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AD Hoc On-demand non Overlapped Multipath Distance Vector Routing Protocol (AONOMDV)

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Abstract

In this paper, we propose a scheme to improve existing Ad-Hoc On-Demand Distance Vector (AODV) routing protocol by discovering and maintaining multiple non-overlapped routes. Our routing protocol is a multipath version of AODV routing protocol that considers only the disjoint path. Due to non-overlapping among paths, when a link breaks in the network, only one of paths is expired. The presented routing protocol, called Ad hoc On-demand Non Overlapped Distance Vector (AONOMDV), is implemented by some modifications over AODV module in ns-2 simulator. Results of simulations show that AONOMDV has better performance in comparison with AODV and AOMDV in terms of the average end-to-end delay, the packet delivery ratio and the route discovery frequency.

Keywords: *AODV, Mobile Ad-hoc Networks, Routing*

1. Introduction

Recently mobile ad hoc networks have became very popular. Mobile ad hoc networks perform the difficult task of multi-hop communication in an environment without a dedicated infrastructure, with mobile nodes and changing network topology. Communication between mobile nodes within this network is wireless and all mobile nodes act as either a host or a router, forwarding messages to nodes within radio range, according to the network needs. Such networks are highly suitable for applications involving emergencies, communications, natural disasters and military operations [1][2].

One of the most challenging aspects of MANETs is their routing. Routing protocols for mobile ad hoc networks have been the subject of extensive research over the past several years [3][4][5]. Notable among them is a class of protocols called "on-demand" protocols, e.g. Dynamic Source Routing (DSR) [6], Ad hoc On-demand Distance Vector (AODV) [7], Temporally Ordered Routing Algorithm (TORA) [8]. A significant amount of current research has been directed to design efficient dynamic routing protocols for ad hoc networks. Unlike more traditional "proactive" protocols such as link-state or distance vector, that run on the internet, on-demand protocols attempt to reduce the routing overhead by maintaining routes only between those nodes that take part in data communication. Specifically, whenever a traffic source needs a route to a destination, the protocol initiates a route discovery process. Route discovery typically involves a network-wide flood of a route request and waiting for a route reply. Prior performance studies have shown that on-demand protocols have better overhead savings in comparison with their proactive counterparts.

However, on-demand approach is not problem-free. Since routes are computed only on-demand, route discovery latency can add to the end-to-end delay, unless a previously computed "cached" route is available. Buffering of data packets during the route discovery process can also contribute to packet losses due to buffer overflow. With single path routing, this problem becomes severe as the network becomes more dynamic. Frequency of route discoveries grows with increase in the rate of link failures. Also, since each route discovery incurs substantial packet overhead, its frequency impacts the performance. The frequency can be controlled by computing multiple paths with a single route discovery. This will improve the overall performance.

One of the effective strategies for improving routing protocols of mobile ad hoc networks is to calculate and maintain backup routes. This paper develops an on-demand multipath protocol that provides the advantages of multiple paths without suffering from any additional overheads. This protocol is an on-demand multipath distance vector protocol that is designed based on AODV routing protocol. Primary objective behind the design of AONOMDV is to provide efficient fault tolerance in the sense of faster and efficient recovery from route failures. The key feature of the proposed protocol is the on-demand computation of multiple routes that do not share any common links and nodes.

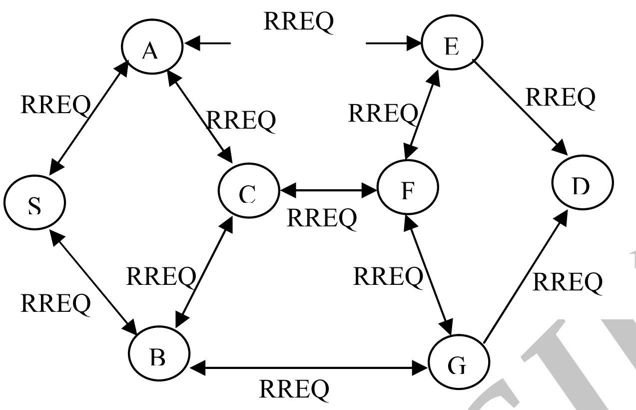
An overview of the AODV protocol is presented in section two. In section three, the AONOMDV protocol is described in details. Performance of AONOMDV is studied in section four by a simulative experiment. Conclusion is presented in section five.

