An Enhanced Receiver-Based Ad hoc On-Demand Routing Protocols for Mobile Ad hoc Networks

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Abstract

In high mobility and high traffic load network situations, the delay time is affected with high end-to-end delay in reactive routing protocols such as AODV. In this paper we proposed an enhanced receiver-based AODV (ERB-AODV) routing protocol by improving the maintenance phase in AODV. ERB-AODV protocol focuses on decreasing the end-to-end delay and the control overhead in high mobility and traffic load. The receiver node uses a controller agent to update the sender node of the current available path. The agent works depend on the history of receiving data packets. Using glomosim, the ERB-ADOV protocol outperforms the AODV protocol in high mobility and traffic load. Results show that, in high mobility, the delay is decreased by 81% and the control overhead is decreased by 77%.

Keywords. Mobile Ad hoc Network; reactive routing protocol; AODV; glomosim

Introduction

Mobile ad-hoc networks (MANETs) consist of a set of devices with wireless facility (nodes) that are connected together through wireless links. This type of network is suitable in applications with limited resources and time. Examples of applications in MANETs are include military, rescue and emergency, conferences and meetings. MANET is easy to deploy in fast and simple ways as it requires only two or more mobile nodes [1]. In addition to MANET, there are different types of ad hoc networks, which are wireless sensor network (WSN) [2, 3], vehicular networks (VANET) [4], and underwater wireless networks [5]. With these networks and with the absence of a base station, each node acts as a router that manages the network. It learns about the network and communicates with other nodes by responding with different data/control packets. As nodes have limited resources (i.e. limited battery life, memory, bandwidth), the communication life between them is limited and depends on the network environment (for example: static, dynamic, dense, congested, etc.).

Ad hoc on-demand distance vector (AODV) [6] routing protocol is a reactive routing protocol that starts when a sender node has data to send to another node, which is the receiver node. In this case, the sender will broadcast a request packet for the route, RREQ, to discover the path. The receiver node, upon receiving the request packet will send a unicast reply packet, RREP, which follows the reverse path through the upstream nodes toward the source node to start sending data packets. When a link has broken in the route, the intermediate node sends a route error packet, RRER, to inform the sender node of the problem. The sender node starts the discovery phase again if demanded to find new path to the receiver node. Limitation of AODV protocol is as follows: during the discovery phase, if the reply packet faced problems reaching the sender, the sender must start the discovery process all over again which increases the overhead in high mobility and high traffic load and affects the network performance especially in terms of increasing network delay. In addition, reliability to find new paths with less network flooding to discover a new path becomes one of the important challenges which has attracted researchers in improving distance vector routing protocols [7, 8]. Different protocols try to improve the AODV by focusing on the network QoS such as delay, bandwidth, or decreasing the control overhead. Examples of these protocols are in [9, 10], and a review for QoS protocols can be found in [11]. These protocols may not work efficiently when the network is less reliable with the limited resources of the network or with high mobility.

In receiver-based routing protocol RB-AODV [12], the authors have proposed a protocol based on broadcasting reverse request packets focused on the sender node. When the receiver node receives the first request packet, the reply packet will be sent as unicast to the sender node. After that, the receiver waits for a period of time to receive data packets. When this timer expires, the reverse request control packet is broadcasted to update the sender with the new path. The intermediate nodes treat this control packet like the request packet issued by the sender in AODV. When the sender node receives the first control packet, it starts sending the data packets using this new path. The receiver node continues broadcasting the control packets until three successive expired times with no received data from the sender. This protocol decreases the delay and overhead when compared with AODV protocol. The protocol still suffer of increasing control overhead while there is no controlling when to stop broadcasting control packets in the network

.The authors in [13] have suggested to do bidirectional repair process, to improve the maintenance phase in ad hoc on-demand routing protocol, by allowing the intermediate nodes to send error packets to both end nodes, i.e. source and destination nodes. The destination node along with sender node, broadcast a reverse RREQ packets. The control packets will not be farther broadcasted when intersected in an intermediate node. The intermediate node then send reply packet to update the nodes in the path toward the sender. However, even with the use of the receiver node in discovery or maintenance processes, the distance vector on-demand single paths routing protocols suffer from high end-to-end delay in high mobility conditions and traffic load [14].

Therefore, in this paper, the Enhanced Receiver-Based Routing Protocol (ERB-AODV) protocol tries to decrease the delay and overhead in high mobility and traffic load. The idea is to face the congestion be sending broadcast from the receiver during the demand of the receiver to send data. These packets will travel through uncongested nodes and find available paths with less repairing time as in other on-demand protocols. The receiver role is to update the sender of the currently available path that can be used. As a result, the path acquisition time is decreased and the overhead is also decreased. This paper enhanced (RB-AODV)[12] protocol by decreasing the number of control packets issued by the receiver for updating the sender for the new path. This is by tracking the received data packets during a specified time.

The flow of this paper is outlined as follows: section 2 explains the ER-AODV routing protocol. Section presents the simulation results. Section 4 concludes the paper works.

