A Comparative Analysis of AODV and R-AODV Routing Protocols in MANETS

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ABSTRACT
In Mobile Ad hoc Networks (MANETs), dynamically changing network topology affects the performance of various on-demand routing protocols significantly. Ad-hoc On-Demand Distance Vector (AODV), one of the most widely studied on-demand routing protocol uses single route reply packet along the reverse path for replying to the source node in the route discovery process. Due to increase in the instability of the network topology, the likelihood of route reply packet loss increases, that in turn degrades the performance of the routing protocol. So an optimized AODV, namely Reverse AODV (R-AODV) was proposed that introduces multiple recent and shorter routes at the source node by the use of reverse route request mechanism. In this paper, a detailed implementation process and the simulation study of R-AODV has been presented based on NS-2 that improves the performance of AODV significantly in terms of packet delivery fraction, communication delay and energy consumption.

Keywords
MANETS, AODV, R-AODV, NS-2.

1. INTRODUCTION
A Mobile Ad hoc Network [1] is a multi-hop temporary autonomous system where the mobile users communicate with each other through wireless links, without any pre-established infrastructure. The decentralized network structure may vary rapidly and unpredictably over time because the nodes in the network are mobile and can be connected dynamically in an arbitrary manner. So routing is really a challenging task for such a highly dynamic and unstable network [3-5]. Based on routing information update mechanism**,** ad hoc routing protocols [1] are classified into three major categories; Proactive or table driven, Reactive or on-demand and Hybrid routing protocols.

In Proactive routing protocol, a node maintains up-to-date routing information regarding every other node in the network by the help of periodic routing information exchange. It increases both the overhead and energy consumption of the network. A different approach from proactive routing is on-demand or reactive routing that creates route only when desired by the application layer for data packet delivery. No periodic exchange of routing information is required in this type of routing. Hybrid routing protocol uses the combined features of both the proactive and reactive routing protocols.

Ad-hoc On-Demand Distance Vector (AODV) routing protocol is both on-demand and destination initiated, that means routes are established by AODV from destination only on demand [2]. In AODV, each node stores information about every other node in the network in its routing table. The intermediate nodes also have the provision to reply to the route request (RREQ) from the routes in their routing table. With increase in randomness of routing environment, the chance of invalidation of these stored stale routes increases. This prevents data packets to get successfully delivered at the destination which enforces AODV to trigger new route discovery process. It increases the average end-to-end delay while reducing the throughput of the network**.**

The degradation in the performance of AODV is also due to loss of routing packets especially route reply (RREP) packets. AODV and most of the reactive routing protocols [1] such as TORA, DSR etc. make use of single RREP packet [3-7] that is unicast along the reverse path back to the source node. The drastically altering environment prevents the single RREP packet from getting delivered to the source node. As a result of which the source node starts rebroadcasting RREQ packets in order to find a route to the destination. It increases the routing overhead of the network quite significantly as each such RREP packets are obtained by flooding the entire or partial network with RREQ packets. It also enhances the average consumed energy of the network.

So an optimized AODV called Reverse AODV (R-AODV) [7] was proposed that takes into account the above discussed problems and floods the RREP packet throughout the network in order to find the source node. This process of Reverse RREQ generates multiple discovered routes at the source node that ensures both successful route discovery and data packet delivery. It improves the robustness of the protocol.

In this particular paper, a detailed analysis of the routing strategy used to implement R-AODV protocol has been presented. A comparative study between AODV and R-AODV has also been carried out that considers a simulation environment that is highly dynamic (lesser pause time and higher nodes speed). In such a stressful situation, R-AODV performs comparatively better that AODV in most of the metrics including packet delivery ratio and communication delay.

2. AODV ROUTING PROTOCOL
Ad hoc On-Demand Distance Vector (AODV) [2] is reactive routing protocol that uses the sequence number concept to ensure the freshness of the discovered routes and creating loop free routes. It is self starting and applicable for large scale networks. The working principle of AODV is based on two important phases: Route Discovery and Route Maintenance.

2.1 Route Discovery Phase

In the route discovery phase, a node disseminates a RREQ message when it determines that it needs a route to a destination and does not have one available in its routing table. The repeated processing of RREQ packet at intermediate nodes is prevented by checking for the originator IP address and RREQ ID pair [2][3]. If the node is not the intended destination then a reverse route for the source node is either created or updated and the RREQ packet is further broadcasted.

A node generates a RREP if it is itself the destination of the packet or it has an active and valid route to the destination. The RREP packet is unicast back towards the originator node along the reverse path. When an intermediate node receives the RREP message, it first creates or updates forward route entry in its route table before forwarding it to its next hop towards the source node.

