A REVERSE AND ENHANCED AODV ROUTING PROTOCOL FOR MANETS

M. Sanabani[1], R. Alsaqour[2] and S. Kurkushi[1]
[1]Faculty of Computer Science and Information Systems, Thamar University, Thamar, Republic of Yemen
[2]School of Computer Science, Faculty of Information Science and Technology, University Kebangsaan Malaysia, Bangi, Selangor, Malaysia
E-Mail: raed.ftsm@gmail.com

ABSTRACT

Mobile Ad Hoc Network (MANET) is an autonomous collection of mobile users that communicate over relatively bandwidth constrained wireless links. Since the nodes are mobile, the network topology may change rapidly and unpredictably over time. The network is decentralized, where all network activity including discovering the topology and delivering packets must be executed by the nodes they, i.e., routing functionality will be incorporated into mobile nodes. An Ad-hoc On-demand Distance Vector routing (AODV) is a representative among the most widely studied on-demand ad hoc routing protocols. Previous protocols have shown some shortcomings on performance of AODV. AODV and most of the on demand ad hoc routing protocols use single RREP along the reverse path. Rapid change of topology causes that the RREP could not arrive to the source node, i.e., after a source node sends several RREQ packets; the node obtains a reply packet, especially on high speed mobility. This increases both in communication delay and power consumption as well as decrease in packet delivery ratio. To avoid these problems, a Reverse AODV (RAODV) has been proposed. RAODV tries multiple route replies which reduces the path fail correction packets and obtains better performance than other protocols. But RAODV has the most control packet overhead. Therefore, in this paper, we propose an Enhanced (EN-RAODV) that is improving the RAODV. The performance is evaluated through NS-2 simulator. Simulation results show that the proposed EN-RAODV improves the performance of network comparing with RAODV and AODV in most selected performance metrics such as packet delivery ratio, end to end delay, throughput, routing packet sent and routing overhead.

Keywords: AODV, reverse AODV, enhanced AODV, simulation, performance evaluation.

INTRODUCTION

A MANET is a type of wireless networks. This type depends on the mobile nodes and there is no infrastructure in such type. There are no routers, servers, access points or cables [1, 2]. Nodes (mobiles) can move freely and in arbitrary ways, so it may change its location from time to time. Each node may be a sender or a receiver, and any node may work as a router and do all router functions. This means that it can forward packets to other nodes. Many applications of MANET's are implemented and used until today like in meeting conferences; military operations; search and rescue operations, all of them are examples of MANET networks [3].

Proactive routing protocols require nodes to exchange routing information periodically and compute routes continuously between any nodes in the network, regardless of using the routes or not. This means a lot of network resources such as energy and bandwidth may be wasted, which is not desirable in MANETs where the resources are constrained [4]. On the other hand, on-demand routing protocols do not exchange routing information periodically. Instead, they discover a route only when it is needed for communication between two nodes. Due to dynamic change of network on MANETs, links between nodes are not permanent. In occasions, a node cannot send packets to the intended next hop node, and as a result packets may be lost. Loss of packets may effect on route performance in different ways. Among these packet losses, loss of RREP brings many more problems because source node needs to re-initiate route discovery procedure [3].

A drawback of existing on-demand routing protocols is that their main route discovery mechanisms are not well concerned about a RREP packet loss. More specifically, most of today's on-demand routing is based on single RREP packet. The loss of RREP packet may cause a significant waste of performance. Reverse AODV (RAODV) which has a novel aspect compared to other on-demand routing protocols on MANETs. In RAODV, RREP packet is not unicast, rather, destination node uses reverse RREQ to find source node. It reduces path fail correction packets and can improve the robustness of performance. Therefore, success rate of route discovery may be increased even though high node mobility situation [5].

MATERIALS AND METHODS

In MANET networks, nodes may move from one location to another on a variety of node speed. As the result, the network topology changes continuously and unpredictably. Only within a short period of time neighboring nodes can lose communication link, especially when the mobility is high. In on-demand routing protocols, losing a communication link between nodes brings route breaks and packet losses [6-9]. Especially, losing the route reply (RREP) packet of AODV protocol produces a large impairment on the AODV protocol. In fact, a RREP packet of AODV is obtained by the cost of flooding the entire network or a

ISSN 1819-6608
ARPN Journal of Engineering and Applied Sciences

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partial area [5]. RREP loss leads to the source node reinitiate route discovery process which causes degrade of the routing performance, like high power consumption, long end-to-end delay and inevitably low packet delivery ratio.