Enhanced Receiver-Based AODV Routing Protocol

Sending broadcast control packets from the receiver to the sender will decrease the control overhead in the network as proven in R-AODV protocol for minimizing the overhead during the discovery process. The proposed ERBAODV is using this mechanism in maintenance phase to reduce the overhead especially in high mobility and high traffic load networks. In such condition, paths currently in use are vulnerable to breakage and the sender node will broadcast the network looking for new a path.

Another advantage is that the broadcast packets , issued by receiver node, given the chance to decrease the time needed to discover new path, and hence the delay time is less compared to ordinary mechanisms such in AODV protocol. The source node uses the current active path when receiving first control packet. The proposed ERB_AODV protocol follows the same AODV routing protocol with two main phases, discovery phase and maintenance phase.

Discovery Phase

In this phase, when a sender node needs to communicate with the destination node, it first looks in the routing table for any available path. If there is no valid path, the sender will broadcast a control packet requesting for a path to the destination. This control packet, called route request packet (RREQ), contains information like the address of both sender and receiver nodes addresses and sequence numbers, the number of hops and the broadcast ID. Every intermediate node sends the first RREQ packet received with the same broadcast ID issued by the sender node looking for a destination node. In addition, the intermediate node saves this information in the routing table to be used when building the path. When the destination received the first RREQ packet, it sends a unicast reply packet (RREP) back to the sender node. The sender node then starts sending data packets upon receiving the reply packet.

Maintenance Phase

In this phase, when the first session was created between the sender and receiver nodes through the discovery phase, the receiver node started controlling communication status. This is done by designing the receiver controller agent (Rec_Ctrl) as shown in Table 1. The receiver node starts a timer known as waiting time (Wtime) when sending the reply packet. The purpose of this timer is to check the number of times the receiver node receives data packets. If the receiver did not receive any data packets during this time (dataReceivedFlag =0), then the receiver node broadcasts a receiver route request packet (RRREQ) looking for a path to connect with the sender node as depicted in Figure 1. The isSent will be set to 1, and the agent will re-establish the Wtime again. isSent is used here to determine if the agent must be restarted even when receiving new request packets. A value of 1 means the agent is in the action of communicating with the sender node and will broadcast the RRREQ when Wtime expires. If zero, the receiver node has stopped broadcasting the RRREQ packets. The RRREQ acts like the RREQ in the discovery phase. Upon receiving the first RRREQ packet by the sender node, the sender starts using this new path to send data packets directly.

Table 1: Rec-Ctrl agent

Rec-Ctrl variables	role
dataReceivedFlag	Indicate if there is data received
Counter	Count the number of sent RRREQ
isSent	Indicate if already sent RRREQ
Wtime	Period of time waiting to receive data packets
Cthreshold	Maximum number of sent RRREQ without receiving data packets of each Wtime

In Equation 1, the Wtime is calculated as follows:

$$\boldsymbol{Wtime = x \times nodetraversaltime \times numberofhops_i} \quad (1)$$

where x is used to define the number of times we need to wait to receive data packets.

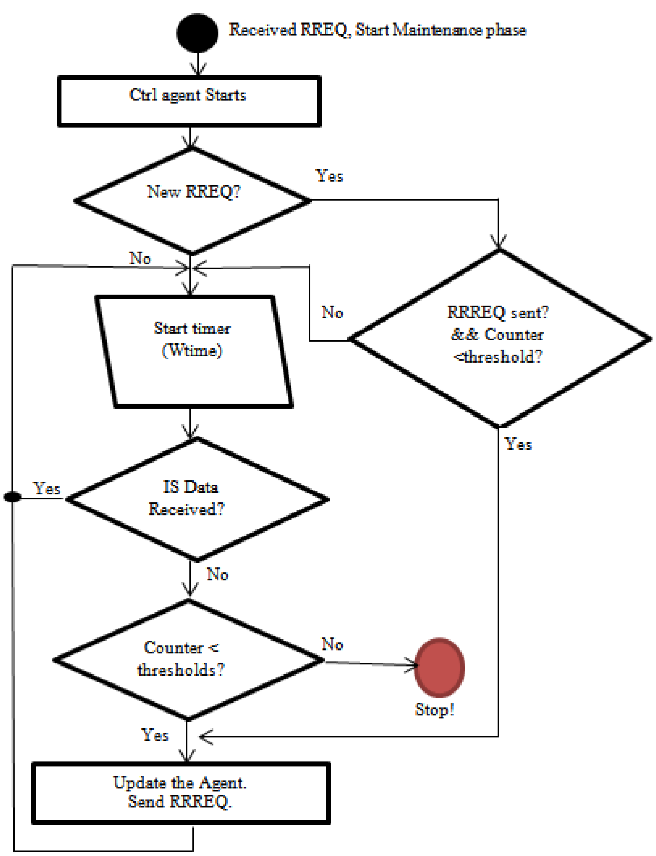

Figure 1: Maintenance phase when receiver node receives RREQ packet

If the receiver node has received any data packets during Wtime timer, then it will start the Wtime again without sending the RRREQ packet. The agent here assumes that the current connection still working with no problem. If after Wtime expires and there is no data received, the RRREQ packet will be broadcasted through the network. The controller will stop sending the update packets when the counter reaches Cthreshold. The agent learns there are no need for another connection and waits for new session to start.

