DEVELOPMENT AND EVALUATION OF ENHANCED AODV PROTOCOL FOR ROUTE DISCOVERY IN MOBILE AD-HOC NETWORK

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ABSTRACT

Ad-hoc On-demand Distance Vector (AODV) routing protocol is one of the most popular routing protocol for mobile ad-hoc networks. This work optimizes AODV protocol by minimizing the sum of load and delay. Enhancements include developing an improved version of AODV protocol which uses load and delay parameters to select a path with minimum weight. This is a weight based algorithm where weight is calculated in terms of load (i.e. Number of packets received at a node) and delay (End-to-End delay). Recently, we have proposed this multipath based routing scheme on MANETs. It is an appealing scheme which outperforms AODV [1] and TAODV [2] in terms of End-to-end delay, packet delivery ratio in different simulation scenarios. In this paper we evaluate performance of the proposed scheme based on different performance metrics like Load balancing efficiency, jitter, End-to-end delay, packet delivery ratio, etc. and compare it with some of the recent techniques proposed in [3], [4], [5], [6] and [7] considering more parameters like jitter and load balancing efficiency in the network. The simulation is done using NS3.13 simulator. The results show that the proposed enhancement outperforms many of the existing algorithms and it is expected to achieve efficient resource utilization.

Keywords: Mobile Ad-Hoc Networks, AODV, Route Discovery, Weight, Load, Delay.

I. INTRODUCTION

An ad-hoc wireless network consists of a set of wireless nodes that communicate with each other without any fixed infrastructure. Mobile Ad-Hoc networks have benefits and versatility for many applications in commercial, educational and military where setting up of a fixed network is difficult.
Generally Mobile Ad-hoc networks work with reactive routing protocols that initiate route discovery only on demand, for routing of packets. In reactive routing protocols, routes from source to destination are maintained all the time. Therefore, when packets are to be sent the route is already available unlike reactive protocols. Hence reactive routing protocols incur more route discovery delay. Mobile Ad-hoc networks involve hosts with limited resources. Therefore, there is a need of protocols which consume minimum resources. Since, in reactive protocols, routes are not maintained on permanent basis, maintenance cost and control overhead is less and hence is more suitable for Mobile Ad-hoc networks.

This type of network does not depend on any fixed infrastructure or base stations. The mobile devices are expected to work as routers and thus perform route discovery and maintenance. Fig. 1 illustrates a typical Mobile Ad-Hoc Network. The topology in MANET is dynamic and it changes unpredictably. As a result, routing is a challenging issue in Ad-Hoc network. A few other important issues of Mobile Ad-Hoc network are Security, limited resources like power and bandwidth, absence of centralized control.

This paper proposes an enhancement of AODV routing protocol considering load balancing and minimization of delay.

Rest of the paper is organized as follows. Section II explains the literature relevant to proposed work. Section III explains proposed idea and algorithm implementation. Section IV focuses on simulation and its results. Also, it explains comparison of proposed work with some already existing schemes. Finally, Section V puts forth the conclusion of work performed and future enhancements possible.

II. LITERATURE SURVEY

In the wired networks, the routing protocols Routing Information Protocol (RIP, distance vector routing) and Open Shortest Path First (OSPF, link state routing) are suitable. The dynamic nature of MANET causes random and unpredictable changes in the routes of the network owing to which above protocols cannot be used here as they require more CPU memory, Battery, etc.[8].

![Fig. 1: Example of MANET](image)

The most popular protocol used in Mobile Ad-Hoc network is the Ad-hoc on-demand distance vector (AODV) [1] which is a reactive routing protocol. It discovers a shortest and updated route when required using broadcast message. It uses sequence number to maintain updated routes as in DSDV. It operates with the help of four control messages explained as follows.

Route Request (RREQ): When a source node wants to send packet for which route is not available, it floods a RREQ message to all its neighbours. This message contains information viz. Source IP, request ID, source sequence number, Destination IP, Destination sequence number and hop count.

Route Reply (RREP): If a node receiving RREQ is itself a destination or has a valid route to destination it sends a RREP to source node which contains information viz. Source IP, Destination IP, Destination sequence number, lifetime and hop count.
Route Error (RRER): When a node in active route is lost, a RRER message is sent to notify others of link breakage on both the sides.

A node initiates a RERR message if

1. If it detects a link break for the next hop of an active route in its routing table, or
2. If it gets a data packet destined to a node for which it does not have an active route, or
3. If it receives a RERR from a neighbour for one or more active routes

HELLO Messages: Each node sends a HELLO message to its neighbours to inform them that the link is active. Nodes do not forward these messages. The receiving neighbours update the lifetime of sending node link in routing table.

Route discovery process: When a source node wants to send packet to a node it forwards a RREQ to all its neighbours. Receiving node checks freshness of request using source IP, sequence number, request ID. If it has latest route to destination or is the destination then it replies with a RREP. If it does not have route then it forwards the RREQ to its neighbours and sets a reverse path to source node. If request is duplicate, it is discarded.

