Protract Route Optimization in ZRP through Novel RA Approach

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Abstract: Background and Objective: Affected by the recent developments in the high potential technological fields, the world is observing a tremendous rise in the popularity of wireless networks. Wireless networks provide the users with the advantage of experiencing interruption free computing services along with complete autonomy to freely travel to different locations. Adhoc Networks prove to be an effective solution for the users under crisis as they provide all the advantages provided by wireless networks even in the absence of any infrastructure.

Methods: The driving force behind the functioning of Adhoc Network is the Routing Protocol, which undertakes the charge of all the services needed for efficient transfer of data from one device to another. Zone Routing Protocol was assumed to be an effective routing protocol as compared to its purely Reactive and purely Proactive counterparts. However, various researches have proved that the flat protocol with highly overlapping zones requires a lot of storage for large networks due to the absence of aggregation of routing information resulting in an increase in memory requirement and inversely impacted performance.

Results and Discussion: This paper proposes an effective technique to aggregate the routes such that the superfluous route requests are avoided and reduction in control overhead is achieved along with the Performance Optimization.

Conclusion: This paper lastly compares the performance of ZRP-RA (Zone Routing Protocol-Route Aggregation) and ZRP. The simulation results discussed in this paper validate the novel RA based approach by optimizing the various QOS parameters.

Keywords: Optimization, route aggregation, ZRP, ZRP-RA, QOS, hybrid routing protocols.

1. INTRODUCTION

In the computing world, researchers in the field of MANET have devised various topology based routing protocols classified as Proactive, Reactive and Hybrid Routing Protocols [1-3]. The proactively designed protocols comprise of diligently active nodes, maintaining a record of all the routes within the network and thus, provide faster data transmission but suffer from abundant routing overhead in maintaining updated routes within the entire network considering the dynamically changing topology of MANET. The reactively designed protocols comprise of nodes only attempt a route discovery when required, thus saving the routing overhead involved in the maintenance of updated routes but it suffers from latency involved in the determination of route [4]. Various studies have concluded that hybrid routing protocols successfully could find a trade-off between the routing overhead in case of proactive and the latency in the case of reactive protocols, thus prove to perform efficiently than other protocols but there are a few limitations faced by the hybrid protocols [5-10]. The focal point of this paper is to improve ZRP performance by aggregating the routes to render the protocol to work efficiently in Mobile Ad-hoc Network and achieve route optimization both in the case of large routing zones when the protocol behaves as purely proactive and small routing zones where the protocol behaves as pure-
ly reactive [11]. The arrangement of this paper is as follows: section 1 discusses the Zone Routing Protocol (ZRP) and its limitations; section 2 provides the brief idea of the proposed algorithmic approach; section 3 contains the simulation analysis and the results examining the performance of the proposed approach. The results discussion and conclusions form section 4 and 5 followed by the section 6 constituting the references.

1.1. ZRP Routing

Routing in ZRP commences with the preparation of zones [2]. This process is undertaken by the Neighbor Discovery Protocol deployed by ZRP for the nodes to know their proximate nodes. The functions of NDP serve two purposes [12]:
- Recognizing the proximate nodes.
- To keep an updated status of links to take alternate measures in case of link failures.

Fig. (1) demonstrates the ZRP Architecture. The NDP process starts by relaying “HELLO” beacons at periodic intervals. After the beacon is created and broadcasted simultaneously a beacon Transmit Timer is started [5-8]. The beacon transmit timer takes care of the periodic transmission of the beacon as soon as the timer times out the next scan is scheduled thus, NDP quickly updates the new node entry in the zone as well as the elimination of any expired route. Regular updates on the link help in keeping the nodes in a zone appraised of each other’s states.

NDP sets a time limit to receive the acknowledgement for the beacon sent. Ack Timeout Timer determines the limit. If the acknowledgement is received before the timeout of the timer, the neighbor table and the IARP table are updated [5-8]. In case of no acknowledgement even after the timer time out, the link is demarcated as down and neighbors are dropped and thus, the tables are updated at both ends NDP and IARP.

