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Implementation of Adaptive Delay Multicast Routing Protocol

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ABSTRACT: A Mobile Ad-Hoc Network(MANET) represents a system of wireless mobile nodes that can freely and dynamically self organize into arbitrary and temporary network topologies without the presence of any fixed infrastructure. High degree of mobility and Limited bandwidth are two important issues for routing protocols in MANETs. Multicasting can improve the efficiency of the wireless link when sending multiple copies of messages by exploiting the inherent broadcast property of wireless transmission. Routing protocols for MANETs have traditionally used shortest path routing to obtain paths to destinations, and do not consider traffic load or delay as an explicit factor. This paper proposes a new multicast routing protocol called Adaptive delay multicast routing protocol(ADRP). ADRP adopts mesh structure and takes paths to destinations where delay is lesser than mean delay. ADRP considered energy limitations of mobile nodes as a constraining factor. A ns-2 simulation study performed and our results revealed that ADRP gives better performance in highly mobility environments. These results are checked in various environments.

Keywords: Mobile Ad hoc networks, Multicast Routing, Adaptive Delay Multicast Routing, NS-2.

I. INTRODUCTION

A mobile ad-hoc network(MANET)[1] is an autonomous collection of mobile nodes that communicates over bandwidth constrained wireless links. This network is not supported by any fixed infrastructure or central administration. The nodes are self organized and can be deployed anywhere, any time to support a particular purpose. Typically application areas of it includes battle fields, rescue sites and data acquisition in remote areas. An ad-hoc network is also useful in conventions and classrooms where participants share information dynamically.

In a typical ad hoc environment, network hosts work in groups to carry out a given task. Hence, multicast data transfer is more predominant than unicast data transfer. In military networks, multicast traffic dominates due to need of group communications. Multicasting involves the transmission of a datagram to a group of zero or more hosts identified by a single destination address, and is intended for group oriented computing. The use of multicasting within MANETs has many benefits. It can improve the efficiency of wireless channel while sending multiple copies of same data to different hosts. Instead of sending data via multiple unicast, multicasting minimizes channel consumption, sender and router processing, energy consumption and delivery delay.

Multicast routing[13] in MANETs is much more complex than in wired networks and faces several challenges. Multicast group members move, which prevents the use of a fixed infrastructure multicast topology. Various multicast protocols have been proposed to perform multicasting in ad-hoc networks. Multicast Routing protocols for MANETs have traditionally used shortest path routing to obtain paths to destinations, and do not consider traffic load or delay as an explicit factor. This paper proposes a new multicast routing protocol which gives a path source to destinations in which the delay is less than mean delay. The proposed protocol ADRP is an extension to wardrop routing protocol[3] in ad-hoc networks which is unicast , multipath and does not consider energy limitations as a constraining factor. ADRP considered energy limitations of mobile nodes as a constraining factor.

This paper is organized as follows: In Section 2 we survey related work and classification of multicast protocols. Section 3 provides description of ADRP. Section

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4 presents the simulation environment we used. Section 5 provides simulation results and concluding remarks in section 6.

II. RELATED WORK

Multicasting plays a crucial role in many applications of mobile ad hoc networks . It can significantly improve the performance of these networks, the channel capacity (in mobile ad hoc networks, especially single-channel ones, *capacity* is a more appropriate term than *bandwidth*, capacity is measured in bits/s and bandwidth in Hz) and battery power of which are limited. In the past couple of years, a number of multicast routing protocols have been proposed. In spite of being designed for the same networks, these protocols are based on different design principles and have different functional features when they are applied to the multicast problem. These protocols must deal with a number of issues, including, but not limited to, high dynamic topology, limited and variable capacity, limited energy resources, a high bit error rate, a multihop topology, and the hidden terminal problem.

