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Implementation of Multicast Routing Protocol for Wireless Ad-Hoc Networks

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Abstract

The evolution of telecommunications is characterized by an increase of availability of bandwidth and the user mobility. It takes to a revolution in offers of the service quality. The notion of Quality of Service (QoS) becomes then an important concept if one wants to transport information with a maximum of reliability. A Mobile Ad-hoc Network (MANET) is actually a set of nodes which are self-configured and organized dynamically. Furthermore, nodes can communicate with each other without any fixed infrastructure as the base stations.

Ad hoc on Demand Distance Vector Routing (AODV) is a routing protocol for mobile ad hoc networks and other wireless ad hoc networks. It is a reactive routing protocol that is it establishes a route to a destination only on demand. In contrast, the most common routing protocols of the Internet are proactive meaning that they find routing paths independently of the usage of the paths. AODV is capable of both unicast and multicast routing.

Multicast Ad hoc On-Demand Distance Vector (MAODV) is the multicast protocol associated with the Ad hoc On-Demand Distance Vector (AODV) routing protocol, and as such it shares many similarities and packet formats with AODV. The Route Request and Route Reply packet types are based on those used by AODV, as is the unicast Route Table. The purpose of this project is to be implemented and compare the performance of MAODV and AODV using NS2.34. In this project the traffic soureses using UDP and TCP. In this project, and also to compare the AODV and MAODV using the parameter such as average end-to-end delay and packet delivery fraction (PDF) and routing-overhead.

Keywords—Mobile Ad hoc network, AODV, MAODV, QoS, delay, packet delivery fraction, routing-overhead, Performance analysis using NS2.34.

I. INTRODUCTION

The mobile ad-hoc network is a collection of two or more wireless nodes which might be mobile and able to communicate with each other either directly within radio range or by multi hop data forwarding operation if they are not directly within radio range. The wireless ad-hoc network is formed by any wireless devices which have networking capability and they are within radio range without any support of central administration and infrastructure. In such a way, ad-hoc network has been created, organized and administered by wireless node itself on the fly. None of the wireless node has right of administration and control to support the network. Only interaction among them is used to provide such functions in a network. According to the wireless nodes movement, ad-hoc network is classified in two major categories: Static ad-hoc network and Mobile ad-hoc network. In static ad-hoc network, location of mobile node is not frequently changed once network is deployed. In mobile ad-hoc network, all nodes are free to move without any restriction and topology of network is changing dynamically without any prior notice. This kind of network is abbreviated as MANET. A ―mobile ad-hoc network□ (MANET) is an autonomous system of mobile routers connected by wireless links. The routers are free to move randomly and organize themselves arbitrarily; thus, the network‘s wireless topology may change rapidly and unpredictably. Such a network may operate in a stand-alone fashion, or may be connected to the larger internet. MANETs create a network among themselves dynamically without the need for any infrastructure or support from some other wired entity. Hence, we can say that Ad-hoc networks are self-organizing, self-creating, self-administering and autonomous in their function. If a direction connection between one mobile node and another cannot be established, then other intermediate nodes act as routers or relays. Hence each node in a MANET acts as a host, a router, a receiver and a transmitter. In current large scale wireless systems, this feature is absent. The enormous benefit and the potential of MANET lie in the fact that there are no costs or the need to setup an infrastructure to form such a network. Setting up traditional networks is very costly. Take the example of telephone systems where we need local loops, trunks, exchanges, which all need to be interconnected. For cellular networks, we have a number of base stations, each of which covers a small geographical area and these base stations have to communicate with a Mobile Switching Office (MSO), which acts a centralized control centre. For mobile ad-hoc networks, no such costs are involved. Further, in situations like a disaster recovery site or remote areas where the fixed infrastructure based services are either not available or cannot be relied on, MANETs are the only possible solution.

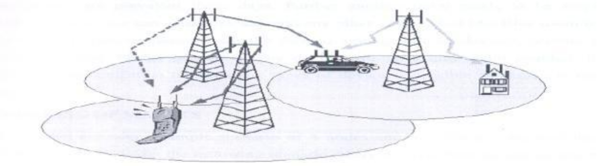

Figure .i. Illustration of cellular networks

We may evaluate mobile ad-hoc networks (MANET) comparing them with cellular networks, as they are wireless networks as well. The main differences between cellular networks and mobile ad-hoc networks are as follows.