Therefore, we are considering how simply to decrease the loss of RREP packets. We can see a situation in Figure-1, where *S* is a source node, *D* is a destination node and others are intermediate nodes. In traditional AODV, when route request (RREQ) packet is broadcasted by node *S* and each node on a path builds reverse path to the previous node; finally the reverse path $D \rightarrow 3 \rightarrow 2 \rightarrow 1 \rightarrow S$ is built. This reverse path is used to deliver RREP packet to the source node *S*. If node 1 moves towards the arrow direction and goes out of transmission range of node 2, RREP packet missing will occur and the route discovery process will be useless. We can easily know that several alternative paths built by the RREQ packet are ignored. There are some possibilities that after sending a number of RREQ packets, source node can obtain a RREP packet [5].

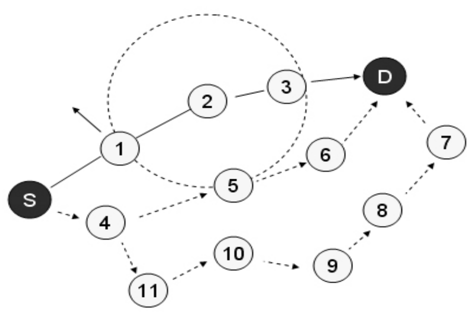

Figure-1. AODV RREP delivery fails.

The proposed RAODV protocol was designed to avoid RREP loss and improve the performance of routing in MANET. RAODV uses absolutely same procedure of RREQ of AODV to deliver RREP packet to the source node. We call the RREP packets as *reverse route request (R-RREQ)* packets. RAODV protocol can reply from destination to source if there is at least one path to the source node. In this manner, RAODV prevents a large number of retransmissions of RREQ packets, and hence diminishes the congestion in the network. Moreover, RAODV improves the routing performance such as packet delivery ratio and end-to-end delay. But there were some problems affected performance of the RAODV, the wastes were the overhead there was affecting about performance of the network.

Ad hoc on-demand distance vector (AODV)

AODV routing protocol creates routes on-demand [10]. In AODV, a route is created only when requested by a network connection and information regarding this route is stored only in the routing tables of those nodes that are present in the path of the route. AODV is a reactive protocol based upon the distance vector algorithm. The algorithm uses different types of packets to discover and maintain links [11]. Whenever a node wants to try and find a route to another node it broadcasts a RREQ to all its neighbors. In this protocol, each terminal does not need to keep a view of the whole network or a route to every other terminal. Nor does it need to periodically exchange route information with the neighbor terminals. Furthermore, only when a mobile terminal has packets to send to a destination does it need to discover and maintain a route to that destination terminal. In AODV, each terminal contains a route table for a destination. A route table stores the following information: destination address and its sequence number, active neighbors for the route, hop count to the destination, and expiration time for the table. The expiration time is updated each time the route is used. If this route has not been used for a specified period of time, it is discarded [12].

A reverse AODV routing protocol

The main objective of developing RAODV protocol is to provide solutions to some conditions which rapidly change in the topology of MANET. These conditions cause RREP packet does not reach the source node, especially when a node moves.

The RAODV protocol discovers routes on-demand using a reverse route discovery procedure. During route discovery procedure, source node and destination node plays the same role from the point of sending control packets. Thus, after receiving RREQ, destination node floods R-RREQ to find the source node. When source node receives an R-RREQ packet, data packet transmission is started immediately [13].

Route discovery in RAODV

Since RAODV is a reactive routing protocol; no permanent routes are stored in nodes. The source node initiates route discovery procedure by broadcasting a RREQ packet which contains the following information: packet type, source address, destination address, broadcast ID, hop count, source sequence number, destination sequence number and request time (timestamp). Whenever the source node issues a new RREQ, the broadcast ID is incremented by one. Thus, the source and destination addresses, together with the broadcast ID, uniquely identify this RREQ packet. The source node broadcasts RREQ to all nodes within its transmission range. These neighboring nodes then rebroadcast the RREQ to other nodes in the same manner. As the RREQ is broadcasted in the whole network, some nodes may receive several copies of the same RREQ. When an intermediate node receives a RREQ, it checks if already received a RREQ with the same broadcast id and source address. Intermediate node drops the redundant RREQ packets. Same as the route discovery process in AODV.