2.1 Classification of Multicast Routing Protocols

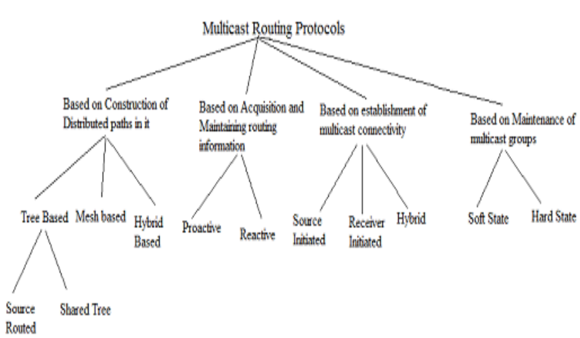

Fig 1: Classification Multicast Routing Protocols

a) Classification Based on Construction of Distributed paths in it

Multicast routing protocols for MANETs can be classified based on how distribution paths are constructed among group members. According to this, existing multicast protocols for MANETs can be divided into tree based, mesh based and hybrid multicast protocols.

Tree based protocols (e.g.,MAODV[14], ABAM[10], ADMR[8]) can be further divided into source rooted and shared tree based schemes according to the roots of the multicast trees.

In a source rooted scheme, each source node creates a single multicast tree spanning all the members in a group. This requires a source to be aware of the topology information and addresses of all its receivers in the multicast group. In a shared tree based approach, only one multicast tree is created for a multicast group which includes all the source nodes. Each source uses this tree to initiate a multicast.

Compared to source rooted approach, shared tree based approach is less efficient in multicast. Because in shared tree based the traffic is not evenly distributed through out the network and is aggregated on the shared tree which leads to low throughput. However in source rooted approach the traffic is evenly distributed through out the network which leads to better throughput but it has less scalability problem.

Tree based multicast routing protocols provide high data forwarding efficiency at the expense of the low robustness.

In a mesh based routing protocol(e.g., ODMRP[6],CAMP[15][16][17][11],NSMP[9] a multicast mesh connecting a source to all receivers in the network is constructed. Route discovery and mesh building are accomplished by using broadcasting to discover routes or by using core or central points. There are multiple paths connecting the source and destination in the pair. These redundant paths provide more robustness and higher packet delivery but at the same time more overhead because of data packet duplication.

Hybrid-based multicast routing protocols combine the advantages of both tree and mesh-based approaches. Hence, hybrid protocols address both efficiency and robustness. Using this scheme, it is possible to get multiple routing paths, and duplicate messages can reach a receiver through different paths. However, they may create non-optimal trees with nodes mobility.

b) Classification Based on Acquisition and Maintenance of Routing information

Another classification method is based on how routing information is acquired and maintained by mobile nodes. Using this method, multicast routing protocols can be divided into proactive routing and reactive routing.

A proactive multicast routing protocol is called"table-driven" multicast routing protocol. In a network utilizing a proactive routing protocol, every node maintains one or more tables representing the entire topology of the network. These tables are updated regularly in order to maintain up-to-date routing information from each node to every other node. To maintain up-to-date routing information, topology information needs to be exchanged between the nodes on a regular basis, leading to relatively high overhead on the

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network. On the other hand, routes will always be available on request. There are some typical proactive multicast routing protocols, such as CAMP[15][16][17][11] and AMRIS[12].

A reactive multicast routing protocol is also called"on-demand" multicast routing protocol. Reactive protocols seek to set up routes on-demand. If a node wants to initiate communication with a node to which it has no route, the routing protocol will try to establish such a route. Reactive multicast routing protocols have better scalability than proactive multicast routing protocols. However, when using reactive multicast routing protocols, source nodes may suffer from long delays for route searching before they can forward data packets. ACMRP[4] and ABAM[10] are examples for reactive routing protocols for MANETs.

c) Classification Based on Establishment of Multicast Connectivity

Based on how multicast connectivity is established and maintained, multicast routing protocols are classified into the following two approaches.

(i) The Source-Initiated approach(e.g.,ODMRP[6]), in which a multicast group is initiated and maintained by the source node (multicast group/source). The source constructs a multicast mesh or tree by flooding the network with a Join Request message. Any receiver node wishing to join a multicast group replies with a Join Reply message

(ii) The Receiver-Initiated approach(e.g.,DDM[7]), in which any receiver node wishing to join a multicast group floods the network with a Join Request message searching for a route to a multicast group. The management of the membership of a multicast group is usually assigned to a core (rendezvous) node. All sources of the same multicast group share a single multicast connection.