In cellular networks, routing decisions are taken in a centralized manner with more information about the available destination node; whereas in mobile ad-hoc networks those decisions are taken in the node due to absence of a base station. Consequently, nodes have to manage routing information and host information in a distributed manner.

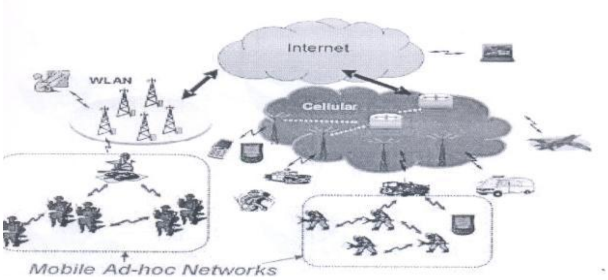

Figure.ii. Comparison of MANET with other networks

It is clear from the above illustrations that MANETs are different from the wireless networks that are prevalent these days. Further another point needs to be emphasized. In MANETs, any device can communicate with any other device. Mobile phones can communicate with PDAs, laptops or any device, which is Bluetooth enabled. Similarly in MANETs, communication between any types of device is possible.

II. ROUTING INFORMATION UPDATE MECHANISM

Routing protocols in MANETs are classified in three different groups based on the routing information update mechanism, they are: proactive, reactive and hybrid.

Proactive protocols follow the same mechanism as link- state and distance vector protocols used for wired networks; each node of the network has its own table with all neighbor nodes and the cost of each different path. The primary problem in proactive routing protocols is that every intermediate node has to update constantly a table with all the information about other nodes in the network. Moreover, each time control messages are sent in the network, this excess of information, may generate congestion in the network and loss of data packets due to buffer overflows and MAC contention. The maintenance of the paths is expensive because constantly routes can be broken because of the nodes mobility, which generate constant updates of information in each node. Therefore, link-state protocols are not suitable in high mobile MANET, with many route table changes, because in each node topology information is replicated.

A. DESTINATION SEQUENCED DISTANCE VECTOR (DSDV) ROUTING PROTOCOL

The destination sequenced distance vector routing protocol is a proactive routing protocol .This protocol adds a new attribute, sequence number, to each route table entry at each node. Routing table is maintained at each node and with this table; node transmits the packets to other nodes in the network. This protocol was motivated for the use of data exchange along changing and arbitrary paths of interconnection which may not be close to any base station

Reactive (or on demand) protocols, start a route discovery each time that they have a packet to send to a destination and its route is not known. Usually, nodes that implement reactive protocols have a cache where all the routes discovered are stored for future uses; routes not used recently are expired even if they are still valid. The key feature of on-demand protocols is acquiring routing information only when it is actually required, avoiding maintaining long routing tables. Sender will have to acquire a route to the destination before the communications start which suppose an increase of the transmission time for the first packet.The goal of an on-demand protocol is o offer optimal path for each node that requires it, without having obligation to maintain updated information.