When destination node receives first RREQ packet, it generates R-RREQ packet and broadcasts it to neighbor nodes within its transmission range like the RREQ of the source node does. R-RREQ packet contains the following information: reply source id, reply

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destination id, reply broadcast id, hop count, destination sequence number, reply time (timestamp). When broadcasted R-RREQ packet arrives to an intermediate node, it checks for redundancy. If it already has received the same packet, the RREQ packet is dropped; otherwise it can be forwarded to next nodes.

Furthermore, node stores or updates the following information of routing table:

a) Node IP addresses.
b) Destination and source node address.
c) Number of hops to destination.
d) Destination sequence number.
e) Route expiration time and next hop to the destination node.

Whenever the source node receives the first R-RREQ packet it starts data packet transmission, and the lately arrived R-RREQs are saved for future use. The alternative paths can be used when the primary path fails to keep the connection. Destination node does not unicast reply along the pre-decided shortest reverse path $D\rightarrow 3\rightarrow 2\rightarrow 1\rightarrow S$. Rather, it floods R-RREQ to find source node S and forwarding path to destination are built through this R-RREQ. Following paths might be built, Path $S\rightarrow 4\rightarrow 5\rightarrow 6\rightarrow D$ and path $S\rightarrow 4\rightarrow 11\rightarrow 10\rightarrow 9\rightarrow 8\rightarrow 7\rightarrow D$. Node S can choose the best one of these paths and start forwarding data packet. So RREP delivery failure problem in AODV does not occur in this case, even though node 1 moves from transmission range.

RAODV route update and maintenance

When control packets are received, the source node chooses the best path to update, i.e., first the node compares sequence numbers, and higher sequence numbers mean recent routes. If sequence numbers are same, then compares the number of hops up to destination, routing path with fewer hops is selected. Since the wireless channel quality is time varying, the best path varies over time. The feedback from the MAC layer can be used to detect the connectivity of the link. When a node notifies that its downstream node is out of its transmission range, the node generates a Route Error (RERR) to its upstream node. If failure occurs closer to the destination node, the nodes which receive RRER packet can try local-repair; otherwise the nodes forward RRER until it reaches the source node. The source node can select alternative route or trigger a new route discovery procedure [14].

RESULTS AND DISCUSSIONS

Proposed EN-RAODV protocol

A RAODV routing protocol offered the best services. It used on-demand routing protocol. So it organized routing path when started sending a packet. And it created expire time for maintain the routing table during expire time. So, If nodes do moving during expire time, routing path do not change. If it finds a new shortest routing path than already created a path during expire time, it does not change routing path because RAODV routing protocol must maintain routing path during expire time. Therefore, we proposed Enhanced RAODV (EN-AODV) routing protocol for reset a new shortest routing path during sending a packet.

RAODV uses a simple request-reply mechanism for the discovery of routes. It can use hello packets for connectivity information and signals link breaks on active routes with error packets. Every routing information has a timeout associated with it as well as a sequence number. When a source node S wants to send data packets to a destination node D but does not have a route to D in its routing table, then a route discovery has to be done by S. The data packets are buffered during the route discovery.

Figure-2 is the virtual network topology for EN-RAODV. The source node is 0 and destination node is 4. If it starts routing with fixed nodes, the routing table makes like Tables 1 and 2 for RAODV and EN-RAODV respectively. The values of Table-1 and Table-2 have shown same. Like this, enhanced and original RAODV routing protocol created same routing path when with fixed nodes.

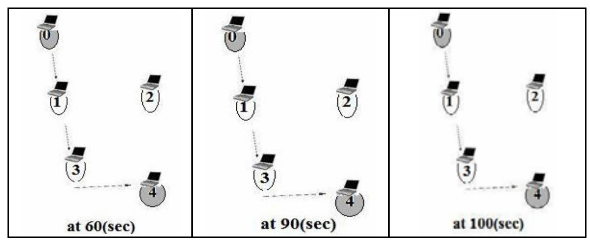

Figure-2. EN-RAODV network topology.

Table-1. RAODV routing table with fixing nodes.

Time	Source	Des	Next hop	No. of hops
60	0	4	1	3
90		0	0	1
		4	1	3
100		4	1	3

Table-2. EN-RAODV routing table with fixing nodes.

