FUZZY BASED SCHEDULING AND LOAD BALANCING FOR ZONE ROUTING PROTOCOL (ZRP) IN MOBILE AD HOC NETWORKS

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INTRODUCTION

MANET is a group of active, automated and radiofortified nodes deprived of any substructure. MANET need every single intermediary node to perform as forwarders, getting and advancing data to every another node. This sort of network is commonly positioned in numerous situations in which immediate connectivity turns out to be the on-going need, either in alternative circumstances such as a calamitous emptying condition or in an unplanned gathering for performances [1]. Due to frequent node mobility, network disconnections and link failures are common in this network [2]. Hence, routing becomes a critical job in MANET [3].

ZRP [4] handles issues by combining the best properties of both proactive and reactive routing protocols [4]. But still, many issues exist in ZRP which are to be solved. Data forwarding is performed by each node with maximum power thus ignoring its position in the zone. If the distance between the source and destination node is minimum, it leads to power wastage. On the other hand, if the distance is high, the destination may lie outside the zone radius. While increasing its broadcast attempts to determine the border node, the bandwidth consumption of source node will increase [5].

Location Based Topology Control approach was proposed by Niranjan Kumar Ray et al. [6]. It combines topology control and power management techniques to reduce the transmission power of each node. Nodes are put into sleep mode based on the traffic load such that the network is not disconnected.

Zone based Collision Guided (ZCG) protocol has been developed by Shadi S. Basurra et al. [7]. ZCG uses parallel and broadcasting techniques for route determination. The determined routes have high connectivity and lesser energy consumption. It splits the network into various zones in which reliable leaders are elected.

A new routing algorithm was proposed by Indrajit Bhattacharya et al. [8], which uses ZRP and Minimum Estimated Expected Delay (MEED) protocols. In this algorithm, the data is transmitted to the destination, within a specific deadline.

The routing protocol proposed by Bency Wilson et al. [9], combines both proactive and reactive routing methods. Like ZRP, it applies proactive routing inside the zones and reactive routing outside the zones. The speed and locations of each node are monitored continuously. This approach results in increased bandwidth utilization, reduced power consumption and less routing overhead.

Nassir Harrag et al. [10] have proposed an algorithm Particle swarm optimization (PSO) and ZRP, to adaptively adjust the zone radius of each node. It enhances the performance of ZRP by reducing the delay, increasing the delivery ratio and reducing the control overhead.

A Genetic Zone Routing Protocol (GZRP) was proposed by Sateesh Kumar et al. [11]. It applies Genetic algorithm for IERP and BRP components of ZRP. It determines multiple paths to the destination to perform load balancing. GZRP outperforms the existing ZRP to provide scalability and robustness.

An improved ZRP has been proposed by Xueqin Yang et al. [12]. It divides the networks into various clusters and proactively selects the cluster head in each cluster.

An enhanced IERP has been proposed by Yuria Oigawa et al. [13]. The node id of each zone is stored in a Bloom filter, which is exchanged between the border nodes. The Bloom filter assists in forwarding the routing packet to the specified link, thereby reducing the control overhead.

MATERIALS AND METHODS

This paper proposes Fuzzy based power scheduling and load balancing technique for ZRP in Mobile Ad Hoc Network (MANET). In this technique, the duty-cycles of the border nodes are adaptively adjusted based on the queue state, predicted residual energy and distance to border nodes. During each round, the nodes are in active state and then enter into the sleep mode based on estimate duty-cycle length. Then the zone leaders (ZL) are adaptively changed whenever its load exceeds.

In ZRP, a routing zone (RZ) with radius r is constructed for each node, individually. (ie) Each zone consists of nodes within r hop distance at the maximum. Hence zones may overlap each other. ZRP contains a proactive and reactive routing modules: Intra-Zone Routing Protocol (IARP) and Inter-zone Routing Protocol (IERP). IARP manages a routing table for all nodes which belongs to its RZ. IERP applies route discovery...
technique to set up routes for the nodes which are outside the zone.

The FLD model is illustrated in Figure 2.

For example, let us consider the network depicted in Figure 1. In this network, R is fixed as two hops. S and X indicate the sender and receiver nodes and their routing zones are marked in blue and brown circles, respectively. S examines the routing table to find if X belongs to its zone. When S receives the request, it again broadcasts to its border nodes P, R and T (marked brown color in figure). Since the destination X belongs to the routing zone of T, it includes a path from itself to X. Then X sends route reply which contains reverse route to S.

Fuzzy logic is used to determine the optimum duty cycle period by considering the predicted residual energy and distance to the ZL parameters, as input. Depending on the output of fuzzy logic, duty cycle is adaptively adjusted.

Fuzzification: In this phase, the input variables are represented as fuzzy sets with three values high, medium, and low. Figures 3, 4 and 5 show the fuzzy sets and membership functions of the input variables. Triangular fuzzy set is used in our model.

Fuzzy rules aggregation: Table 1 shows fuzzy decision rules, based on the membership functions. The outcome of each rule is combined to derive a fuzzy decision.