2.2 Route Maintenance Phase

In the route maintenance phase, a node initiates a route error (RERR) message if it detects a link break for the next hop of an active route in its routing table or it gets a data packet destined to a node for which it does not have an active route and it is not attempting any local repairing. Upon receiving the RERR message the source node either looks for a valid route in its routing table or reinitiates route discovery process.

3. R-AODV ROUTING PROTOCOL

The reverse AODV (R-AODV) [7], an extension of AODV, is a reactive routing protocol that uses a reverse route discovery methodology. In the route discovery phase, the control packets are flooded at both the ends (source and target) in order to find their respective destinations. The RREQ packet format includes the following fields: broadcast ID, destination IP address, destination sequence number, source IP address, source sequence number and request time. The R-RREQ packet [7][10] includes the same fields as considered in case of RREQ packet except the source sequence number.

The R-AODV algorithm provides an efficient approach to overcome the effect of RREP packet loss and improves the robustness of performance [7]. The routing strategy used in this work to implement R-AODV can be briefly discussed under following sub headings:

3.1 Generating RREQ

The RREQ generation in case of R-AODV follows the same methodology as adopted by AODV where the source node initiates a RREQ message based on demand that is flooded in the entire network or partial area [2] until it reaches the destination node.

3.2 Receiving and processing RREQ

When a node receives a RREQ packet, it first checks for the source address and broadcast id pair in order to avoid the multiple processing of the packet. If the node is the intended destination of the RREQ packet then a reverse route request (R-RREQ) packet is initiated otherwise the packet is forwarded to the neighbor nodes. The R-RREQ packet is flooded in the whole network in order to find the source node. An intermediate node does not reply to the RREQ packet unless it is the destination node of the packet.

3.3 Receiving and Processing R-RREQ

An intermediate node processes the R-RREQ packet in the same manner as processing of RREQ packet was done. If the node that received the R-RREQ packet is not the target node then a forward route entry is created and the packet is forwarded to its neighbor nodes. When the source node receives the R-RREQ packet, it either adds the new path (path including a different next hop) or updates the existing path (path including the same next hop) based on greater sequence number or lesser number of hops (if sequence numbers are same). The maximum number of routes that a node can maintain equals to the number of neighbors of that node. The source node starts transmitting data packets after receiving first R-RREQ packet where as the packets that arrive late are reserved in the nodes routing table for future use.

3.4 Generating and Processing RERR

When the link to the upstream node is found broken, the downstream node generates the RERR packet and forwards it to its neighbor nodes and so on the process is repeated until it reaches source node. After receiving the RERR message the source node either uses a new backup route from its route table or reinitiates new route discovery process.

4. SIMULATION MODEL

The simulation software NS-2 [15] has been used for performance assessment of AODV and R-AODV based on various performance metrics. NS-2 is an open source network simulator that is widely used for networking research. The simulation setup and the energy related parameters are shown in Table 1 and 2 respectively.

Table 1. Simulation Parameters

Parameters	Values
Routing Protocol	AODV, R-AODV
MAC type	Mac/802_11
Bandwidth	2MHz
Channel frequency	2.4GHz
Radio Transmission Range	250 m
Mobility Model	Random Way Point
Number of nodes	10,20,30,40,50,75
Terrain Area	1000 m X 1000 m
Simulation time	100.0 sec
Traffic Type	CBR
Packet size	512 bytes
Nodes Maximum Speed	2,5,10,25,50,75 m/s
Pause Time	2 sec
Packets/sec	4

Table 2. Energy Parameters

Parameters	Values
Receiving Power	1.0 watt
Transmitting Power	1.4 watt
Idle Power	0.83 watt
Sleep Power	0.13 watt
Transition Power	0.2 watt
Nodes' Initial Energy	300 joules

5. RESULTS AND DISCUSSION

The simulation results are obtained on the basis of following performance metrics [7][10]:

5.1 Packet Delivery Fraction

It is the fraction of number of packets received at the destination to the number of packets sent from the source.

5.2 Average End-to-End Delay

It is the time interval between sending the packet by the source node and receiving it at the destination node, which includes buffering of data packets during route discovery, queuing at the interface queue and retransmission delays at the MAC.

5.3 Routing overhead

It is the sum of all the control packets such as route request packets, route reply packets and route error packets transmitted from both the ends (source and target).

5.4 Average Energy Consumed

It is the mean value of energy consumed by a node in the entire simulation process.

5.5 Total Hop Count

It is the total no hops taken by the data packets to travel from source to the destination.