B. AD-HOC ON-DEMAND DISTANCE VECTOR ROUTING PROTOCOL (AODV)

A mobile ad hoc network is a mobile, multihop wireless network that does not rely on any preexisting infrastructure. Mobile adhoc networks are characterized by dynamic topologies due to uncontrolled node mobility, limited and variable shared wireless channel bandwidth, and wireless devices constrained by battery power. One of the key challenges in such networks is to design dynamic routing protocols that are efficient, that is, consume less overhead. A new class of on-demand routing protocols e.g., DSR, AODV for mobile ad hoc networks has been developed with the goal of minimizing the routing overhead. These protocols reactively discover and maintain only the needed routes, in contrast to proactive protocols e.g., DSDV which maintain all routes regardless of their usage. The key characteristic of an on-demand protocol is the source-initiated route discovery procedure. Whenever a traffic source needs a route, it initiates a route discovery process by sending a route request for the destination (typically via a network-wide flood) and waits for a route reply. Each route discovery flood is associated with significant latency and overhead. This is particularly true for large networks. Therefore, for on- demand routing to be effective, it is desirable to keep the route discovery frequency low. Among the on-demand protocols, multipath protocols have a relatively greater ability to reduce the route discovery frequency than single path protocols. On demand multipath protocols discover multiple paths between the source and the destination in a single route discovery. So, a new route discovery is needed only when all these paths fail. In contrast, a single path protocol has to invoke a new route discovery whenever the only path from the source to the destination fails. Thus, on-demand multipath protocols cause fewer interruptions to the application data traffic when routes fail Many researchers in Mobile Ad-hoc Networks (MANETs) assume that nodes are equal in terms of their characteristics such as transmission range and signal-to-noise ratio (SNR). Such assumptions are not true particularly in real life situations, where a node‗s characteristics are very much influenced by its location, power consumption, mobility and etc. Some existing routing protocols are equally restricted in that equal bidirectional links and symmetrical paths are implicit in their operation. For example, the AODV routing protocol asserts that only bidirectional links must be used to create forward and reverse routes. This is because AODV routing operation over unidirectional link may increase delay and routing overhead. Nevertheless, some previous researchers also have shown that by utilizing unidirectional links in addition to the existing use of bidirectional links can improve MANET performance in terms packet delivery ratio and end-to-end delay.

The Ad-hoc On-Demand Distance Vector (AODV) algorithm enables.Dynamic,self-starting,multihop routing between participating mobile nodes wishing to establish and maintain an adhoc network. AODV is designed for networks with tens to thousands of mobile nodes. One feature of AODV is the use of a destination sequence number for each routing table entry. The sequence number is created by the destination node. The sequence number included in a route request or route reply is sent to requesting nodes. Sequence number are very important because they ensures loop freedom and is simple to program. Sequence numbers are used by other nodes to determine the freshness of routing information. If a node has the choice between 2 routes to a destination, a node is required to select the one with the greatest sequence number.

AODV deals with routing table. Every node has a routing table. When a node knows a route to the destination, it sends a route reply to the source node. Its entries are:

- Destination IP Address
- Prefix Size
- Destination Sequence Number
- Next Hop IP Address
- Lifetime (expiration or deletion time of the route)
- Hop Count (number of hops to reach the destination)
- Network Interface
- Other state and routing flags (e.g., valid, invalid

original RREQ from the source S. These identifying values have to be stored for a time that is long enough to ensure no other node in the ad hoc network could still be processing messages resulting from the route discovery operation. It is same difficult to predict how long this time is, because it depends on the present state of congestion in the network as

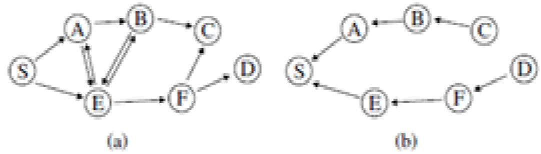

Figure.iii. Route discovery. (a) RREQ broadcast and (b) RREP propagation

Fig. (a) Illustrates the flooding of a RREQ, originating at the source node S, through the network. In this example, we assume nodes C and D have routes to the destination D.A node creates a RREP by placing the IP address of the destination node, as well as its record of the destinations sequence number, into the RREP. It also includes the source node IP address and it distance, in hops, to the destination. The node then unicast the RREP to the next hop towards the source node. In Fig. (b), both nodes C and D have routes to the destination D that meet the reply criteria. Hence, both nodes generate a RREP. When the next hop receives the RREP, it first increments the hop count value in the RREP and then creates a forward route entry to both the destination node and the node from which it received the reply. This ensures that all nodes along the path will know the route to the destination in the event that the source selects this route for data packet transmission.

The node then unicast the RREP to its next hop towards the source node. This hop-by-hop forwarding continues until the RREP reaches the source. Once the source receives a RREP, it can begin using that path for data packet transmission. In the event that the source receives multiple RREPs along different paths, it selects the route with the greatest destination sequence number and the smallest hop count for communication with the destination. Route discovery operations often require processing and communications capacity at every node in the ad hoc network. For this reason, we often describe the discovery operation as ‗flooding‘‘ even though the RREQs are only locally broadcast messages. Since the messages are changed at each hop by AODV processing, we could not use any system-wide broadcast or multicast address. Nevertheless, it is of great importance to use careful broadcast techniques to minimize any spurious retransmission of RREQ packets. For instance, each node is required to keep track of which RREQ messages it has received, and to discard duplicates that it receives from multiple neighboring nodes. In order to detect duplication, the node identifies each RREQ by using the IP address of the originating node, and the RREQ ID for the RREQ message data. In Fig.(a), by this algorithm node E would discard RREQs it hears from nodes A, B, and F after receiving the well as the size and current topology of the network. For correctness, it is better to err on the side of caution, maintaining the broadcast identification information for perhaps even minutes. In an ad hoc network, links are likely to break due to the mobility of the nodes and the