Then the predicted residual energy of current node can be computed by

\[ \text{RE}_p = \text{CRE}(t) - n \times \text{TEC}(t) \]  

where \( \text{RE}_p \) is the current residual energy of node, \( \text{CRE}(t) \) is the predicted residual energy of the node, \( \text{TEC}(t) \) is the total energy consumed by the node, and \( n \) is the number of packets transmitted.

The value of \( w \) is adaptively adjusted using Fuzzy logic, as explained in the next section.
Algorithm- Load Balancing at Zone Leaders

1. For each S transmitting data to D
2. For each ZL
3. \( PC_j = 1 \)
4. If another source \( S' \) tries to transmit data through \( ZL_j \),
   then
   \( PC_j = PC_j + 1 \)
5. End if
6. If \( PC_j > PC_{max} \) then
7. \( ZL_j \) is overloaded
8. Transmission through \( ZL_j \) is stopped
9. Determine \( O\text{Lrate}_i \) as
   \( O\text{Lrate}_i = Q_i - C_{max} \)
10. \( ZL_j \) transmits \( O\text{Lrate} \) value as
    a feedback to \( S_j \)
11. \( S_j \) transmits the overloaded part of the traffic through
    another ZL
12. End if
13. End For
14. End For
15. End For

RESULTS AND DISCUSSION

FSLBZRP is implemented in NS2 and contrasted against PSOIZRP [11] protocol. The experimental settings are given in Table 2.

<table>
<thead>
<tr>
<th>Table 2 Experimental settings</th>
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<tbody>
<tr>
<td>Number of nodes</td>
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<tr>
<td>Topology size</td>
</tr>
<tr>
<td>MAC protocol</td>
</tr>
<tr>
<td>Traffic type</td>
</tr>
<tr>
<td>Number of connections</td>
</tr>
<tr>
<td>Type of propagation</td>
</tr>
<tr>
<td>Antenna model</td>
</tr>
<tr>
<td>Assigned energy</td>
</tr>
<tr>
<td>Transmit power</td>
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<tr>
<td>Receive power</td>
</tr>
<tr>
<td>Data sending rate</td>
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<td>Speed of nodes</td>
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Case -1 Varying the nodes
In first test case, the network size is increased from 25 to 100 nodes.

Figure 6 E2D for case-1
Figure 6 shows the results of E2D for case-1. As per the figure, the delay of FSLBZRP, varies from 16.8 ms to 24.6 ms and delay of PSOIZRP varies from 18.2 ms to 28.1 ms. Hence FSLBZRP achieves 8% lesser delay than PSOIZRP.

Figure 7 PDR for case-1
Figure 7 shows the results of PDR for case-1. As per the figure, the PDR of FSLBZRP, decreases from 0.87 ms to 0.32 and PDR of PSOIZRP decreases from 0.54 ms to 0.16. Hence FSLBZRP achieves 33% higher PDR, than PSOIZRP.

Figure 8 Number of packet drops for case-1
Figure 8 shows the number of packet drops for case-1. As per the figure, the number of dropped packets for FSLBZRP increases from 43090 to 58372 and the same for PSOIZRP increases from 62975 to 79615. Hence FSLBZRP achieves 28% lesser packet drop than PSOIZRP.

Case-2 Varying the node speed
In second test case, speed of the mobile node is varied from 5 to 25 m/s.

Figure 9 Energy Consumption for case-1
Figure 9 shows results of average energy consumption for case-1. As per the figure, consumed energy of FSLBZRP varies from 18.1 joules to 18.8 joules and consumed energy of PSOIZRP increases from 18.5 joules to 19 joules. Hence FSLBZRP achieves 2% lesser energy consumption than PSOIZRP.

Figure 10 E2D for case-2
Figure 10 shows the results of E2D for case-2. As per the figure, the delay of FSLBZRP, varies from 23.6 ms to 26.4 ms and delay of PSOIZRP varies from 25.1 ms to 27.7 ms. Hence FSLBZRP achieves 4% lesser delay than PSOIZRP.

Figure 11 PDR for case-2
Figure 11 shows the results of PDR for case-2. As per the figure, the PDR of FSLBZRP, decreases from 0.72 ms to 0.28 and PDR of PSOIZRP decreases from 0.62 ms to 0.24. Hence FSLBZRP achieves 11% higher PDR, than PSOIZRP.
REFERENCES

The authors don’t have any Conflict Of Interest.

CONCLUSION

In this work, Fuzzy based power scheduling and load balancing technique for ZRP (FSLBZRP) has been proposed. In this protocol, the sleep time period of zone member nodes is adaptively adjusted. Then the zone leaders (ZL) are adaptively changed whenever its load exceeds. The proposed FSLBZRP technique is implemented in NS2 and its performance is compared with PSO-IZRP protocol. Simulation results have shown that FSLBZRP attains increased PDR with reduced energy consumption.

FUTURE SCOPE

Future work focus on integrating some location based routing protocols over zone routing protocols.

Conflict Of Interest:
The authors don’t have any conflict of Interest.

REFERENCES