Some multicast protocols may not fall strictly into either of these two types of approach when they do not distinguish between source and receiver for initialization of the multicast group. Initialization is achieved either by the source or by the receiver. This type can be identified as a hybrid approach.

d) Classification based on Maintenance of multicast groups

MANETs suffer from frequent link breaks due to the lack of mobility of the nodes, which makes efficient group maintenance necessary. Maintaining the multicast group can be achieved by either the Soft-State approach or the Hard-State approach.

In the Soft-State approach, the multicast group membership and associated routes are refreshed periodically (proactively) by the flooding of control packets, whereas in the Hard-State approach, broken links are reconfigured by deploying two different approaches. The first is reactive, where routes are reconfigured, by sending control packets, only when a link breaks. The second is proactive, where routes are reconfigured before a link breaks, and this can be achieved by using local prediction techniques based on GPS or signal strength. The proactive approach is more reliable than the reactive approach, because it has much less packet loss, that is, it has a higher packet delivery ratio.

The Hard-State approach is much more efficient in terms of overhead. In contrast, the Soft-State approach is much more efficient in terms of reliability (packet delivery ratio). We can, therefore, conclude that there is a tradeoff between overhead and reliability.

2.2 Different Multicast Routing Protocols

Other multicasting protocols have been proposed for ad hoc networks. The Reservation-Based Multicast (RBM) routing protocol [20] builds a core (or a Rendezvous Point) based tree for each multicast group. RBM is a combination of multicast,resource reservation, and admission control protocol where users specify requirements and constraints. The Lightweight Adaptive Multicast (LAM) algorithm [21] is a group sharedtree protocol that does not require timer-based messaging.

Similar to other core-based protocols, it suffers from disadvantages of traffic concentration and vulnerability of the core. The Adhoc Multicast Routing Protocol (AMRoute) [5] is also a shared-tree protocol which allows dynamic core migration based on group membership and network configuration. The Ad hoc Multicast Routing protocol utilizing Increasing id numbers (AMRIS) [12] builds a shared-tree to deliver multicast data. Each node in the multicast session is assigned an ID number and it adapts to connectivity changes by utilizing the ID numbers. A multicast extension of Ad Hoc On Demand Distance Vector (AODV) routing protocol has been newly proposed in [14]. Its uniqueness stems from the use of a destination sequence number for each multicast entry. The sequence number is generated by the multicast grouphead to prevent loops and to discard stale routes. Similar to ODMRP, the Core-Assisted Mesh Protocol (CAMP)[15][16][17][11] uses a mesh. However, a conventional routing infrastructure based on enhanced distance vector algorithm (e.g., WRP [22]) is

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required for CAMP to operate. Core nodes are used to limit the traffic required when a node joins a multicast group.

III. ADAPTIVE DELAY MULTICAST ROUTING PROTOCOL OVERVIEW

ADRP is mesh based multicast routing protocol which includes the neighboring concept and load adaptive concept. The routes are built and maintained using traditional request and reply messages. A soft state approach is used for multicast group maintenance.

3.1 Different Steps in ADRP

Step 1: **Neighbor Awareness in ADRP**

In this each node gets neighbor information by periodically sending HELLO packet.

Type	Source ID	Sequence	Neighbor ID	Neighbor Delay

Fig 2:Hello Packet

Step 2: **Creation of Mesh**

In this source node sends ROUTE-REQ packet to create mesh to destination node.

Type	Sequence	Source ID	Neighbor ID	Destination ID	FC	Delay

Fig 3: ROUTE-REQ Packet

Step 3: **Maintenance of Mesh**

Mesh is maintained by periodically sending LOCAL-REQ packet.

Type	Sequence	Source ID	Mesh node ID	Delay

Fig 4:LOCAL-REQ Packet

Step 4: **DATA Packets Transmission**

Duplication of data is checked by sending DATA caches.

Source ID	Group ID	Sequence Number

Fig 5:DATA cache

In the following subsections each step is explained in detail.

