage capacity, processing capabilities and so on. The energy of a mobile node in the MANET environment is the most critical factor as the life time of a MANET is based on the energy of the participating nodes. OLSR is one of the routing protocols used in the MANET environment to support optimized flooding and to utilize the available resources in an efficient way. In this paper Fuzzy Logic is used to improve the quality of the OLSR protocol. The paper takes into consideration the various metrics of the nodes to improve the quality of the OLSR protocol.

Key Words: MANET, OLSR, MPR, Energy, Stability.

1. INTRODUCTION

Network without any fixed infrastructure, non centralized control & dynamic topologies is known as mobile ad hoc network (MANET) [1]. The MANET consists of a large number of nodes connected in an arbitrary fashion through a wireless link. MANET is collection of nodes having limited number of resources like energy, storage capacity, processing power, buffer occupancy. The flooding and energy consumption can be reduced in the MANET by using the optimized flooding. This technique is used by the OLSR routing protocol that uses the concept of multi point relay (MPR) to reduce the transmission overhead. It is the responsibility of the MPR nodes to forward the information up to the two hop neighbors’ node in the network. It reduces the network and energy consumption but it has some problems also. The main drawback of this approach is that network and energy consumption is mainly concentrated to the MPR nodes. Therefore main focus of the paper is to apply the SC approach for the prediction & selection of QMPR nodes.

The rest of the paper is organized as follows: Section 2 provides an overview of OLSR & the work related to it. Section 3-7 contains the concept and proposed Fuzzy based approach. Section 8-9 discusses the simulation results of the proposed QMPR selection technique for the QOLSR. Section 10 provides the conclusion & future prospects of this technique.

2. THE OLSR PROTOCOL

The optimized link state routing (OLSR) protocol [2] is proactive protocol for MANET that uses the link state routing protocol as the base. It optimized the flooding of packets by reducing the number of redundant retransmissions and improves the quality of the network. It stores the information about the nodes and their neighboring nodes into the routing table and mainly focuses to provide the best path link in a route. It uses the concept of multi point relays (MPR) [3] to reduce the size the overhead of the network by optimizing the size of the control messages. In this approach a node shares the information about the set of links with MPR nodes only. MPR have the responsibility for forwarding and controlling the traffic of the network. As the efficiency of the OLSR protocol is totally dependent on the MPR. So, it becomes essential to select the best nodes of the network as the MPR node. The main focus of the paper is to predict the nodes that possess the best qualities for their selection as QMPR. In the recent years many researchers have proposed the various techniques for the MPR selection in an efficient way [4, 5] but none of them have applied the SC approaches to find the best MPR.

3. PROPOSED FUZZY BASED APPROACH AND MODEL FOR QMPR SELECTION

Zadeh [6] derived the concept of Fuzzy Logic (FL) to implement vagueness in linguistic variables. The concept of FL implements and simulate the human knowledge as nature implements it in daily life. The important feature of the proposed methodology is the Fuzzy Inference System (FIS). It is a combination of fuzzification system that takes crisp values an input and transforms them into the fuzzy sets by the use of fuzzification function, fuzzy inference engine it is responsible for matching and validating the inputs with the fuzzy rule base, and fuzzy rule base is a combination of IF-THEN rules and defuzzification system that transforms the fuzzy output into the crisp values. To interpret the if-then rule
involves fuzzification of the input and applying the suitable fuzzy operators [7]. The architecture of the model used in the proposed approach is shown in Fig. 2.

Fig 2: Architecture of FIS

4. FUZZY BASED MPR SELECTION MODEL FOR OLSR PROTOCOL

In the proposed approach, a fuzzy based system to predict the quality nodes for the OLSR protocol in a MANET environment is given. To calculate the quality of a node in the network, sum of all the quality factors like energy level, stability, node density have been taken for all the nodes. Mathematically the relation between the nodes attributes and their probability to be chosen as MPR can be given as follow:

\[ Q_f = F_m[E_n, S_n, D_n] \]

\[ T(n) = \begin{cases} \frac{P}{1 - P \times (r \mod \frac{1}{P})}, & \text{if } n \in \text{Nand}Q_f \geq 0 \\ 0, & \text{otherwise} \end{cases} \] (1)

In the proposed approach there are three crisp inputs in the form of node energy-level, stability and node density. These crisp inputs are passed to the inference engine after the fuzzification process. Inferences engine consists of a rule base that are used to predict the quality nodes that can be selected as MPR. In the proposed approach Mamdani’s method is used for the inference process. The crisp input values are provided to the system and antecedents are evaluate using the fuzzy rule base and a conclusion is obtained that is used to predict the quality of the node.

5. FUZZIFICATION PROCESS

In this approach node energy-level, stability, node-density these three attributes have been considered to predict the quality nodes that can be used as the QMPR node for the OLSR protocol. These three attributes are used to form a fuzzy set and then the membership function for the each attribute is determined. Three membership functions have been used to determine the degree of membership of the input functions. In the output function 9 membership functions have been used to predict the quality nodes.

