2nd National Conference on Information and Communication Technology (NCICT) 2011
Proceedings published in International Journal of Computer Applications® (IJCA)

Modified AODV Protocols: A Survey

Aditya Dhatrak
Department of Electronics & Telecommunication Engineering, VIT Pune

Amruta Deshmukh
Department of Electronics & Telecommunication Engineering, VIT Pune

Rahul Dhadge
Department of Electronics & Telecommunication Engineering, VIT Pune

ABSTRACT
Recently there has been substantial work done in the field of developing an energy efficient and reliable routing protocol for enhanced performance in Ad hoc networks. The field is maturing exponentially and is becoming one of the key research areas in the field of Communications with an objective of improving the quality of Ad hoc networks. The Ad-hoc on demand distance vector (AODV) routing algorithm is a routing protocol designed for Ad-hoc mobile devices. AODV is a combination of DSR and DSDV. It has basic on-demand mechanism of Route Discovery and Route Maintenance similar to DSR, and the use of hop by hop routing, sequence numbers and periodic beacons similar to DSDV. In this paper we have studied and analyzed the enhanced versions of AODV protocol to improve the Quality of Service (QoS).

General Terms
MANET, AODV

Keywords
MANET, AODV, RAODV, ES-AODV, SP-AODV, MRAODV, LBAODV

1. INTRODUCTION
The MANET (Mobile Ad-hoc Network) is collection of nodes which can connect in a wireless medium and form an arbitrary dynamic network with wireless links and without any supporting infrastructure. That means the link between the nodes themselves work as route. The network can dynamically change with time, new nodes can join and other nodes can leave the network.
The routing protocols for ad hoc networks are classified as proactive [1], reactive [2] and hybrid [3, 4] depending upon whether route is updated continuously or on-demand.

A. *Proactive or Table driven routing protocols:* In this, each node maintains the network topology information in the form of routing tables by periodically exchanging routing information with neighboring nodes. Routing information is generally flooded in the whole network. Whenever a node needs a route to the destination it runs an appropriate path finding algorithm on the topology information it maintains. E.g. DSDV, CGSR, WRP.
B. *Reactive or On demand routing protocols:* These protocols do not maintain the network topology information. They obtain the necessary route when it is required, by using a connection establishment process. Hence these protocols do not exchange routing information periodically. E.g. DSR, AODV, TORA
C. *Hybrid routing protocols:* This type of protocols combines the advantages of proactive and reactive routing. The routing is initially established with some proactively prospected routes and then serves the demand from additionally activated nodes through reactive flooding. The choice of one or the other method requires predetermination for typical cases. E.g. HRPLS, ZRP, HWMP.

1.1 The Ad-Hoc on-Demand Distance Vector Routing Protocol

1.1.1 Route discovery process
The route discovery process is started whenever a source node wants to communicate with another node for which it has no routing information. Every node maintains two separate counters: a node sequence number and a broadcast-ID. The source node initiates path discovery by broadcasting a route request (RREQ) packet to its neighbors. The RREQ packet format is shown in Fig. 1 [5].

The pair <Sourceaddr; Broadcast-ID> uniquely identifies a RREQ packet. Broadcast-ID is incremented whenever the source issues a new RREQ packet. Each neighbor either satisfies the RREQ by sending a route reply (RREP) back to the source if it knows the path to destination or rebroadcasts the RREQ to its own neighbors after increasing the hop count field. A node may receive multiple copies of the same RREQ packet from various neighbors

Type	J|R|G|D|U	Reserved	Hop count
RREQ ID			
Destination IP address			
Destination sequence number			
Originator IP address			
Originator sequence number			

Fig. 1:The RREQ packet format

When an intermediate node has already received a RREQ with the same Broadcast-ID and source address, it drops the redundant RREQ packet and does not rebroadcast it. If a node cannot satisfy the RREQ, it keeps track of the following information in order to implement the reverse path setup, as well as the forward path setup that will accompany the transmission of the eventual RREP:

- Destination IP address
- Source IP address
- Broadcast-ID
- Expiration time for reverse path route entry
- Source node's sequence number

1.1.2 Reverse path setup

Two sequence numbers (in addition to the Broadcast-ID) are included in a RREQ as shown in Fig. 1 [5]. The source sequence number is used to maintain freshness of information about the reverse route to the source and the destination sequence number specifies how much fresh a route to the destination must be before it can be accepted by the source.