Time	Source	Des	Next hop	No. of hops
60	0	4	1	3
90		0	0	1
		4	1	3
100		4	1	3

Figure-3 is shown routing path with moving nodes. At first, the node 2 moved near node 1. Next, the node 2 moved far from node 1. Finally, the node 4 moved near node 1. The original RAODV maintain one's path during moving nodes. So, the routing table and routing path shown in Table-3. The EN-RAODV reset the shortest routing path during moving nodes. So, the routing path table and routing table for EN-RAODV are showing in Figure-4 and Table-5, respectively.

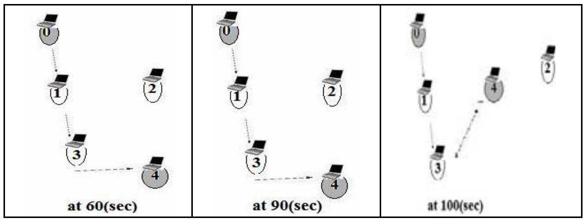

Figure-3. Routing path of RAODV during moving nodes.

Table-3. RAODV routing table with moving nodes.

Time	Source	Des	Next hop	No. of hops
60	0	4	1	3
90		0	0	1
		4	1	3
100		4	1	3

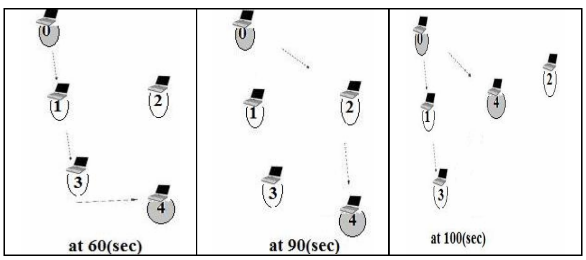

Figure-4. Routing path EN-RAODV during moving nodes.

Table-4. EN-RAODV routing table with moving nodes.

Time	Source	Des	Next hop	No. of hops
60	0	4	1	3
90		0	0	1
		4	2	2
100		4	4	1

Performance metrics

There are a number of qualitative and quantitative metrics that can be used to compare reactive routing protocols. Most of the existing routing protocols ensure the qualitative metrics. Therefore, the following different quantitative metrics have been considered to make the comparative study of these routing protocols through simulation.

Routing overhead

This metric describes how many routing packets for route discovery and route maintenance need to be sent so as to propagate the data packets.

Average delay

This metric represents average end-to-end delay and indicates how long it took for a packet to travel from the source to the application layer of the destination. It is measured in seconds.

Average throughput

This metric represents the total number of bits forwarded to higher layers per second. It is measured in bps. It can also be defined as the total amount of data a receiver actually receives from sender divided by the time taken by the receiver to obtain the last packet.

Packet delivery ratio

The ratio between the amount of incoming data packets and actually received data packets.

Routing packet sent

This metric describes how many routing packets for route discovery and route maintenance [5].

Simulation environment

Our simulations are implemented using Network Simulator version 2 (NS-2) [15]. The simulation parameters are shown in Table-5.

Table-5. Simulation parameters.

Parameters	Values
Simulation time	200 s
Simulation area	1000 m x 1000 m
Number of nodes	10, 20, 30, 40 and 50
Traffic type	UDP, CBR traffic
Node speed	2, 5, 10, 25, 50 and 75 m/s
Transmission range	250 m
MAC layer	IEEE 802.11
Mobility model	Random waypoint [16]
Routing protocols	AODV, RAODV and EN-RAODV

To evaluate the performance of EN-RAODV with that RAODV and AODV protocols, we compare them using the five performance metrics mentioned above.

Figure-5 shows routing overhead, packet delivery ratio, average delay, average throughput and routing packet send for AODV, RAODV and EN-RAODV as a function of the number of nodes. Figures 5(a) and 5(e) show the routing overhead and routing packet sent required by the transmission of the routing packets. AODV has less routing overhead. RAODV floods RREP

VOL. 9, NO. 2, FEBRUARY 2014 ISSN 1819-6608
ARPN Journal of Engineering and Applied Sciences

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packet but EN-AODV reduce overhead and near to AODV.