Table 1: Input Functions

<table>
<thead>
<tr>
<th>Input</th>
<th>Degree of Membership</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(0)</td>
</tr>
<tr>
<td></td>
<td>(1)</td>
</tr>
<tr>
<td></td>
<td>(2)</td>
</tr>
</tbody>
</table>

Table 2: Output Functions

<table>
<thead>
<tr>
<th>Output</th>
<th>Membership Function</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(1)</td>
</tr>
<tr>
<td></td>
<td>(2)</td>
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<td>(3)</td>
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<td></td>
<td>(5)</td>
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<tr>
<td></td>
<td>(6)</td>
</tr>
</tbody>
</table>

Table 2: Output Functions

<table>
<thead>
<tr>
<th>Probability of a node to be an QMPR</th>
<th>Very Low</th>
<th>Low</th>
<th>Medium</th>
<th>Lower</th>
<th>High</th>
<th>Higher</th>
</tr>
</thead>
</table>
6. FUZZY RULE BASE

In the proposed system a rule base is created for the fuzzy inference engine. There are 27 rules that are used by the inference engine. Some of the proposed rules are shown as:

- If the node-energy is High, stability is high and node-density is high then the probability of the node to be selected as MPR will very high.
- If the node-energy is medium, stability is medium and node-density is medium then the probability of the node to be selected as MPR will medium.
- If the node-energy is low, stability is low and node-density is low then the probability of the node to be selected as MPR will very low.

7. DEFUZZIFICATION PROCESS

The proposed system uses a defuzzification process to obtain the crisp values from the conclusions. These conclusions are obtained by fuzzy inference engine using the fuzzy rule base. Here centroid method is used for the defuzzification process. After the defuzzification process the below formula is used to predict the quality nodes for the QMPR selection:

\[ G(i) = \frac{\sum_{j=1}^{n} x_j \cdot u(x_j)}{\sum_{j=1}^{n} u(x_j)} \]  

8. SIMULATION RESULTS

The proposed approach is verified using the Matlab 7.12. The result clearly shows that the node-energy, stability & node-density play an important role to make the network a quality one. If these attributes are considered for the selection of quality nodes as a MPR, the QoS of the OLSR protocol will be improved.

It is shown that a node having higher energy-level and stability has the highest probability to be elected as a MPR. As the stability of the node degrades its probability to be selected as MPR node will also decreased. Node stability in the network with the energy is the most crucial factors for the MPR selection and the OLSR a quality one. If a node having low energy level there is no need to assign it higher responsibilities by making it a MPR node.

9. FUZZY LOGIC BASED QMPR SELECTION ALGORITHM FOR OLSR PROTOCOL

In this section an algorithm for the QMPR selection in OLSR protocol based on Fuzzy Logic is shown. It is the modified version of MPR selection algorithm based on Fuzzy Logic heuristic for selecting the quality nodes as MPR. It ensures improved network life time and less energy consumption in MANET and thus improves the efficiency of the whole network. The following terminology is used in describing this algorithm:

- \( N(x) \): The set of one hop neighbors of node x created by changing HELLO messages between nodes.
- \( N2(x) \): The set of two hop neighbors of node x created by changing HELLO messages. It do not contain any one hop neighbor of node x.
- \( D(x, y) \): The degree of hop neighbor y. The number of nodes in \( N2(x) \) that are covered by y.
- \( D[x, y] = \text{number of elements of } N[y] - \{x\} - N[x] \)
1. Start
2. MPR[x] = Ø
3. For each node n ∈ N[x] do
   Find D[x, y] and Q
4. For each node n ∈ N[x] do
   If Q > 0 then
     { 
     \[ G(i) = \frac{\sum_{j=1}^{n} x_j \cdot u(x_j)}{\sum_{j=1}^{n} u(x_j)} \]
5. For \( G(i) = 1; G(i) \geq 0; G(i) = - \)
   { 
6. First select as MPRs those nodes in N[x] which provides the “only path” to reach some nodes in N2[x]
7. While there still exists some nodes in N2[x] that is not covered by MPR[x]:
   - For each node in N[x], calculate the number of nodes in N2[x] which are not yet covered by MPR[x] and are reachable through this one hop neighbor;
   - Select as a MPR that node of N[x] which reaches the maximum number of uncovered nodes in N2[x]. In case of a tie, select that node as MPR whose D[x, y] is greater.
8. To optimize, process each node y in MPR[x], one at a time, and if MPR[x]-{y} still covers all nodes in N2[x] then remove y from MPR[x]
   { 
   } 
9. Discard that node for MPR selection
   { 
10. Stop

10. CONCLUSION
The fuzzy logic based OLSR protocol was proposed to make the OLSR a quality one for the MANETs. The network lifetime is increased by selecting the quality nodes to serve as MPRs based on their energy, stability in the network & node-density. The proposed approach helps in increasing the throughput & lifetime of the network. In future different set of metrics can be used to improve the efficiency of the proposed fuzzy logic based approach for OLSR protocol.

REFERENCES