2. Ad Hoc On-demand Distance Vector Routing (AODV)

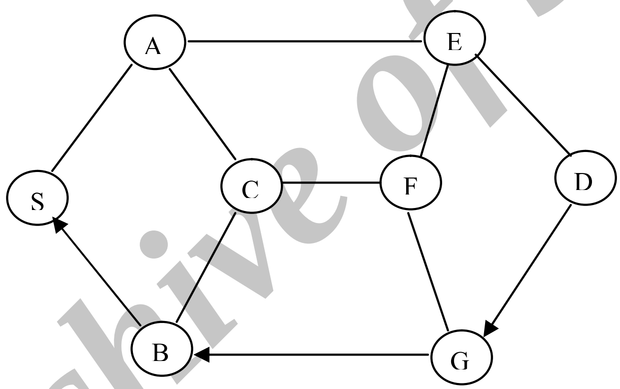
Since the proposed protocol in this thesis has been designed on AODV protocol, in this section the details of this protocol would be investigated. AODV routing protocol is an On-Demand routing protocol where all routes are discovered only when they are demanded and are maintained only during the period they are being used. AODV combines the use of destination sequence numbers as in DSDV with the on-demand route discovery technique in DSR to formulate a loop-free on-demand single path distance vector protocol. In contrast to DSR, AODV uses hop-by-hop routing instead of source routing. Below we review some of the key features of AODV [7].

When a traffic source needs a route to a destination, it initiates a route discovery process. Route discovery typically involves a network-wide flood of a route request (RREQ) for the destination and waiting for a route reply (RREP). Duplicate copies of a RREQ at every intermediate node are discarded. Source attaches a strictly increasing broadcast id with each RREQ it generates. Source id along with the broadcast id of the RREQ is used to detect duplicates. An intermediate node receiving a non-duplicate RREQ first sets up a reverse path to the source using the previous hop of the RREQ as the next hop on the reverse path. If a valid route is available, then the intermediate node generates a RREP, else the RREQ is rebroadcasted. When the destination receives a non-duplicate RREQ for itself, it generates a RREP. The RREP is routed back to the source via the reverse path. As the RREP proceeds towards the source, a forward path to the destination is established.

Figure 1 shows route discovery process by AODV. In this figure node S is the source node and node D is the destination node. Figure 1 (a) shows flooding RREQ packet and Figure 1 (b) shows transmission of RREP packet. As a result, one route is established between source and destination. The discovered route is S, B, G, and D.



(a)



(b)

Figure 1 Routing process in AODV

3. Ad Hoc On-demand Non Overlapped Multipath Distance Vector Routing (NOM-AODV)

AODV is a single path routing protocol for using in mobile ad hoc networks. In each routing process, AODV discovers only the shortest path and uses this route for data forwarding. Therefore, if this route fails, AODV does routing process again. The key concept in AONOMDV is discovering multiple paths per route discovery process. These paths do not share any node and hence routes are non-overlapped. With multiple redundant routes available, the protocol switches to a different route when the current route fails. Therefore with a path failure, it is not necessary to start a new route discovery phase. Route discovery is initiated only when all paths to a specific destination fail. For more performance, only the paths that are not overlapped are computed, so that the paths fail independently of each other. Note that non overlapped routes are sufficient for our purpose, as we use multipath routing for reducing route discovery iterations. After discovering all node disjoint routes between source and destination node, source node uses the shortest path for data forwarding. If the shortest path fails, source node uses the shortest path of other routes. This way, source node is not needed for new route discovery processes. This case causes a decrease in overhead and delay of protocol and an increase in performance of protocol.