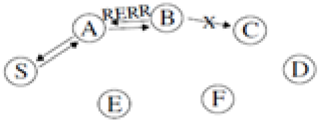

Figure.iv.Link break notification.

Nature of the wireless channel. Hence, there must be a mechanism in place to repair routes when links within active routes break. An active route is defined to be a route that has recently been utilized for the transmission of data packets. When such a link break occurs, the node upstream of the break (i.e., the node closer to the source node), invalidates in its routing table all destinations that become unreachable due to the loss of the link. It then creates a Route Error (RERR) message, in which it lists each of these lost destinations. The node sends the RERR upstream towards the source node. If there are multiple previous hops (so-called precursors) that were utilizing this link, the node broadcasts the RERR; otherwise, it is unicast. In Fig. 3, the link between nodes B and C on the path from S to D is broken. Node B invalidates its route table entries for both nodes C and D, creates a RERR message listing these nodes, and sends the RERR upstream towards the source. When a node receives a RERR, it first checks whether the node that sent the RERR is its next hop to any of the destinations listed in the RERR. If the sending node is the next hop to any of these destinations, the node invalidates these routes in its route table and then propagates the RERR back towards the source. The RERR continues to be forwarded in this manner until it is received by the source. Once the source receives the RERR, it can re- initiate route discovery if it still requires the route.

C.MULTICAST AD-HOC ON-DEMAND DISTANCE VECTOR ROUTING PROTOCOL (MAODV)

The Multicast Ad hoc On-Demand Distance Vector (MAODV) protocol enables dynamic, self-starting, multihop routing between participating mobile nodes wishing to join or participate in a multicast group within an ad hoc network.

The membership of these multicast groups is free to change during the lifetime of the network. MAODV enables mobile nodes to establish a tree connecting multicast group members. Mobile nodes are able to respond quickly to link Breaks in multicast trees by repairing these breaks in a timely manner. In the event of a network partition, multicast trees are established independently in each partition, and trees for the same multicast group are quickly connected if the network components merge. One distinguishing feature of MAODV is its use of sequence numbers for multicast groups. Each multicast group has its own sequence number, which is initialized by the multicast group leader and incremented periodically. Using these sequence numbers ensures that routes found to multicast groups are always the most current ones available. Given the choice between two routes to a multicast tree, a requesting node always selects the one with the greatest sequence number. MAODV is the multicast protocol associated with the Ad hoc On-Demand Distance Vector (AODV) routing protocol, and as such it shares many similarities and packet formats with AODV. The Route Request and Route Reply packet types are based on those used by AODV, as is the unicast Route Table. Similarly, many of the configuration parameters used by MAODV are defined by AODV.

MAODV protocol description: Route Requests (RREQS),Route Replies(RREPS) Multicast Activations (MACTs), and Group Hellos (GRPHs) are the message types utilized by the multicast operation AODV. RREQs and RREPs. These message types are handled by UDP, and normal IP header processing applies. So, for instance, the requesting node is expected to use its IP address as the source IP address for the messages. The range of dissemination of broadcast RREQs can be indicated by the TTL in the IP header. Fragmentation is typically not required.
As long as the multicast group members remain connected (within a "multicast tree"), MAODV does not play any role. When a node either wishes to join a multicast group or find a route to a multicast group, the node uses a broadcast RREQ to discover a route to the multicast tree associated with that group. For join requests, a route is determined when the RREQ reaches a node that is already a member of the multicast tree, and the node's record of the multicast group sequence number is at least as great as that contained in the RREQ. For non-join requests, any node with a current route to the multicast tree may respond to the RREQ. A current route is defined as an unexpired multicast route table entry whose associated sequence number for the multicast group is at least as great as that contained in the RREQ. The route to the multicast tree is made available by unicasting a RREP back to the source of the RREQ. Since each node receiving the request caches a route back to the source of the request, the RREP can be unicast back to the source from any node able to satisfy the request. Once the source node has waited the discovery period to receive RREPs, it selects the best route to the multicast tree and unicasts the next hop along that route a MACT message. This message activates the route. Nodes monitor the link status of next hops on the multicast tree. When a link breaks on the multicast tree is detected, the tree branch should be immediately repaired through the use of the RREQ/RREP/MACT messages.