Route maintenance: A periodic HELLO message is sent by an active node to its neighbours. If a node does not receive HELLO from neighbour it forwards a RRER to the source and route is invalidated. Source node may again initiate route discovery if needed.

The scheme in [6] proposes an improvement over AODV by considering a mixed metric of delay and number of hops. The route selection decision is taken using fuzzy logic. Each node embeds a fuzzy system to calculate fuzzy cost when it receives a request message. The number of hops and delay are fuzzy input parameters.

The scheme in [14] proposes a load-balancing scheme which performs load balancing based on three metrics i.e. residual battery capacity, average interface queue length and hop count along with the its weight values. It achieves load balancing and extended battery life. It selects load balanced path based on weight calculated for each path.

Reference number [20] proposes a load balancing routing protocol which tries to minimize the routing overhead and increase network performance. It divides nodes into 3 categories i.e. trunk, normal and terminal nodes. Every node handles congestion problem by keeping itself congestion free. Congestion threshold depends on queue length which is set to a specific value. In this scheme, however, each node needs to maintain the congestion level information.

The scheme in reference number [21] focuses on improving broadcasting efficiency. It narrows the RREQ flooding based on mobility of nodes. It prefers fast moving nodes for forwarding RREQ based on the assumption that fast moving nodes have better idea of recent routes as compared to slow moving nodes which are not aware of fast changes in topology.

III. PROPOSED WORK

The proposed technique uses AODV routing scheme as the base on which optimization is applied. For a given pair of source node and destination node, multiple paths are generated prioritized according to their weight. Amongst them a path is selected with minimum weight. Weight of path is sum of average load of path and average delay of path. Average load of a path is average of load of all the nodes in the path (including source, destination and all intermediate nodes). Same is the calculation for delay of a path.
This scheme considers queuing delay as the delay parameter and number of packets received at a node as load parameter.

Using above two parameters, weight of a path is given as:

\[
\text{Weight of a path} = pl \times \text{Load} + pd \times \text{delay} \quad (I)
\]

Where \(pl\) and \(pd\) are constants such that their sum is equal to 1. These constants help in giving varying weight age to load and delay.

In the networks with heavy traffic, some nodes may be heavily loaded than others resulting into congestion. This may cause loss of packets. In such type of scenario, load is an important factor over delay. Routes which have less load may be preferred irrespective of delay on that route. This helps in load balancing and avoiding congested paths. Therefore here, \(pl\) value is set significantly greater than \(pd\) (Ex. \(pl=1\) and \(pd=0\)).

In the networks with high mobility rate and long distances, a node may not be loaded due to frequent change in its position. In such a scenario, delay plays an important role than load. Here, \(pd\) is set much greater than \(pl\) according to the requirement (Ex. \(Pl=0\) and \(pd=1\)).

A. Algorithm

The scheme is realized by performing following two processes.

1) Implementation of AODV in NS3
   1. Start simulation using AODV routing protocol
   2. Flood RREQ for every node
   3. Fetch flow statistics such as number of packets received, number of bytes received, delay, etc.
   4. Collect the statistics into an XML file

2) Detection of optimal path and simulation in Java
   1. Read XML file using DOM parser
   2. Fetch average load and delay for every node
   3. Calculate the weight for every path by summing the average load and average delay for each node in the path.
   4. Select a path which gives minimum weight
   5. Display all nodes at their respective x and y co-ordinates along with the optimal path between given source and destination node.

IV. SIMULATION AND RESULTS

A. Introduction

   NS 3.13 simulator was used to implement AODV protocol. In this work, we compare the performance of our scheme with AODV, RTLB, MRFR, FAODV, Packet scheduling Algorithm, AODV-LINE and AODV-LAR based on performance metrics like metrics such as Packet delivery ratio, End-to-end delay, traffic load, average jitter, etc.

B. Simulation Model

   The simulation parameters are given in Table-1. The boundary area fixed for simulation is 400 X 400 m.
### TABLE I

**SIMULATION PARAMETERS**

<table>
<thead>
<tr>
<th>Simulation Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Routing protocol</td>
<td>AODV</td>
</tr>
<tr>
<td>Nodes</td>
<td>18 to 100</td>
</tr>
<tr>
<td>Simulation time</td>
<td>100 seconds</td>
</tr>
<tr>
<td>Packet size</td>
<td>1000 bytes</td>
</tr>
<tr>
<td>Mobility Model</td>
<td>Random Way Point Model</td>
</tr>
<tr>
<td>Traffic Model</td>
<td>Constant Bit Rate</td>
</tr>
<tr>
<td>Node speed</td>
<td>1 to 20 m/s</td>
</tr>
<tr>
<td>Pause Time</td>
<td>5 seconds</td>
</tr>
</tbody>
</table>

C. Simulation Results

Simulation of AODV generates an Xml file which is fed to JAVA simulation program that computes all the paths possible between given source and destination prioritized according to the weight using the simulation statistics contained in Xml file. Finally, it also generates a graphical representation of the optimal path that is with minimum weight.