Intra Zone routing protocol is responsible for the proactive maintenance of routes within the zone. Link State table records all the status of links [5-8]. The routing table is constantly updated after the reception of all updates regarding the links. All neighbors are acquainted with the non-peripheral route updates maintained in the routing tables. Each member node of the zone also maintains a border-cast tree for the peripheral nodes.

The ROUTE-QUERY is multi-casted to a set of nodes only those lying on the periphery of the zone, the process is called border-casting. The ROUTE_REPLY is sent back to the source, providing the source with the route to the destination. Border-Cast Resolution Protocol manages the distribution of border-casting message i.e. route queries pertaining to IERP. Messages are transmitted by the node to all of its peripheral nodes, with the help of border-cast tree [5-8]. The peripheral nodes then determine the presence of destination within their own zone. In case the destination is not discovered in own zone, the ROUTE REQUEST is border-casted again. Border-casting process although performs better than broadcasting but in case of ZRP due to heavy imbricating zones, there is excessive flooding of the network due to ROUTE REQUEST packets to reduce that Query Control is used [5-8].

The ZRP performance exemplified is indicative of the routing overhead issue and that improvement is required. Limitations faced by the ZRP due to the highly overlapping zones [11]. It also points out the increase in storage requirement in case of larger networks. Researchers have discussed the effect of no aggregation of routing information on the memory requirement and the increase in zone area that increases the broadcasts for finding the border nodes, thus increasing the bandwidth utilized. There is need of query control due to overlapping neighboring routing zones.
which results in a forwarding of route requests multiple times hence, increasing the control traffic [5-8]. The proposed algorithm in this paper uses an approach called Route Aggregation and aims to overcome the above-mentioned problems of flooding and help in reducing the amount of control traffic and thus, improve the ZRP performance. The next section of this paper will explain RA in detail.

2. ROUTE AGGREGATION (RA)

The growth of the internet was too burdening for the CPU resources, overloading for the memory resources as it then required a large number of addresses to be saved and the bandwidth requirement was also affected adversely. Route Aggregation also termed as route summarization was authenticated to be beneficent for the implementation of a scalable network. In case of large networks requiring the management of numerous addresses, the routers need to retain big volumes of routes within their routing table. RA incorporates a group of routes and consolidates them into a lone entry corresponding to a common route advertisement [3-17]. Consequently, reduction in the number of routes to be maintained is done by the routers. The process of aggregation and concluding a single address advertisement involve the following steps:

A) The process starts with the translation of the group of contiguous addresses to binary format and positioning in the list.

B) Detecting the similar patterns of binary bits amongst the group of addresses and delineate the end of the similar bits.

C) Calculating the number of similar bits in the addresses and thus, forming the aggregate route to be advertised by representing it by the first block of address succeeded by the slash succeeded by the no. of similar bits.

Fig. (2) explains the formation of the common address generated through aggregation of routes.

The common address is arrived at using the following steps:

Step 1: The addresses are converted to binary format and are arranged in a list.

Step 2: The bit pertaining to the end of common pattern of digits is located.

Table 1. Detected queries table at router R1 before aggregation.

<table>
<thead>
<tr>
<th>128.16.12.0/24</th>
</tr>
</thead>
<tbody>
<tr>
<td>128.16.13.0/24</td>
</tr>
<tr>
<td>128.16.14.0/24</td>
</tr>
<tr>
<td>128.16.15.0/24</td>
</tr>
</tbody>
</table>

Table 2. Detected queries table at router R1 after aggregation.

| 128.16.12.0/22 |

Thus, Fig. (2) reveals that:

- The Routing table of R1 has reduced number of entries after Route Aggregation and thus, memory saving is achieved.
- Bandwidth requirement on the R1, the R2 link is reduced.
- Few entries in the routing table lead to the packet evaluation for fewer routes and therefore, save CPU resources.
The Table 1 shows the routing table of router R1 before aggregation whereas Table 2 shows the table of Router R1 after aggregation. Clearly, aggregation proves to save bandwidth and other scarce resources.