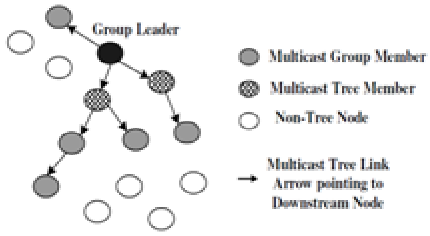

Figure.v. MAODV Multicast tree.

A multicast group leader is associated with each multicast group. The primary responsibility of this node is the initialization and maintenance of the group sequence number. A Group Hello message is periodically broadcast across the network by the multicast group leader. This message carries a multicast group and group sequence number and corresponding group leader IP address. This information is used for disseminating updated group sequence numbers throughout the multicast group and for repairing multicast trees after a previously disconnected portion of the network containing part of the multicast tree becomes reachable once again.

Route Discovery: MAODV routing protocol follows directly from unicast AODV, and discovers multicast routes on demand using a broadcast route discovery mechanism employing the same route request (RREQ) and route reply (RREP) messages that exist in the unicast AODV protocol. A mobile node originates an RREQ message when it wishes to join a multicast group, or has data to send to a multicast group but does not have a route to that group. Only a member of the desired multicast group may respond to a join RREQ. If the RREQ is not a join request, any node with a fresh enough route (based on group sequence number) to the multicast group may respond. If an intermediate node receives a join RREQ for a multicast group of which it is not a member, or it receives a RREQ and does not have a route to that group, it rebroadcasts the RREQ to its neighbors.

As the RREQ is broadcast across the network, nodes set up pointers to establish the reverse route in their route tables. A node receiving an RREQ first updates its route table to record the sequence number and the next hop information for the source node. This reverse route entry may later be used to relay a response back to the source. For join RREQs, an additional entry is added to the multicast route table and is not activated unless the route is selected to be part of the multicast tree. If a node receives a join RREQ for a multicast group, it may reply if it is a member of the multicast group‘s tree and its recorded sequence number for the multicast group is at least as great as that contained in the RREQ. The responding node updates its route and multicast route tables by placing the requesting node‘s next hop information in the tables, and then unicasts an RREP back to the source. As nodes along the path to the source receive the RREP, they add both a route table and a multicast route table entry for the node from which they received the RREP, by creating the forward path.

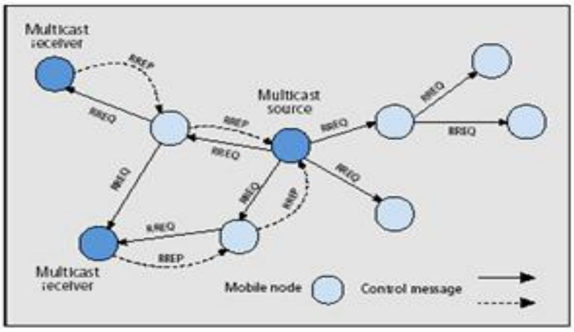

Figure.vi. Route Discovery in MAODV

Multicast Route Maintenance: When a source node broadcasts an RREQ for a multicast group, it often receives more than one reply. The source node keeps the received route with the greatest sequence number and shortest hop count to the nearest member of the multicast tree for a specified period of time, and disregards other routes.

At the end of this period, it enables the selected next hop in its multicast route table, and unicast an activation message (MACT) to this selected next hop. The next hop, on receiving this message, enables the entry for the source node in its multicast routing table. If this node is a member of the multicast tree, it does not propagate the message any further. However, if this node is not a member of the multicast tree, it would have received one or more RREPs from its neighbors. It keeps the best next hop for its route to the multicast group, unicast MACT to that next hop and enables the corresponding entry in its multicast route table. This process continues until the node that originated the chosen RREP (member of tree) is reached. The activation message ensures that the multicast tree does not have multiple paths to any tree node.