As the RREQ travels from a source to various destinations, it automatically sets up the reverse path from all nodes back to the source. To set up a reverse path, a node records the address of the neighbor from which it received the first copy of the RREQ. These reverse path route entries are maintained for at least enough time for the RREQ to traverse the network and produce a reply to the sender.

1.1.3 Forward path setup

Eventually, a RREQ will arrive at a node (possibly the destination itself) that possesses a current route to the destination.

<table>
<tr><td>Type</td><td>R|A</td><td>Reserved</td><td>Prefixed Sz</td><td>Hop Count</td></tr>
<tr><td colspan="5">Destination IP address</td></tr>
<tr><td colspan="5">Destination sequence number</td></tr>
<tr><td colspan="5">Orininator IP address</td></tr>
<tr><td colspan="5">Life time</td></tr>
</table>

Fig. 2:A RREP packet format

If an intermediate node has a route entry for the desired destination, it determines whether the route is current by comparing the destination sequence number in its own route entry with the destination sequence number in the RREQ. If the RREQ's sequence number for the destination is greater than that recorded by the intermediate node, the intermediate node must not use its recorded route to respond to the RREQ. Instead, the intermediate node rebroadcasts the RREQ. The intermediate node can reply only when it has a route with a sequence number that is greater than or equal to that contained in the RREQ. If it has a current route to the destination and if the RREQ has not been processed previously, the node then unicasts a route reply packet (RREP) back to its neighbor from which it received the RREQ. A RREP packet format is shown in Fig. 2 [5].

1.1.4 Route maintenance

Movement of nodes not lying along an active path does not affect the route to that path's destination. If the source node moves during an active session, it can reinitiate the route discovery procedure to establish a new route to the destination. When either the destination or some intermediate node moves, a special RREP is sent to the source node. Periodic hello messages can be used to ensure symmetric links as well as to detect link failures.

Once the next hop becomes unreachable, the node upstream from the breaking point propagates an unsolicited RREP with a fresh sequence number (i.e., a sequence number that is one greater than the previously known sequence number) and hop count of 1 to all active upstream neighbours. Those nodes subsequently relay that message to their active neighbours and so on. This process continues until all active source nodes are notified. Upon receiving notification of a broken link, source node can restart the discovery process if it still requires a route to the destination.

We studied modified AODV protocols which were based on energy saving, route maintenance, route stability. The rest of the paper is organized as follows: in section **2**, we discuss the modified protocols and its scope and in section 3 the paper is concluded with future scope.

2. DISCUSSION OF THE MODIFIED PROTOCOLS

A) Based on the alternate back up route

In this section we will look at two modified AODV protocols viz. Load Balancing AODV (LBAODV) [6], Robust AODV [7].

In LBAODV protocol [6], all the discovered paths are simultaneously used for transmitting data. Due to this, data packets are balanced over discovered paths and energy consumption is distributed across many nodes.

In route discovery the source broadcasts RREQs. When destination receives RREQs, it reverses the route record from the received RREQs and uses this route to send RREPs to the source. When a node receives multiple RREPs from an another node, it increments the number of route reply, *Count Reply,* received from this node in its *route table* field which means how many routes from this next hop to the destination exist. Each node that receives data packets sends them to the next hops according to their *CountReply* values. More is the count reply greater is the amount of data sent and vice-versa.

This protocol helps to achieve better packet delivery ratio and distributed energy consumption. Due to simultaneous transmission of data packets source to destination delay may be reduced.

In Robust AODV [7] with Local Update, the route is built on demand and maintained by locally updating route information. Multiple back up routes are built around active route and the highest priority back up route will be switched to become new active route when the current active route is less preferred. The route discovery process is almost same as in original AODV protocol except that all the routes are back up routes. Route entries are updated whenever a link breakage is detected and if backup route exists we switch to a new route. The broadcasted route update message which replaces the AODV hello message contains all the necessary route information.