D. Performance metrics

We conducted at least 40 experiments to plot data graphs in all the charts below.

We vary the traffic load, the degree of mobility and network size in the simulations. We vary traffic load by changing the packet sending rate. We control the degree of mobility through the pause time. We use pause times of 0 (i.e. constant movement), 20, 40, 60, 80 and 100 seconds. This scenario arranges the movement and the position of the nodes according to the random waypoint model.

**Packet Delivery Ratio vs. Traffic Load**

Fig.2 shows the plot of Packet Delivery Ratio as a function of packet sending rate for proposed scheme, AODV, RTLB and MRFR. The Packet delivery decreases with increase in traffic load. For packet sending rate 3 and above the Packet delivery ratio of proposed algorithm is significantly greater than AODV and MRFR.

**End-to-End Delay vs. Traffic Load**

Fig.3 shows comparison of proposed algorithm with AODV, FAODV and RTLB based on End-to-End Delay. There is a gradual increase in delay but the delay of proposed algorithm is lesser than AODV for all traffic scenarios, nevertheless it is dominated by RTLB. For increased traffic i.e. 3, 4, 5, we give more weight to load parameter (pl) in comparison to delay parameter (pd). Hence during calculation of optimal path, a path with lesser load is preferred giving very minimal emphasis to delay value for that path. If delay parameter (pd) is given more emphasis in this case, the end-to-end delay is reduced to a greater extent an average of 0.05 for all traffic scenarios.
In Fig. 4 we show the comparison of proposed scheme with AODV, MRFR and RTLB. There is a significant decrease in Average Jitter achieved by proposed scheme as compared with AODV. It is comparable with that of RTLB and MRFR.

**Packet Delivery Ratio vs. Pause Time**

We compared proposed algorithm with AODV and Packet scheduling algorithm based on their Packet Delivery ratio as a function of Pause time. The rate of increase in PDR for proposed scheme is greater than that of AODV and packet scheduling algorithm as shown in Fig. 5. It is
expected to converge with others if pause time is increased further by 40 seconds. We obtained best results for a 20 node network with inter packet interval of 5 seconds.

Fig. 5: Comparison of Proposed Algorithm with Packet scheduling based AODV and basic AODV based on Packet Delivery Ratio vs. Pause time

![Comparison of Proposed Algorithm with Packet scheduling based AODV and basic AODV based on Packet Delivery Ratio vs. Pause time](image1.png)

Fig.6: Comparison of Proposed Algorithm with AODV, AODV-LINE and AODV-LAR based on Packet Delivery Ratio vs. No. Of nodes

![Comparison of Proposed Algorithm with AODV, AODV-LINE and AODV-LAR based on Packet Delivery Ratio vs. No. Of nodes](image2.png)

Fig. 7: Load balancing efficiency of Proposed Algorithm vs. CBR Traffic

**Packet Delivery Ratio vs. Number of Nodes**

We compared Packet Delivery Ratio of proposed scheme with AODV, AODV-LAR and AODV-LINE as a function of number of nodes. The PDR decreases by approximately 1% to 2% for each increase in network size. But delivery ratio achieved by proposed scheme is greater than all other schemes compared in Fig. 6. Hence, we can infer that proposed scheme is more scalable than AODV, AODV-LINE and AODV-LAR in terms of Packet delivery ratio. Here we set inter packet interval to 1 second.
**Load Balancing Efficiency vs. CBR Traffic Load**

Fig. 7 shows the load balancing efficiency of the proposed scheme as a function of traffic load. The load is considered in terms of data packets sent per second. Efficiency varies from 61% to 90%. It increases gradually from lightly loaded network to heavy loaded network. It can be inferred that the load handling capability of the proposed scheme is magnified for heavy loaded network. This is achieved by giving more weightage to load parameter (pd) while calculating weight of a path by using equation 1. For heavy traffic scenarios we set pl=1 and pd=0 thus giving complete preference to load over delay.

We calculate load balancing efficiency as the percentage difference in load of selected path and average load of alternative paths available.

**V. CONCLUSIONS**

Our work focuses on maintaining Quality of Service by optimizing AODV on the basis of load and delay. Also, we maintain multiple routes between given source and destination prioritized according to their weight. This helps in quick recovery after failure. In this work we evaluated the performance of proposed algorithm and compared the results with RTLBM, MRFR, AODV-LINE and AODV-LAR, FAODV and packet scheduling algorithm. We found that it outperforms said schemes in terms of Packet delivery ratio, average jitter and End-to-End delay for different network scenarios. Also the weight based formulation of path increases load balancing efficiency in heavily loaded network conditions.

The technique may be extended to reduce routing overhead by using localization technique. The location information of nodes can be used to narrow down blind flooding of RREQ. This is expected to reduce the route discovery delay significantly.

**REFERENCES**