Group Leader in the Multicast Tree: The first member of the multicast group becomes the leader for that group, which also becomes responsible for maintaining the multicast group sequence number and broadcasting this number to the multicast group. This update is done through a Group Hello message. The Group Hello contains extensions that indicate the multicast group IP address and sequence numbers (incremented every Group Hello) of the multicast group.

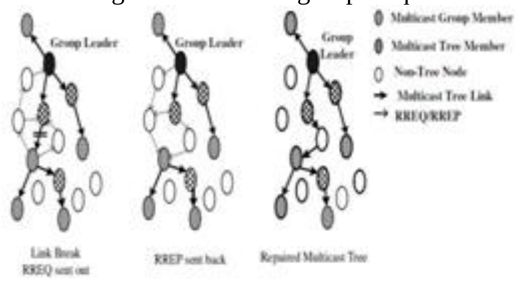

Figure.vii. MAODV Repair of Multicast tree.

*Link breakage in the network***:** Since ad hoc networks are highly dynamic by nature. The changes in the network topology may lead to two different situations*:* A link may be broken and the multicast tree may be partitioned. A node discovers a link breakage either actively or passively.

Active discovery means that the MAC layer informs upper layers about reach ability problems. Passive discovery happens, if the node has not heard from it‘s neighbor for a while. In this case, it might try to ping the neighbor or ask a route towards it via RREQ. Be it either case, when the node discovers connectivity loss with the multicast tree neighbor, if it is the downstream neighbor, it is responsible for correcting the situation. Now, the node sends a RREQ with a Multicast Group Leader Extension. This extension contains the old distance of the node to the group leader. Only multicast tree member nodes that have distance to the group leader equal or less than the one set in the extension may answer with RREP. This prevents the nodes on the same side of the break as the initiator of the RREQ from answering and thus creating possible loops. If the repair leads to a situation, where the node‘s new distance to the group leader is greater than the old one, and then it must inform its downstream nodes about this. This is done with MACT message where the update flag is set. This MACT message is multicast to all of the tree members, also upstream. But upstream members see that this message comes from a downstream node and therefore discards the message.

An OTcl script will do the following:

Reconnecting the disconnected Link: When the node tries to reconnect the disconnected link and does not get an answer to the RREQ message number of retries times, then it must assume that the tree is partitioned. If this is the case and it is a member of the group, then it becomes a new group leader. It broadcasts group hello message with update-flag set indicating that there is a new group leader. However, if the node has multiple downstream nodes, then it selects any one of these and sends a MACT message with grpldr-flag set. This indicates that the receiving node should become group leader. If it is a group member, it becomes a leader, otherwise it continues seeking the leader with the previously described methods .When the group leader is finally found, it broadcasts group hello message with update-flag set to indicate that changes has occurred in the network. If the node trying to repair the break is not a multicast group member, then it must try to find a new group leader from the downstream nodes it has. If there is only one downstream node, then the node prunes itself from the tree.

III. SIMULATIONS AND RESULTS

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As shown in the simplified user‘s view of Figure 8, NS-2 is an Object-oriented Tcl (OTcl) script interpreter that has a simulation event scheduler and network component object libraries and network set-up module libraries.

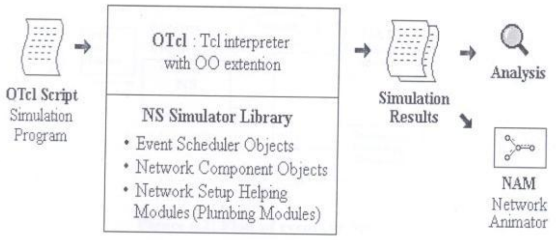

Figure .viii: Simplified View of Network Simulator.

To use NS-2, a user programs in the OTcl script language.

- Initiates an event scheduler
- Sets up the network topology using the network objects.
- Tells traffic sources when to start/stop transmitting packets through the event scheduler.