The main point of AONOMDV protocol is that in this protocol in a route discovery process, instead of a single route, all routes of distinct node between source and destination are discovered. In this protocol all routes between source and destination nodes will be discovered if there is no shared node within routes, that is, discovered routes would not have any node overlap. This characteristic causes destruction of only one node when there is a route failure due to reasons such as movement of nodes or when a node runs out of battery. Mechanism of using discovered routes is in a way that the shortest discovered route is used to forward data and in terms of loss of this route, the shortest route is used among discovered routes and this causes no need to rerouting and also causes reduction in routing overload.

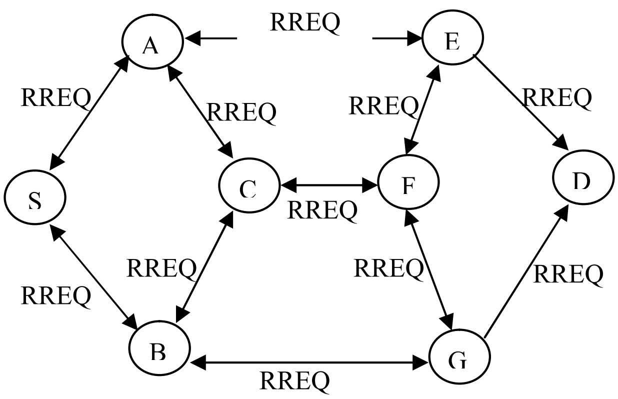
Some routing protocols on AODV have been presented in recent years. Ad hoc on-demand multipath distance vector (AOMDV) is a multipath version of AODV [11]. The discovered routes in AOMDV have shared nodes. Therefore, in AOMDV failure of a route may affect other routes; while in AONOMDV failure of one route is independent of other routes.

A few changes are necessary in the basic AODV route discovery mechanism in order to enable computation of multiple non overlapped routes between source and destination pairs. We should note that any intermediate node on the route between a source and a destination can also form such multiple routes to destination that lead to a large number of routes available between source and destination.

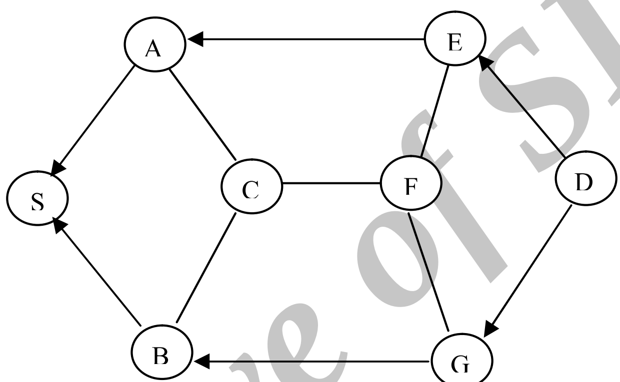
We should recall that in the route discovery processes a reverse path is set up backwards to the source via the same path as the route request (RREQ) has traversed. If duplicates of the RREQ coming via different paths are ignored as before, only one reverse path can be formed. In AONOMDV to form multiple routes, destination node replied all RREQ packets via reverse path using RREP packets. In reverse path, intermediate nodes forward one RREP. As a result, the routes that are created do not have common nodes and discovered routes are not overlapped.

After route discovery, AONOMDV protocol uses the shortest route to forward data. In case of loss of this route due to link failure, it uses available discovered routes instead of rerouting.

Figure 2 shows route discovery process by NOM-AODV. In this figure node S is source node and node D is destination node. Figure 2 (a) shows flooding RREQ packet and Figure 2 (b) shows transmission of RREP packet. Flooding of RREQ packet is similar to AODV but they are different in transmission of RREP. Figure 1 shows route discovery process by AODV. In this figure node S is source node and node D is destination node. Figure 2 (a) shows flooding RREQ packet and Figure 2 (b) shows transmission of RREP packet. As a result, AONOMDV discovers all non-overlapped routes between source and destination. The discovered non overlapped routes are S, B, G, D and S, A, E, D.