This protocol works best in case of high mobility. It is preferred when the energy of node is not a matter of concern but a strong and reliable network is desired. Disadvantage of this protocol is the complexity in implementation and high power consumption.

B) Based on the routing techniques

In this section we will look at two modified AODV protocols viz. Reverse AODV (RAODV) [8], Modified Reverse AODV (MRAODV) [9].

In Reverse AODV (RAODV), destination node uses reverse RREQ to find source node. It reduces path failure correction messages and can improve the robustness of performance. Therefore, success rate of route discovery may be increased even in high mobility situation. When broadcasted *reverse request* packet arrives to intermediate node, it will check for redundancy. If it already received the same message, the message is dropped, otherwise forwards to next nodes and when the source node receives first *reverse request* message, then it starts packet transmission, and late arrived R-RREQs are saved for future use. Even if packet delivery ratio is increased there are other disadvantages. Due to multicasting by destination there is considerable amount of energy wastage of nodes in the network and as well control packet overhead increase.

In Modified Reverse AODV (MRAODV) stability estimation method is used for route selection and to increase performance. In the proposed routing algorithm, when a source node wants to communicate with a destination node, first it broadcasts a RREQ packet. This stage is like that of AODV algorithm. When destination receives a RREQ message, it broadcasts R-RREQ message to find source node. Each intermediate node which receives the R-RREQ message, calculates its route stability for each route using equation given below and this stability is used for selecting the path.

$$RS_r = \Pi\, ns_i \qquad (1)$$

Where RS_r is the route stability of the route r.
L_r is the set of available routes and
ns_i is the stability of node i.

The stability of each node can be calculated by following equation,

$$ns_i = (t-t')/(L_n - L_n') \qquad (2)$$

Where L_n denotes the location of node ni at the time t. For t computation of stability for each node we need to obtain t-t' delay.

Semi-Proactive AODV (SP-AODV) [10] is a combination of pro-active and reactive dynamic routing protocol. It is node centric rather than based on zones or areas as in hybrid approaches of routing protocol. The efficiency of this protocol lies in the fact that some nodes which are often used will dynamically update some sections of their routing table like pro-active protocol and other nodes which are used less operate like reactive routing protocol. The results showed that the routing protocol has more packet delivery ratio and less end-to-end delay compared to AODV. Furthermore, control packet overhead in SP-AODV is less than AODV in low and medium mobility of nodes; however, it is more than AODV in high mobility of nodes.

C) Based on Energy

In this section we will look at two modified AODV protocols viz. Energy Saving AODV (ES-AODV) [11], Energy Multipath AODV (EM-AODV) [7].

In Energy Saving AODV (ES-AODV) [11] protocol, the power controlled mechanism is adopted to adjust the emission power of node dynamically and to improve the energy saving performance of AODV routing protocol in mobile Ad Hoc networks. ES-AODV protocol focuses on the local repair and minimizes the probability of using source node for the route rebuild. ES-AODV protocol comprehensively evaluates excess energy of nodes, each node in the link calculates its weight which is in inverse proportion with its energy. The routing protocol always chooses the smallest cost link for data transmission. Energy consumption of nodes in the network could be effectively balanced and the average survival time of nodes in the network can be improved. The ES-AODV protocol makes full use of the backup route information which is cached during the stages of route optimization to repair the broken link.

Even with suitable increase in node's speed, its lifetime is better as compared to AODV at same speed. Also increase in number of nodes' reduces the power of communication between nodes, which directly affects the rate of energy consumption and thus prolong nodes' lifetime.

Energy Multipath AODV (EM-AODV) proposes a new adaptive approach which considers the metric "residual energy of nodes" instead of the number of hops in the process route selection. In this we define the rate of energy consumption for each node to estimate its lifetime and as well define a cost that fits this lifetime and the energy level. This information is used for calculating the cost of routes and the path with minimum cost is selected. EM-AODV improves the performance of AODV in most metrics, as the packet delivery ratio, end to end delay, and energy consumption.