3.1.1 Neighbor Awareness in ADRP

Each node n1 keeps the information of all of its neighbors of one-hop distance in a neighbor table. A node periodically transmits HELLO packet shown in fig: (containing its own neighbor table information) to all of its neighbors. If there is already an existing neighbor node n2, it gets the HELLO packet of n1, in which its n2 own ID is included. Consequently, node n1 also gets the HELLO packet from node n2 that is, the neighboring information of node n2. If a neighbor node n2 moves out of the range of node n1, ADRP uses a soft-state approach (e.g., a time out value is assigned to each entry of the neighbor table) to detect the topological change. If a node comes within the neighbor range of another node for the first time, it gets the HELLO packet of that node and finds that its own ID is missing but as it is now within the neighbor range, it informs about its presence by sending a HELLO_REP packet and eventually the neighbor table of each node is updated.

3.1.2 Creation of Multicast Mesh

In ADRP, A new source initially sends a ROUTE-REQ shown in fig 3 packet. The ROUTE-REQ packet has a data payload field. When an intermediate node receives the ROUTE-REQ packet, it caches the upstream node and updates the field with its own address before forwarding it to next nodes. When a receiver receives the ROUTE-REQ packet, it sends a REP packet to the node from which it received the packet. The upstream node receives the REP packet and adds an entry for the group to its routing table. Then it forwards the REP packet to its own upstream node, and the REP packet eventually reaches the source node. The intermediate nodes that relay the REP packet become *forwarding nodes*. A multicast mesh of a group consists of sources, receivers, forwarding nodes, and links connecting them. The nodes in a multicast mesh are called *mesh nodes*. Till this point multicast mesh creation process is same as the NSMP[9].

In addition to above by taking the help of neighbour awareness and delay information in ADRP multicast mesh is created by considering all possible paths. Fig6 illustrates how a multicast mesh is built.

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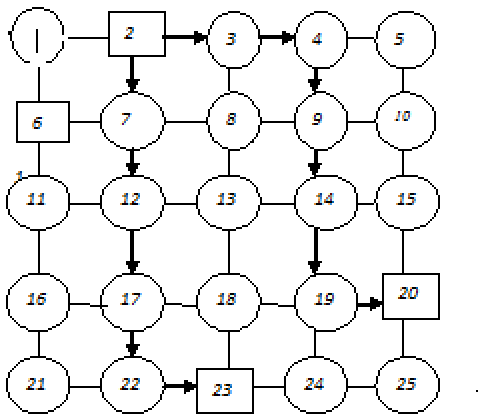

Fig 6: Mesh Creation

Assume that nodes 20 and 23 are receivers of a multicast group. When node 2 joins group as source, it broadcast ROUTE-REQ packet. By using neighboring information, ROUTE-REQ packet reaches nodes 3,7 and 1.when node 20 receives the packet it sends reply packet to all nodes from which it receives ROUTE-REQ packet. Those nodes are considered as upstream nodes and they in turn send reply to their upstream nodes. Like this all the reply packets reaches the node 2 with delay information. At node 2 average delay is calculated. Out of all the routes one is selected which has lesser delay than average delay.

Same process is applicable to all the receiver nodes. After identifying paths, between source and receivers in a group multicast mesh is created.

3.1.3 Multicast Mesh Maintenance

Each source node periodically transmits a LOCAL-REQ packet shown in Fig 4 and only mesh nodes and group neighbor nodes relay the packet. Therefore, all nodes two hops away from the mesh nodes receive the LOCAL-REQ packet. This mechanism repairs most link failures caused by node movements. REP packets to LOCAL-REQ packets are relayed to a source in the same way as REP packets to ROUTE-REQ packets. Forwarding nodes and group neighbor nodes along a multicast mesh are updated as REP packets are relayed to a source.

Fig 7 & 8 shows how multicast mesh is maintained.