5.6 Maximum Hop Count

It defines the longest path from source to the destination in terms of number of hops.

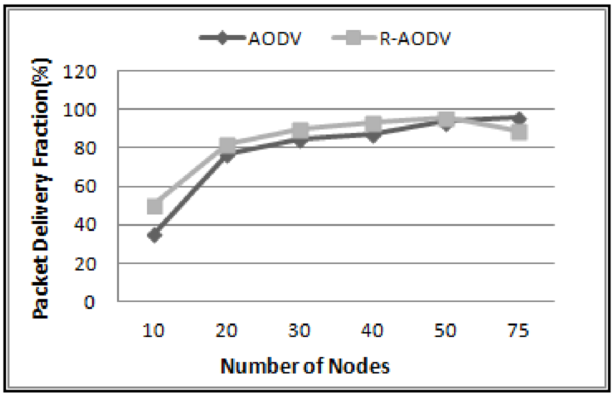

Fig 1: Packet Delivery Fraction, when number of nodes varies

The performances of both the protocols are observed by varying number of nodes and nodes maximum speed [7-14].

From **Figure 1** it is clear that R-AODV has better packet delivery ratio than AODV as we take the variation with number of nodes. The result is due to the fact that the R-AODV utilizes multiple recent routes at the source node which are fresh enough

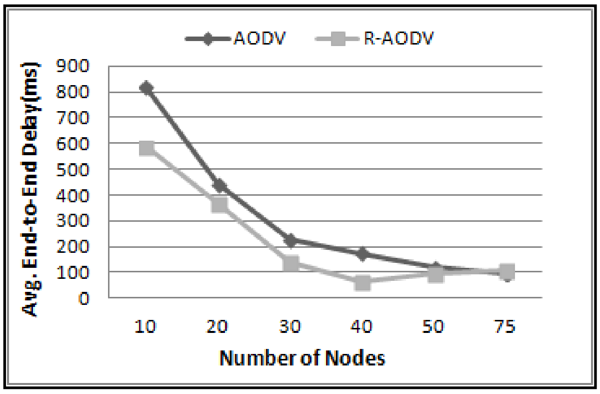

Fig 2: Average End-to-End Delay, when number of nodes varies

Figure 2 shows the Average End-to-End Delay profile of both the protocols. The result shows that R-AODV is having significantly lesser delay than AODV because rapid change of topology causes that the route reply could not arrive at the source node, which triggers the route discovery process again.

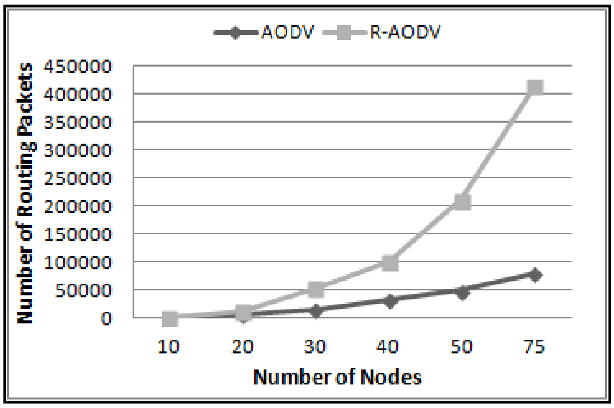

Fig 3: Routing Overhead, when number of nodes varies

Figure 3 clearly shows that the routing overhead of R-AODV is very large than AODV because R-AODV broadcasts route reply packets, whereas it is unicasted in AODV

From **Figure 4 and 5** it is clear that R-AODV completely outperforms AODV when performance is considered by varying Nodes Maximum Speed. The reason is that R-AODV utilizes multiple discovered routes with better consistency to overcome the rapid topology change due to higher nodes speed. It also reduces the communication delay due to successful delivery of data packets