3. CONCLUSION AND FUTURE SCOPE

We analysed and reviewed variety of routing protocol for Ad-Hoc networks. Energy saving, intelligent routing techniques and stability of routes are the important parameters for mobile nodes in Ad-Hoc networks. With the appropriate increase in the mobility or no. of nodes, there is considerable improvement in the nodes lifetime as that of AODV. We observed that if the packet overhead was less the efficiency of the protocol improved quite considerably. And as well if the mobility of the node was increased there was a sudden dip in performance. Overall we concluded that there was need of a protocol which could adopt itself to the high mobility of nodes to perform optimally. The non-existence of a good routing protocol is a matter of great concern. We suggest that extensive amount of research needs to be done in this field to develop highly reliable and highly performing new protocol for routing.

4. ACKNOWLEDGMENTS

Our sincere thanks to our **Prof. Mrs Sangita Kurundkar** for her constant guidance and support throughout the development of this paper. And our special thanks to **Mr. Pratik Gondane**, **Mr. Manish Karani** and **Mr. Snehal Shendware** for their anytime help and incessant motivation.

5. REFERENCES

[1] H. Idoudi, M. Molnar, A. Belghith, B. Cousin, "Modeling uncertainties in proactive routing protocols for Ad hoc networks", 5th International Conference on Information and Communications Technology, 2007, pp. 327-332.

[2] K. Khamforoosh, A. M. Rahmani and A. Sheikh Ahmadi, "A new multi-path AODV routing based on distance of nodes from the network center", Mosharaka International Conference on Communications, Propagation and Electronics, 2008, pp. 1-5.

[3] S. Roy and J.J. Garcia-Luna-Aceves, "Node-Centric Hybrid Routing for Ad Hoc Networks", Proc. 10th IEEE/ACM International Symposium on Modeling, Analysis and Simulation of Computer and Telecommunications Systems, Texas, October 12, 2002.

[4] L. Wang and S. Olariu, "A Two-Zone Hybrid Routing Protocol for Mobile Ad Hoc Networks", IEEE transactions on Parallel and distributed systems, December 2004 (Vol. 15, No. 12, 2004, pp.1105-1116.

[5] C. Perkins, E. Belding-Royer, S. Das, Ad hoc On-Demand Distance Vector (AODV) Routing, RFC3561, July: 2003

[6] Mehdi Effat Parvar, Mohammad Reza Effat Parvar, Amir Darehshoorzadeh, Mehdi Zarei, Nasser Yazdani "Load Balancing and Route Stability in Mobile Ad Hoc Networks base on AODV Protocol" 2010 International Conference on Electronic Devices, Systems and Applications (ICEDSA2010)

[7] Suhua TANG'and Bing ZHANG', A Robust AODV Protocol with Local Update, 10th dsia-pacific Conference on Camrmnications and 5th International Symposium an Multi-Dimensional Mobile Communications , 2004

[8] Humaira Nishat, Vamsi Krishna K, Dr. D.Srinivasa Rao and Shakeel Ahmed, Performance Evaluation of On Demand Routing Protocols AODV and Modified AODV (R-AODV) in MANETS, International Journal of Distributed and Parallel Systems (IJDPS) Vol.2, No.1, January 2011

[9] Pushpendra Kumar, Rohit Kumar, Satyendra Kumar and Rajendra Kumar Dwiwedi, Improved Modified Reverse AODV Protocol, International Journal of Computer Applications (0975 – 8887) Volume 12– No.4, November 2010

[10] SP-AODV: A Semi-Proactive AODV Routing Protocol for Wireless Networks, Tooska Dargahi, Amir Masoud Rahmani, Ahmad Khademzadeh, International Conference on Advanced Computer Theory and Engineering 2008

[11] Xinsheng Wang, Qing Liu and Nan Xu, The Energy-Saving Routing Protocol Based on AODV, Fourth International Conference on Natural Computation 2008

[12] Said Khelifa and Zoulikha Mekkakia Maaza, "An Energy Multi- path AODV Routing Protocol in Ad Hoc Mobile Networks", IEEE 2010.