The reason for not receiving data packets could be either the sender finished sending data packets, or there is a problem in the active path. It is assumed that the intermediate nodes stop sending error packets to the sender node in the case of error. Error packets increase the overhead in the network and also increase the delay time to find a path. The error notifications will be used when deal with multipath in future works.

Results and Discussion

The simulation is used to test and verify the proposed protocol is GloMosim [15]. The simulation configuration is shown in Table 2. The experiment is to evaluate the performance of ERB-AODV and RB-AODV in different mobility conditions and to compare it with AODV protocol.

Table 2: Simulation configuration parameters

Parameter Name	Terrain size	Number of nodes	Mobility model	Maximum Speed	Pause time	Traffic generator	Packet size	Traffic speed	Wtime(x)
Parameter value	1000x1000	50	RWP	10 m/s	0s, 5s, and 10 s	CBR	512 Bytes	8 pkt/s	8

The routing protocols that are tested: AODV, RB-AODV, and the proposed protocol ERB-AODV. The performance metrics used are the delay, and control overhead. The improvement of proposed protocol compared to AODV protocol is measured using the formula:

$$Improvement = \frac{ERBAODV - other\ protocol\ performance}{other\ protocol\ performace} \times 100 \qquad (2)$$

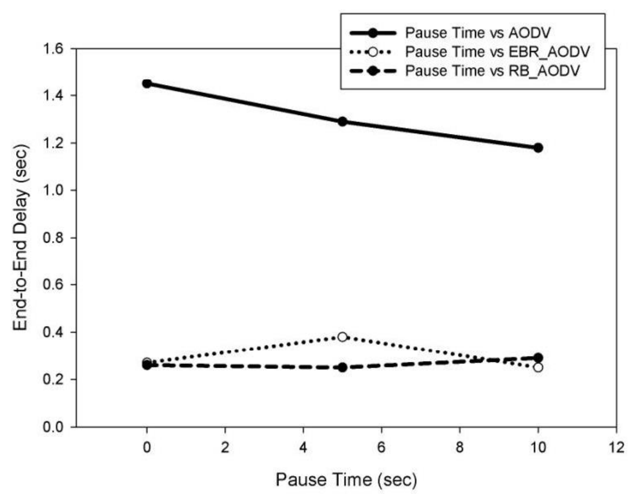

Figure 2: End-to-End delay with varied pausing time

Figure 2 shows the impact of the mobility in high traffic load on the end-to-end delay performance. The performance of both receiver-based mechanisms outperforms AODV protocol. The improvement obtained by ERB-AODV at pause time 0 sec is that the end-to-end delay is less by 81% compared to AODV protocol, and 78.8% less at pause time 10 sec. Although RB-AODV sends update packets periodically which affect the overall control overhead, it gives the sender new path to be used. For that, the delay is close between RB-AODV and the ERB-AODV protocols.

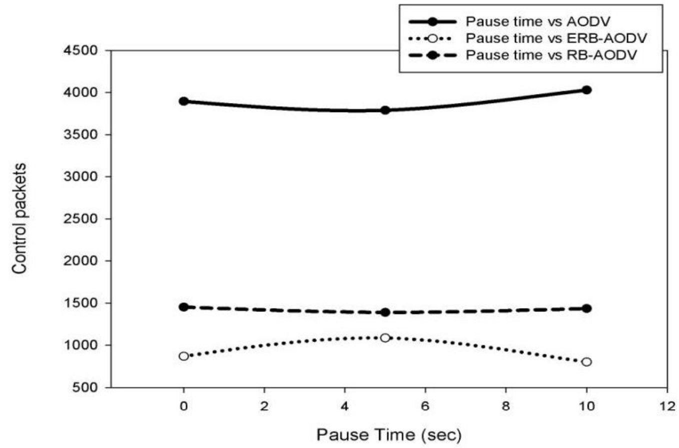

Figure 3: Control overhead with varied pausing time

The average control overhead as shown in Figure 3 verifies that RB-AODV broadcasts more control packets than ERB-AODV. The former broadcasts the update packets from the receiver node after each Wtime expires, whereas ERB-AODV only broadcasts control packets when there is no data packet received during the Wtime period. The improvement obtained by ERB-AODV protocol is that the control overhead is decreased by 77% at pause time 0 sec, and 80% at pause time 10 sec, when compared with AODV protocol.

Conclusion

In this paper, we illustrated the effects of high mobility and traffic load on network performance in MANETs using AODV protocol. We focused on decreasing end-to-end delay and control overhead caused in congested network by proposing an ERB-AODV routing protocol. ERB-AODV protocol proposed enhanced maintenance phase in AODV protocol. The results show that ERB-AODV protocol improved the network performance when compared with the standard AODV protocol. The results show that, the end-to-end delay is decreased by 81% compared to AODV in high mobility. And control overhead is decreased by 77%. Updating the source with new available path before the current used path is broken is important in decreasing the delay and control overhead. For future work, we will focus on enhancing the PDR and study the improvement on performance by selecting multiple paths from update packets.

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