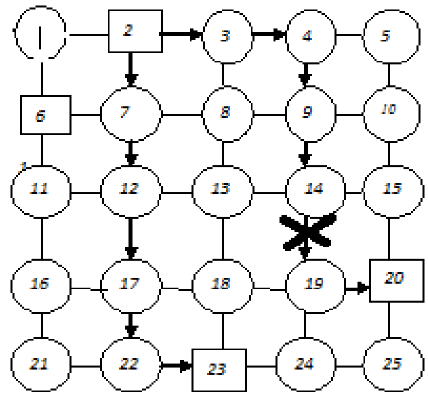

Fig 7: Link failure between 14 and 19 nodes

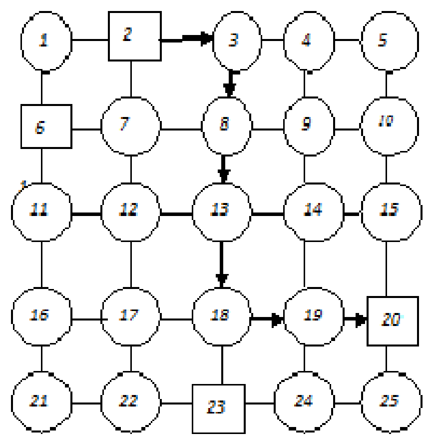

Fig 8 : Alternate route between 2 and 20 nodes

Assume that link is broken between 14 and 19 nodes in Fig 7 which is in mesh between 2 to 20. Node 2 will eventually send a LOCAL-REQ packet since each source periodically performs local route discovery. When node 3 receives a packet, it broadcasts the packet since group neighbour nodes relay LOCAL-REQ packets. When node 19 subsequently broadcasts the packet, node 20 receives it and sends a reply packet to build a new route between 2 and 20 shown in Fig 8.

3.1.4 DATA Packets Transmission

When a node receives a DATA packet, it consults *DataCache* to see if the packet is duplicate. If so, it discards the packet. Otherwise, it updates *DataCache* to reflect the packet header information, especially the sequence number. And the packet is re-broadcast if the receiving node is a forwarding node.

3.2 Node Joining and Leaving a Group

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When a node wants to join a group as a receiver, it waits for a LOCAL-REQ packet for REQ-PERIOD. It will receive one and be able to build a route if it is a mesh node, a neighbor node of the group.

If the new receiver does not receive a LOCAL-REQ packet, it broadcasts a MEM-REQ packet. On receiving a MEM-REQ packet, a node operates analogous when it receives a ROUTE-REQ packet; it needs to update an entry in *Req-Cache*. MEM-REQ uses a *ttl* field. All nodes that receive a MEM-REQ packet relay the packet only if *ttl* value is greater than zero. *ttl* value is decremented by one whenever it is relayed.

Source nodes and forwarding nodes send a REP packet when they receive a MEM-REQ packet. REP packets to MEM-REQ packets are relayed toward the new receiver in the same way as REP packets to SRC-REQ packets. The reception of a REP packet to a MEM-REQ packet also requires routing table update. And some nodes become forwarding nodes or neighbour nodes according to *Upstream* field of the REP packet.

Leaving a group in ADRP does not need any additional control messages. When a node leaves a group, it does not send REP packets to subsequent route discovery packets, and soft states stored in intermediate nodes will expire.

IV. SIMULATION ENVIRONMENT

NS-2 simulator was used for performance simulation. NS-2 is originally developed by the University of California at Berkeley and the VINT project and extended to provide simulation support for ad hoc networks by the MONARCH project [18] at Carnegie Mellon University. Reference [19] gives a detailed description about physical layer, data link layer, and IEEE 802.11 MAC protocol used in the simulation. Recently VINT project[2] gives extensions to ns-2 simulator.

a) Simulation Environment

Our simulation modeled a network of 25 mobile nodes that were placed randomly within 1000m x 1000m area. Radio propagation range for each node was 250 meters and channel capacity was 2 Mbits/sec. Nodes move according to the “random way-point” model which is characterized by a *pause time*.