(a)



(b)

Figure 2 Routing process in AONOMDV

4. Simulations

To investigate the impact of our enhancements, we implemented AONOMDV by making some modification over AODV module of ns-2 simulator [9]. Provided scenarios in these simulations have been selected among the standard scenarios which are produced randomly and selected in a way that they provide networks with various data traffic and topological conditions. Also considered efficiency criteria are basic criteria for evaluating MANET routing protocols, since overall status of a protocol's performance is evaluated with these criteria. The following are the metrics that are used to evaluate and assess the performance of the AODV, AOMDV and AONOMDV routing protocols.

1- Packet Delivery Ratio (PDR): the average number of data packets transmitted by the source per data packet delivered to the destination [10].

2- Average end-to-end delay: the average delay from the time the packet is originated at the source to the time it reaches the destination. This delay includes delaying time of the route discovery process, buffering delay at the intermediate nodes interface queue, the transmission process at the MAC layer, packet processing, and transferring and propagation times [10].

3- Route discovery frequency: the total number of route discovery processes initiated per second [11].

4.1 Results and Analysis

To study the performance of AONOMDV and compare it against AODV and AOMDV, two different types of simulation scenarios are conducted:

1- Pause time simulation: is done by varying the pause time to see how it affects the behaviors of the protocols in terms of measured metrics. In this simulation different pause times have been considered, where in low pause times topological changes are high and in high pause times topological changes are relatively low. In this way both networks with high dynamicity and also networks with low dynamicity are created.

2- Offered load simulation: is done by varying the traffic rate to see how the protocols behave when the load is low, middle and high. In this simulation packet forwarding rate has been considered different to evaluate protocols under various load and data traffic.

4.1.1 Performance metrics versus pause time

In this simulation 20 nodes were simulated for 1000s over a network space of 1000×1000m. The network traffic was modeled as 10 CBR sources with data sent in 512 byte packets at a rate of 10 packets per second. Four movement patterns were produced based on a random waypoint model with pause time: 0, 100, 200 and 500 seconds. The initial energy of nodes is set to 40J. The IEEE 802.11 is used as the medium access protocol. The interface queue is 50-packet drop-tail priority queue. Simulation results are shown in Figs. 3-5.