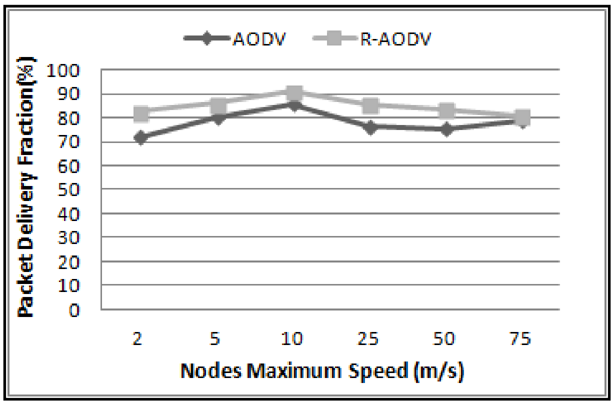

Fig 4: Packet Delivery Fraction, when nodes maximum speed varies

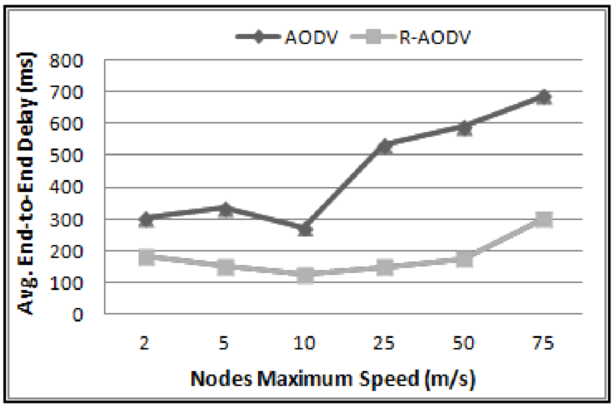

Fig 5: Average End-to-End Delay, when nodes maximum speed varies

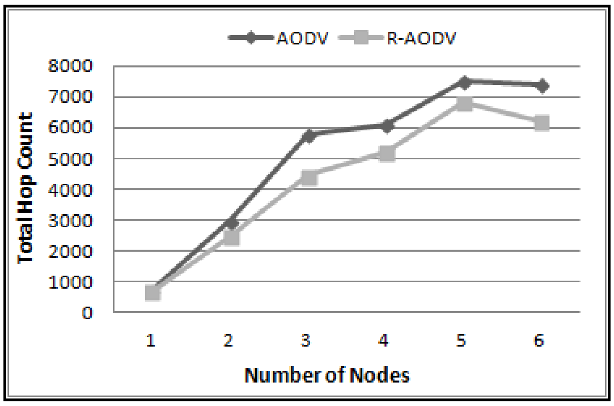

Fig 6: Total Hop Count, when number of nodes varies

Figure 6 shows R-AODV utilizes lesser number of hops to route the data packets from source to the destination. From **Figure 7** it is clear that R-AODV uses shortest paths with fewer hops to reach the destination.

Figure 8 shows that the average consumed energy for R-AODV is less than AODV even if it has transmitted large no of control packets. But in case of R-AODV data packets meet fewer hops in the chosen paths. Energy saving in R-AODV increases the survival of the nodes in the network for a longer period.

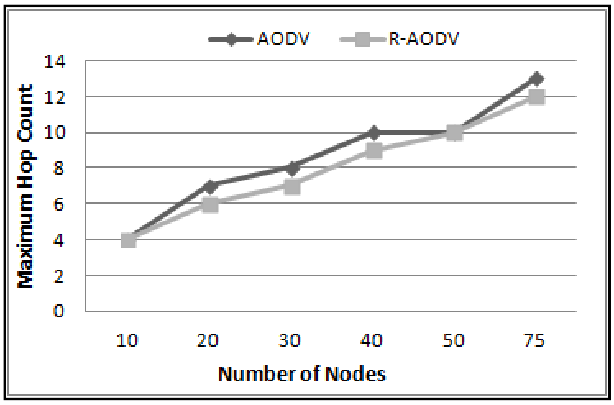

Fig 7: Maximum Hop Count, when number of nodes varies

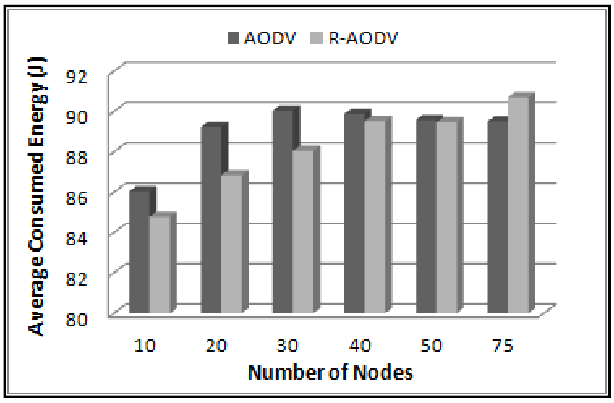

Fig 8: Average Consumed Energy, when number of nodes varies

6. CONCLUSION

A comparative analysis between AODV and R-AODV routing protocols based on large set of simulation parameters gives rise to a set of conclusions. From the above results it can be concluded that the performance of R-AODV in terms of packet delivery fraction, average end-to-end delay and average energy consumption completely dominates AODV at a cost of higher control overhead. It also shows that R-AODV uses lesser number of hops and shortest path to route the data packets.

The future work is to improve the routing overhead statistics of R-AODV protocol without compromising throughput.

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