3. METHODOLOGY

Figs. (3 & 4) elaborate the ZRP-RA process and the formation of Zone Heads and aggregation. The suggested algorithm addresses the problems encountered in the efficient performance of ZRP and proposes a solution for optimizing the ZRP performance for a scalable network. The algorithm is based on the formation of additional bigger zones amongst the already formed zones and the process commences with the formation of a random Zone Head amongst the various already formed zones within the network. The head node maintains the route list for all the nodes in the newly formed bigger zone and thus, functions as a center head for the now formed zone. The algorithm takes care of any new zone entry in the bigger zone and of any lost node in the bigger zone and updates the new zone head accordingly. It then applies RA at the zone head and thus address of the only zone head is advertised to all the nodes in the zone whereas, the zone head contains all the routes pertaining to all the nodes in the bigger zone.

Fig. (3). Aggregation of routes and generation of common route.

The proposed algorithm works similar to ZRP if the destination lies within the zone of the source node. The proposed approach comes into action on the case, the destination lies outside of the source node zone as the ROUTE REQUEST is border-casted to the peripheral nodes. Due to the aggregation of routes applied at Zone Head, each peripheral node checks its Zone Head for a route to the destination node. This saves the computational resources and saves bandwidth between the links. The algorithm selects the nodes from the zones and elects a Zone Head arbitrarily. It then attains the zone table entries for all the nodes now under the bigger zone governed by the Zone Head, succeeded by the listing of possible routes for all the nodes within the zone headed by the Zone Head. Routes are then aggregated at the Zone Head. The algorithm also has a mechanism for constant check and update Zone Head.

4. RESULT ANALYSIS

This section constitutes the comparative review of ZRP and ZRP-RA for distinct evaluation approaches like Packet Loss Ratio, Jitter and Average Energy Consumption with increasing number of nodes.

QOS (Quality of Service) parameters that are being enhanced by ZRP-RA approach are listed and discussed below:
Table 3. Simulation setup for ZRP and ZRP-RA (route aggregation).

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Network Area</td>
<td>1000x1000 m²</td>
</tr>
<tr>
<td>Velocity</td>
<td>1~2 m/s</td>
</tr>
<tr>
<td>No. of Nodes</td>
<td>25, 50, 75, 100</td>
</tr>
<tr>
<td>Packet Size</td>
<td>512 byte</td>
</tr>
<tr>
<td>Traffic Type</td>
<td>CBR</td>
</tr>
<tr>
<td>Number of Connection</td>
<td>20</td>
</tr>
<tr>
<td>Packet rate</td>
<td>2 P/s</td>
</tr>
<tr>
<td>Simulation Time</td>
<td>100</td>
</tr>
</tbody>
</table>

4.1. Packet Loss Ratio

It is given by the aggregate number of packets dropped at a specific time. Packets lost is calculated by subtracting the packets received at the specific time from the packets sent at that time. The lesser the ratio the efficient the data transfer is in the network.

Table 4. Packet loss ratio comparison of ZRP and ZRP-RA.

<table>
<thead>
<tr>
<th>Packet Loss Ratio</th>
<th>25</th>
<th>50</th>
<th>75</th>
<th>100</th>
</tr>
</thead>
<tbody>
<tr>
<td>ZRP</td>
<td>57.79</td>
<td>1.62</td>
<td>48.59</td>
<td>65</td>
</tr>
<tr>
<td>ZRP-RA</td>
<td>47.93</td>
<td>1.22</td>
<td>40.72</td>
<td>58.87</td>
</tr>
</tbody>
</table>

Overall Improvement: 16.84516%

Table 4 and Fig. (5) depict an overall improvement of 16.84516% in reducing the number of packets lost thereby improving the performance of ZRP-RA and thus validating the ZRP-RA approach.

4.2. Average Energy Consumption

The major portion of the node energy is dissipated while transmitting and receiving the data packets. The energy in the battery gets exhausted ascribable to the power needed to transmit control and routing packets. Energy Consumption is calculated by finding the product of power and time. Energy needed for transmitting or receiving the packets with standard size is converted into joules and thus, average energy consumption is computed. The lesser the average energy consumed the longer the network can sustain.

Table 5. Average energy consumption comparison of ZRP and ZRP-RA.