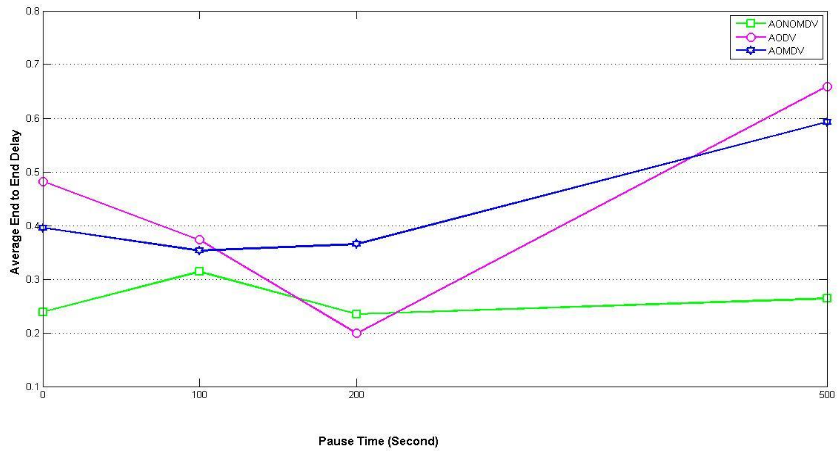


Figure 3 Average End to End Delay versus Pause Time

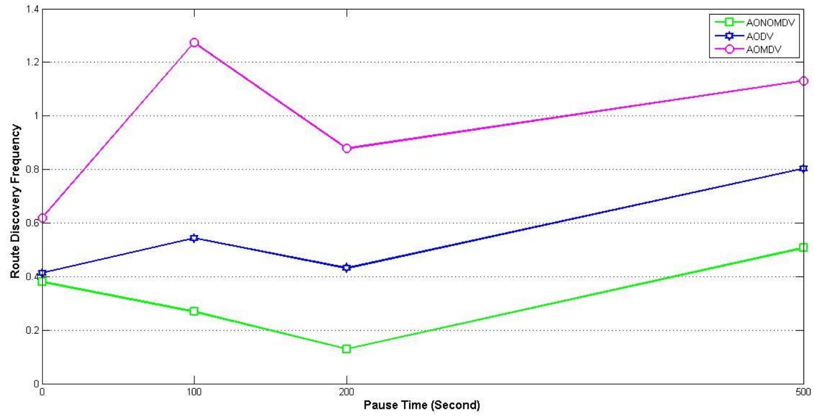


Figure 4 Route Discovery Frequency versus Pause Time

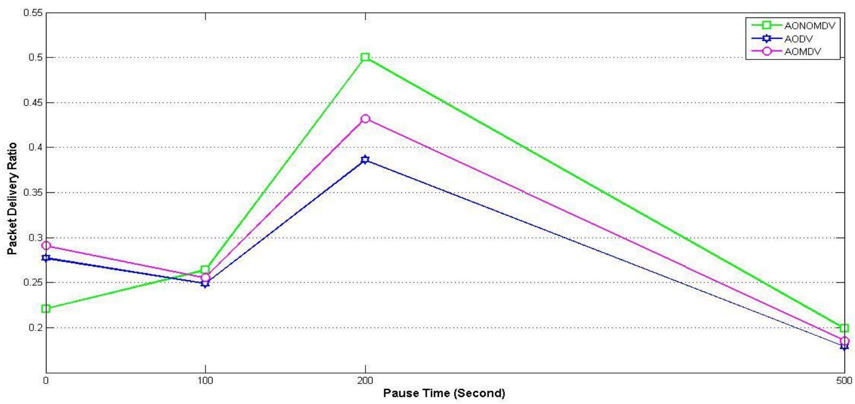


Figure 5 Packet Delivery Ratio versus Pause Time

Figure 3 and Figure 4 present the average end to end delay and the route discovery frequency of the AONOMDV, AOMDV and AODV as the number of nodes changes in the four different pause times. In Figure 5, it is seen that the packet delivery ratio of AONOMDV algorithm is higher than AODV and AOMDV. It was observed that in the variant pause times, the AONOMDV protocol works better than AODV and AOMDV.

4.1.2 Performance metrics versus traffic rate

In this simulation 20 nodes were simulated for 1000s over a network space of 1000×1000m. The network traffic rate was modeled as 10 CBR sources with data sent in 512 byte packets at rates of 5, 10 and 15 packets per second. One movement pattern was produced based on a random waypoint model with pause time 0 second. The initial energy of nodes is set to 40J. The IEEE 802.11 is used as the medium access protocol. The interface queue is 50-packet drop-tail priority queue. Simulation results are shown in Figs. 6-8.