A pause time of 10 seconds was used in our simulation. Each movement scenario was made on the basis of the model. Member nodes were randomly selected. Each member node joins at the beginning of the simulation and

Table : Simulation Environment

Area	1000m*1000m
Radio Propagation range	250m
Channel capacity	2Mbits/sec
Pause time	10 sec
Simulation time	80 sec
Packet size	512 bytes
No of Mobile nodes	25 , 50

remains as a member throughout the simulation. Each multicast source sends two 512-byte packets per second. We averaged 10 runs with different movement scenarios and each simulation executed for 80 seconds of simulation time.

V.SIMULATION RESULTS

We have used the following metrics to discuss the results.

Packet delivery ratio: The ratio of the number of data packets actually delivered to the destinations versus the number of data packets supposed to be received. This number presents the effectiveness of a protocol.

Average latency : The average end-to-end delay from a transmission of the packet to a successful reception at a receiver.

Through Put: Number data packets delivered to destination per data packets transmitted.

5.1 Performance of ADRP

Fig 9 shows the packet delivery ratio of ADRP as a function of mobility speed. The size of multicast group is varied to examine the scalability of the protocol. The result indicates that ADRP delivers high portion of data packets in most of our scenarios. As a number of members increases, the forwarding group mesh creates richer connectivity among members.

It makes the protocol scalable and robust to speed. In a tree configuration, a link break prevents packets from being delivered until the tree is reconfigured. But in mesh, the data can still reach receivers via other redundant routes formed by the forwarding group nodes.

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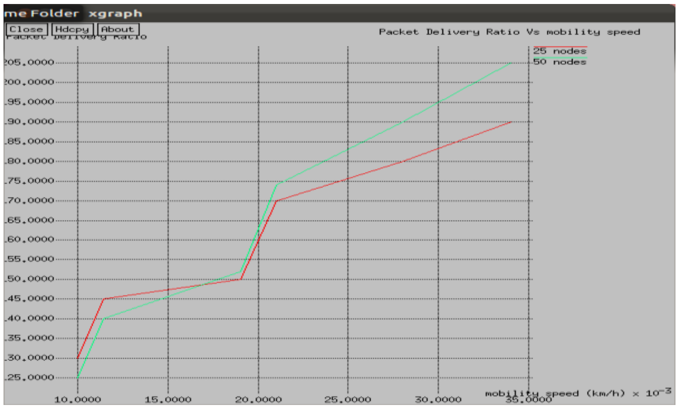

Fig 9: Packet Delivery Ratio of ADRP

We performed the experiment to calculate the end-to-end delay of ADRP as a function of number of source nodes. The number of source nodes is varied to examine the scalability of the protocol. The result indicates that ADRP scales well with increasing number of sources.

ADRP constantly performs as the node speed increases. Initially ADRP gives more throughput but as node speed increases it gives constant performance as shown in fig 10.

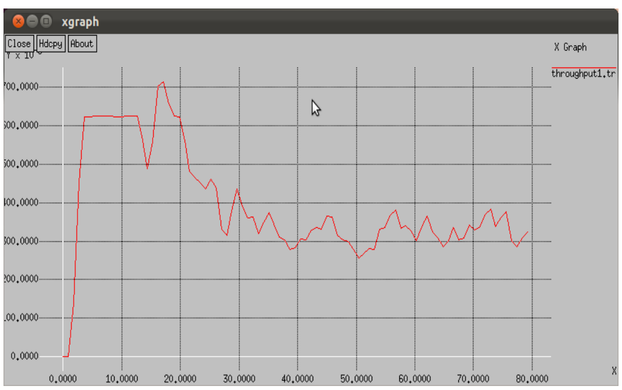

Fig 10: Throughput of ADRP

5.2 Comparison of performances of AODV and ADRP

The comparison of Throughput performance of AODV,ADRP is shown in fig 11 .We can see in figure that ADRP transmits more number of bits than AODV as the mobility speed of nodes increases. Initially when mobile nodes moving with less speed AODV performs, as the speed increases performance of ADRP increases.