<table>
<thead>
<tr>
<th>Average Energy Consumption</th>
<th>25</th>
<th>50</th>
<th>75</th>
<th>100</th>
</tr>
</thead>
<tbody>
<tr>
<td>ZRP</td>
<td>0.69</td>
<td>0.62</td>
<td>0.67</td>
<td>0.72</td>
</tr>
<tr>
<td>ZRP-RA</td>
<td>0.68</td>
<td>0.58</td>
<td>0.63</td>
<td>0.69</td>
</tr>
</tbody>
</table>

Overall Improvement: 4.509426%

Fig. (6). Alterations in the average energy consumption for ZRP and ZRP-RA.

Table 5 and Fig. 6 depict an overall improvement of 4.509426% in the amount of energy consumed, thereby improving the performance of...
ZRP-RA and thus, validating the ZRP-RA approach

Jitter: Jitter is one of the main significant parameters pertaining to the application layer. While considering the QOS of the network, jitter becomes one of the essential parameters. It is defined as the measure of time variation between the packets received. It refers to the dissimilar delays in time between the packets reaching the destination node. The main contributors to the delay are congestion in the network or any changes in the route. The low value of jitter indicates better performance of the protocol.

Table 6. Jitter comparison analysis of ZRP and ZRP-RA.

<table>
<thead>
<tr>
<th>Jitter</th>
<th>25</th>
<th>50</th>
<th>75</th>
<th>100</th>
</tr>
</thead>
<tbody>
<tr>
<td>ZRP</td>
<td>0.013</td>
<td>0.029</td>
<td>0.023</td>
<td>0.031</td>
</tr>
<tr>
<td>ZRP-RA</td>
<td>0.011</td>
<td>0.016</td>
<td>0.016</td>
<td>0.019</td>
</tr>
</tbody>
</table>

Overall Improvement: 32.33917%

CONCLUSION

Section 1 gives a comprehensive view of the problems faced by ZRP. This section details the solution provided by ZRP-RA to all the mentioned issues. ZRP-RA manages to reduce the routing overhead by aggregating the routes at the Zone Head thus, reducing the no. of ROUTE REQUESTs and further, accomplishes an improvement of nearly 17% in the case of Packet losses even under increasing nodes. The improvement is a result of less congestion within the network because of reduced overhead. Another problem faced by ZRP is the storage required in the case of larger networks. ZRP-RA reduces the storage required by aggregating a few routes and replacing with a single route information. This helps achieve memory saving but also involves little computation hence, the Average Energy Consumption is almost similar in both the cases but still amelioration of 4.5% is observed. This could be as a result of a little reduction in the number of computations required by traditional ZRP. Jitter refers to the delay variations, often arising due to different queuing delays experienced by consecutive packets. It can be easily concluded that jitter experiences significant improvement of 32.33917% in case of ZRP-RA. This is an eminent result in comparison to ZRP. The reduction in congestion in the network due to a reduction in the control packets helps reduce queuing delay even without the need of Query Control approaches thus, ZRP-RA can help render a scalable network.

The simulation results are indicative of the development of a better performing algorithmic modification of ZRP. Furthermore, the results manifest saving in the average energy consumption even with a high number of nodes. In the above section validation of the novel, RA based approach is being provided. ZRP-RA manages to reduce the routing overhead by aggregating the routes at the zone head, hence reducing ROUTE REQUESTs packets being sent. Optimization of various QOS parameters is achieved by the novel approach where packet losses are reduced, less congestion within the network because of reduced overhead, reduction in storage required by aggregating a few routes and replacing with a single route information which leads to memory optimization too, reduction in the number of computations required by traditional ZRP, reduction of jitter and reduction in queuing delay. All the above
factors validate the RA based approach. As future work, it can be endeavored to put an energy efficiency constraint and a mechanism can be incorporated to select nodes with more residual energy to be chosen as zone head which can also ensure greater network lifetime [18, 19].

CONSENT FOR PUBLICATION
Not applicable.

CONFLICT OF INTEREST
The authors declare no conflict of interest, financial or otherwise.

ACKNOWLEDGEMENTS
Declared none.

REFERENCES
[13] Le F, Xie GG, Zhang H. On route aggregation. In: proceedings of the seventh conference on emerging networking experiments and technologies 2011; Tokyo, Japan, 6 December, NY, USA.