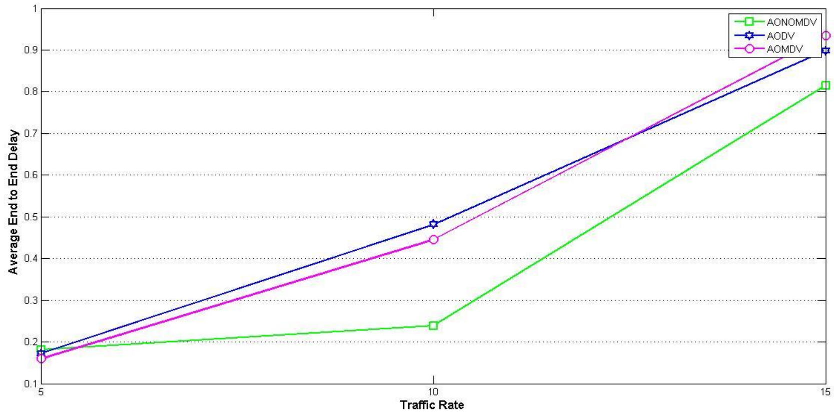


Figure 6 Average End to End Delay versus Traffic Rate

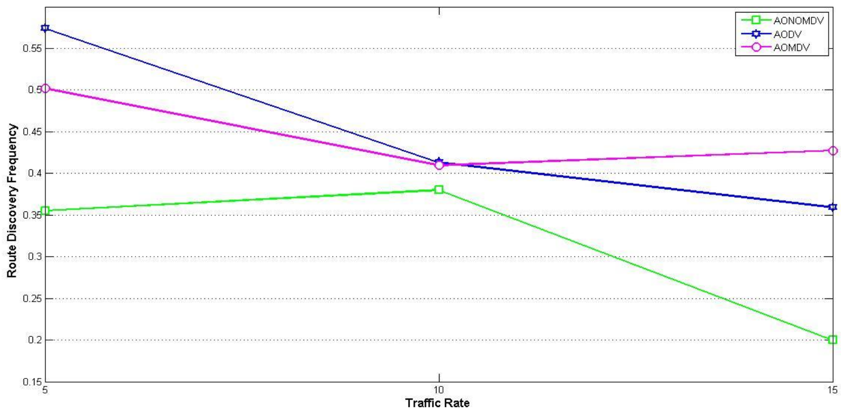


Figure 7 Route Discovery Frequency versus Traffic Rate

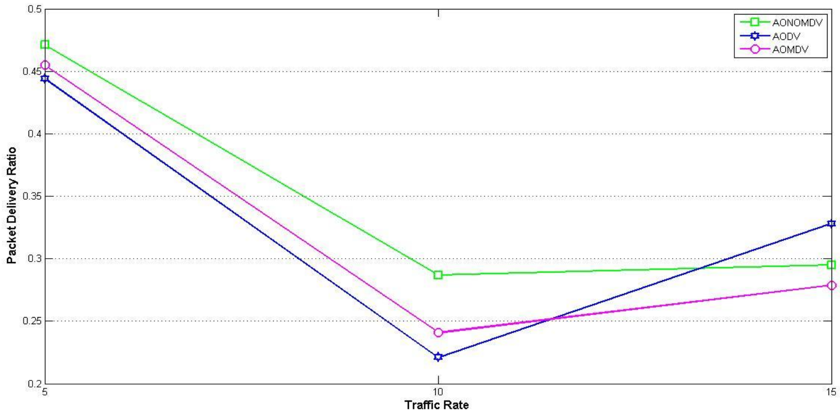


Figure 8 Packet Delivery Ratio versus Traffic Rate

Average end-to-end delay is presented in Figure 6. On the other hand Figure 7 shows that AONOMDV outperforms AODV and AOMDV in terms of route discovery frequency. Figure 8 shows that AONOMDV increases packet delivery ratio in comparison with AODV and AOMDV protocols. The proposed scheme improves the performance of AODV.

5. Conclusion

This paper proposed a routing protocol for mobile ad-hoc networks. This protocol is a non-overlapped multipath scheme that discovers all node disjoint routes. This protocol reduces frequency of route discovery phase and hence has increased performance and reduced overhead. Simulation results demonstrated that the scheme achieved better performance over the original AODV protocol and AOMDV another multipath routing protocol based on AODV, in terms of average end-to-end delay, packet delivery ratio and route discovery frequency. As a direction for future work, this work can be enhanced by considering other parameters such as link stability and mobility information.

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