Figures 5(b), 5(c) and 5(d) show the packet delivery ratio, average end-to-end delay and average throughput of each protocol. We can see that EN-RAODV has higher packet delivery ratio, lower average delay and higher throughput than RAODV and AODV. EN-RAODV performs better than RAODV in terms of routing overhead and routing packet sent.

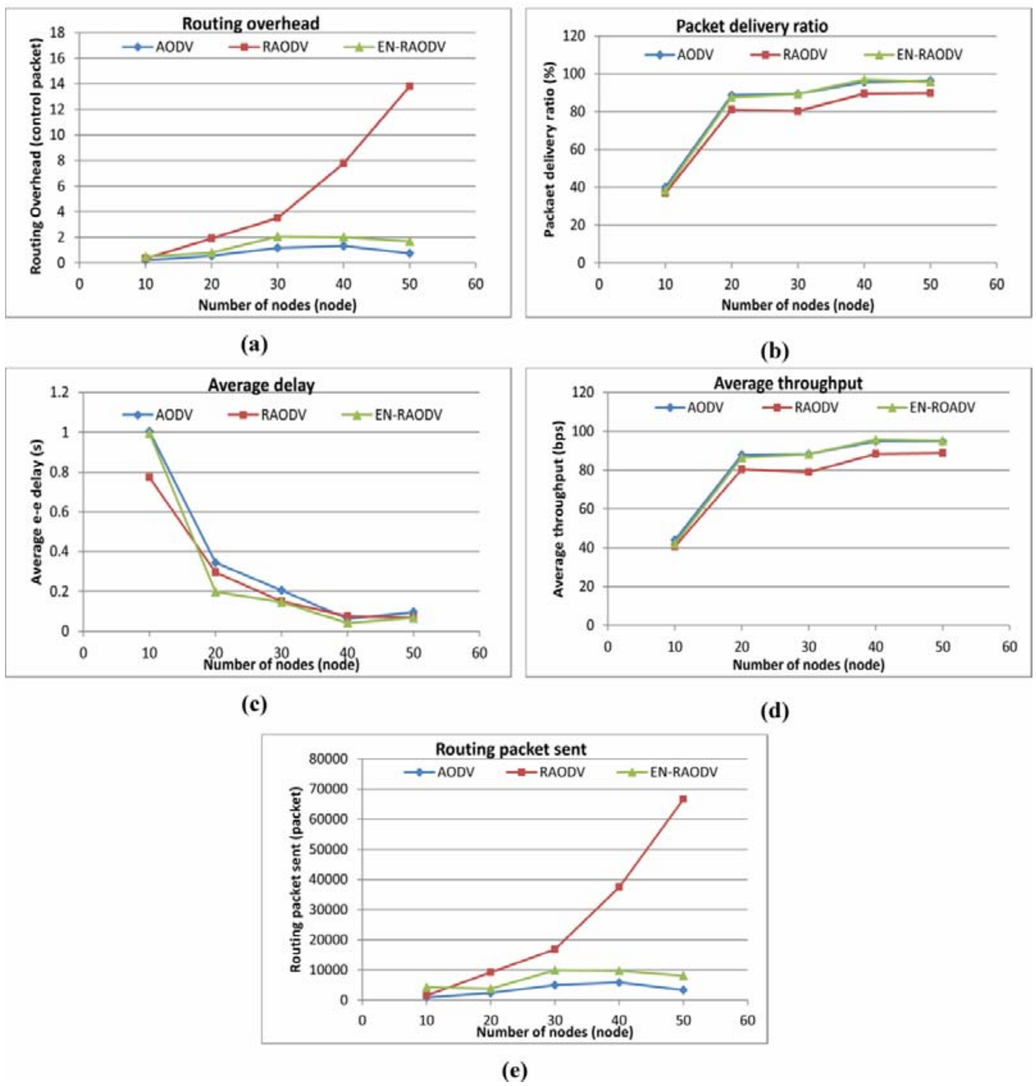

Figure-5. EN-RAODV, RAODV and AODV versus number of nodes.

Figure-6 shows packet delivery ratio of each protocols on varying node speed. EN-RAODV shows better performance in terms of packet delivery ratio, average delay and average throughput.

AODV shows better performance in terms of routing overhead and routing packet sent since AODV does not use flooding mechanism like RAODV and EN-AODV. EN- RAODV performs better than RAODV in terms of routing overhead and routing packet sent.