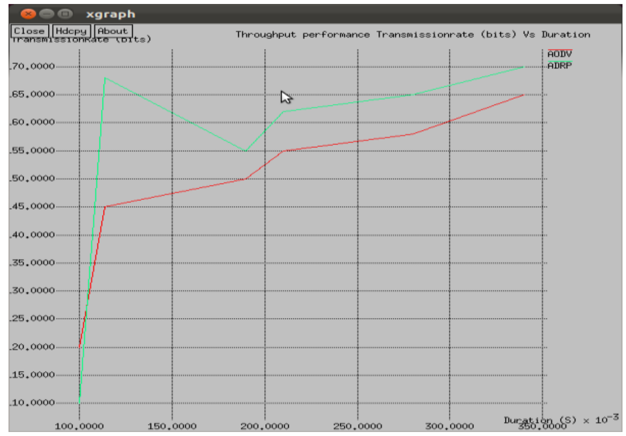

Fig 11: Throughput Comparison of ADRP and AODV

Fig 12 shows the comparison of packet lost in terms of transmission range of AODV and ADRP protocols. In case low transmission range the packet lost in AODV is less and once transmission range increases packet lose also increases when compare to ADRP. Because in case of network failures it is easy to construct tree (used by AODV) in case of low transmission range but very difficult to construct in case of high transmission range. ADRP uses mesh so in case of network failures forwarding nodes automatically construct the alternative route so in ADRP packet lost is less in case of high transmission range when compared to AODV.

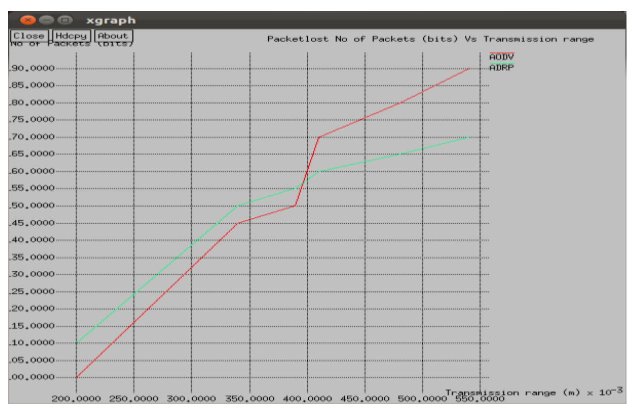

Fig 12: Packet lost comparison of ADRP and AODV

The Comparison of end-to-end delay interms of time of AODV and ADRP is shown in fig 13 .We can see that ADRP end-to-end delay is more if network load is less and end-to-end delay gradually decreases if network load increases when compare to AODV. It is because ADRP uses route whose mean delay is equal or less than average of all mean delays of all routes.

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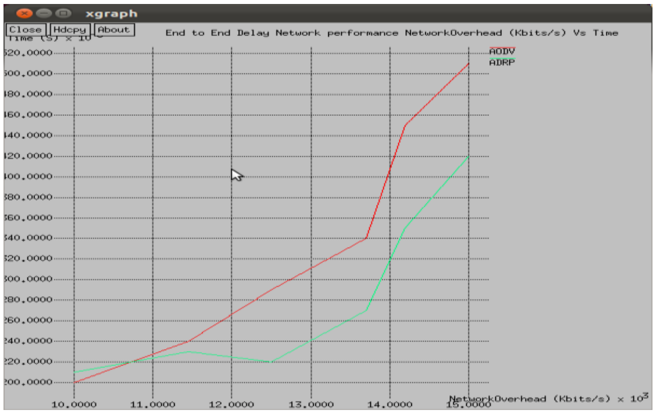

Fig 13: End-to-End delay comparison of ADRP and AODV

VI. CONCLUSION

This paper has proposed a new reactive and mesh based multicast routing protocol for ad hoc networks. The key concept is to use the route from source(s) to destinations which have equal or less delay than the average delay of all the possible routes which improves route efficiency. ADRP considered energy limitations of mobile nodes as a constrained factor.

We simulated ADRP using ns-2 simulator, and results reveal that ADRP effectively controls packet lost and improves throughput. ADRP distributes traffic to all the routes evenly which leads to less congestion in all routes. ADRP substantially reduces end-to-end delay and packet lost compared to AODV. ADRP scales well in high transmission range and high node speed. Future research could be considered applying ADRP to wireless sensor networks and reduce time consumption in gathering of neighbor information.

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