A user can add OTcl modules to NS2-2 by writing a new object class in OTcl. These have to be compiled together with the original source code. Another major component of NS besides network objects is the event scheduler. An event in NS is a packet ID that is unique for a packet with scheduled time and the pointer to an object that handles the event.

The protocols AODV, MAODV are simulated by using network(NS2) simulator for the parameters Packet Delivery Ratio, Average-end-to-end Delay and Routing-overhead.

SIMULATION ENVIRONMENT

A detailed description of simulation environment and models are given:

- Routing protocols: AODV, MAODV
- Number of nodes: 10,20,30,40,50
- Simulator: NS2
- Simulation Time:150secs
- Pause Time:0,10,20,30,40,50secs
- Mobile speed:0~maxspeed: 25m/s
- Area: 1500m*300m
- Transmission range: 250m
- Parameters: Packet Delivery Ratio, Average-end-to- end Delay and Routing-overhead.

SIMULATION RESULTS FOR AVERAGE END TO END DELAY

Average end to end Delay: It is defined as the interval time between sending by the source node and receiving by the destination node, which includes the processing time and queuing time.

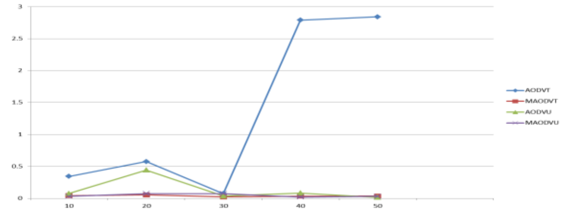

Figure.ix.Average-end-to-end-delay

SIMULATION RESULTS FOR PACKET DELIVERY RATIO (%)

Packet Delivery Ratio: It is defined as the ratio of packets reaching the destination node to the total packets generated at the source node.

Packet Delivery Ratio/Fraction(%):

PDF=(Received packets/Sent packets)x100

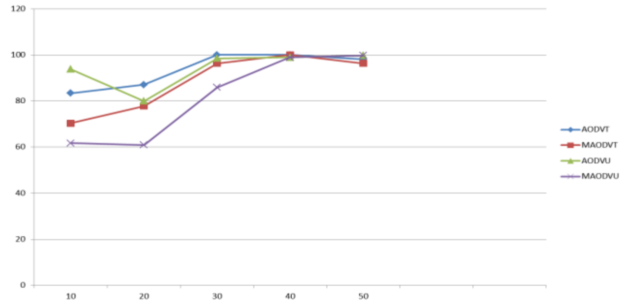

Figure.x. Packet Delivery Ratio

SIMULATION RESULTS FOR ROUTING-OVERHEAD(%) Routing overhead(%): The ratio of total number of control packets sent into the network and the total number of data packets received.

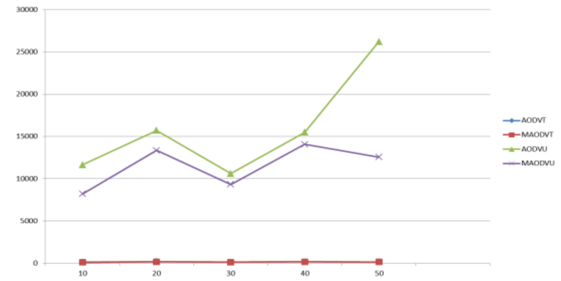

Figure.xi. Routing-overhead

IV. CONCLUSION AND FUTURE SCOPE

CONCLUSION

In this paper presented, performance of AODV and MAODV routing protocol are compared in terms of the performance parameters such as packet delivery ratio, Average end to end delay and routing overhead by using Network Simulator (NS2) for different number of nodes (10, 20, 30, 40, 50) and different number of nodes speed (5, 10, 25) for different pause times (0, 10, 20, 30, 40, 50).

From the results it is clear that at low mobility rate AODV performs better in case of packet delivery ratio but it performs poorly in terms of average end to end delay and routing overhead. At high network load and mobility MAODV performs well with respect to packet delivery ratio and average end to end delay. However it is clear that when mobility is low, AODV performs well among the three and when mobility is high MAODV performs well. Hence it is compare the results of both protocols MAODV is better performances then AODV.

V. FUTURE SCOPE

This paper can extended by increasing the number of nodes to more then hundred and maximum nodes speed and also by increasing the size of packet.

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