VOL. 9, NO. 2, FEBRUARY 2014 ISSN 1819-6608
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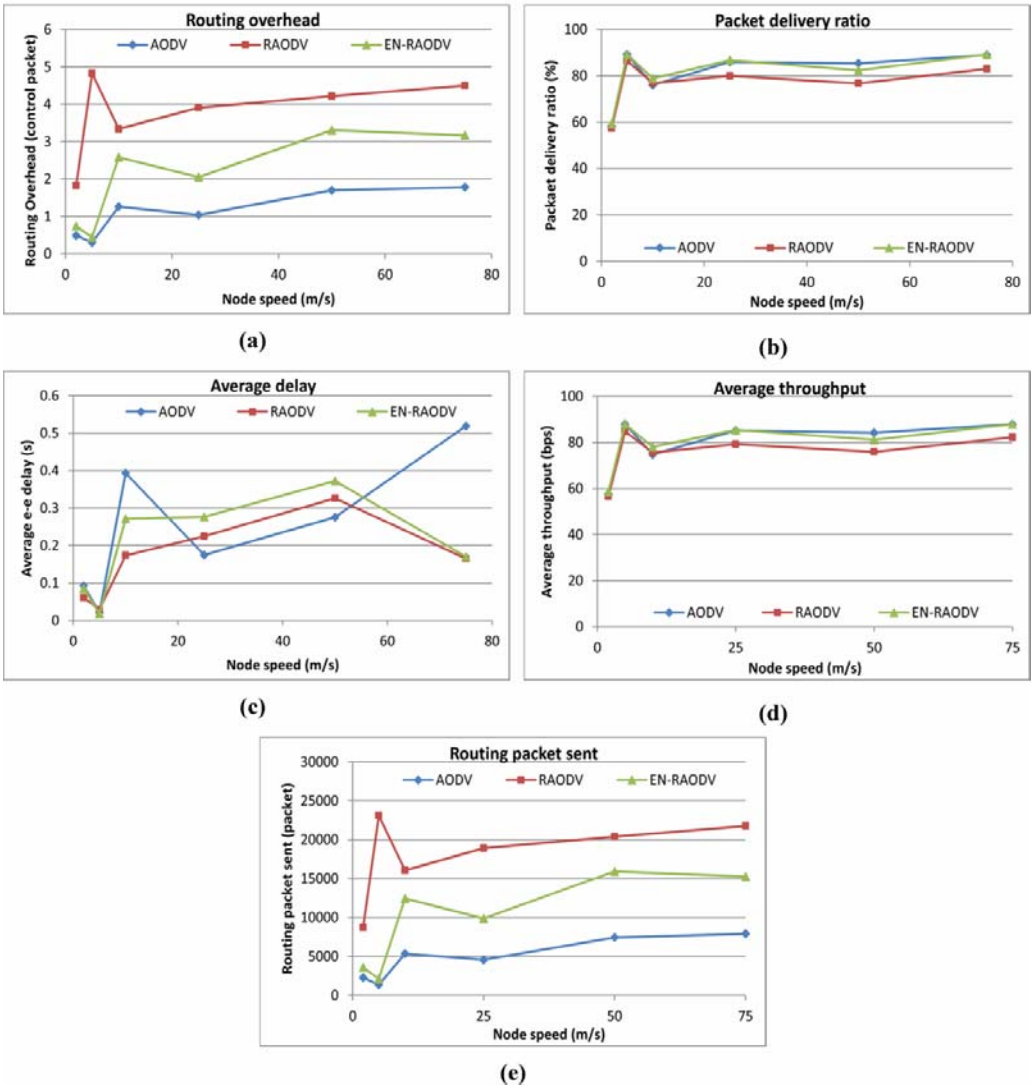

Figure-6. EN-RAODV, RAODV and AODV versus node speed.

CONCLUSIONS

We conducted extensive simulation study to evaluate the performance of EN-RAODV and compared it with that of RAODV and AODV using NS-2. The results show that EN-RAODV improves the performance of RAODV in most metrics, as the packet delivery ratio, average delay, average throughput, routing packet sent and routing overhead.

Our future work will focus on studying practical design and implementation of the EN-RAODV. Multipath routing is another topic we are interested in.

ACKNOWLEDGMENT

This study was partially funded by the University Kebangsaan Malaysia under Grant Nos. UKM-GUP-2012-089 and FRGS/1/2012/SG05/UKM/02/7.

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