HYBRID ROUTING PROTOCOL SIMULATION FOR MOBILE AD HOC NETWORK

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ABSTRACT

MaNet has emerged as one of the most focused and thrust research areas in the field of wireless networks and mobile computing. In ad hoc mobile networks, routes are mainly multi hop because of the limited radio propagation range and topology changes frequently and unpredictably since each network host moves randomly. Therefore, routing is an integral part of ad hoc communications. Many routing protocols are proposed for MaNet. The protocols are mainly classified in to three categories: Proactive, Reactive and Hybrid. Proactive routing protocols attempt to maintain consistent, up-to-date routing information from each node to every other node in the network. Reactive routing protocols creates routes only when desired by the source node. Once a route has been established, it is maintained by a route maintenance procedure.

In this paper, we propose Routing Protocol which combines the merits of proactive and reactive approach and overcome their demerits. We propose variation of this proposed Hybrid Routing Protocol (HRP), the propose protocol creates route only when desired by the source node as in case of reactive routing protocols. The propose protocols maintain routing table at each node as in case of proactive routing protocols. Hence called hybrid routing protocol.

The propose protocol takes advantage of broadcast nature of MaNet to discover route and store maximum information in the routing tables at each node. HRP-Unicast Reply and HRP-Broadcast Reply are compared with existing routing protocol AODV using simulation result. The results of Data packets sent and dropped in the Network shows significant reduction in routing overhead, end- to-end delay and increases packet delivery ratio over AODV.

KEYWORDS: *Mobile ad hoc network, Hybrid Routing Protocol, Proactive Routing Protocols, Reactive Routing Protocols, AODV, Unicast Reply (UR), Broadcast Reply (BR).*

I. INTRODUCTION

MaNet [1] has emerged as one of the most focused and thrust research areas in the field of wireless networks and mobile computing. Mobile ad hoc networks consist of hosts communicating one another with portable radios. These networks can be deployed impromptu without any wired base station or infrastructure support. In ad hoc mobile networks, routes are mainly multi hop because of the limited radio propagation range and topology changes frequently and unpredictably since each network host moves randomly. Therefore, routing is an integral part of ad hoc communications, and has received interests from many researchers. Many routing protocols are proposed for MaNet. The protocols are mainly classified into three types, Proactive, Reactive and Hybrid [2,4]. In Proactive [2, 5] i.e. Table-driven routing protocols attempt to maintain consistent, up-to-date routing information from each node to every other node in the network. These protocols require each node to maintain one or more tables to store routing information, and they respond to changes in network topology by propagating hello messages throughout the network in order to maintain a consistent network view.

Reactive routing protocol [6,8]creates routes only when desired by the source node. When a node requires a route to a destination, it initiates a route discovery process within the network. This process is completed once a route is found or all possible route permutations have been examined. Once a route has been established, it is maintained by a route maintenance procedure until either the destination becomes inaccessible along every path from the source or until the route is no longer desired. The Ad hoc On-demand Distance Vector (AODV) [6, 8, 9] protocol, one of the reactive routing protocol that has receive the most attention, however, does not utilize multiple paths. In AODV [2, 6], at Every instance, route discovery is done for fresh communication which consumes more bandwidth and causes more routing overhead. The data packets will be lost during path break which occurs due to node mobility. When the network traffic requires real time delivery (voice, for instance), dropping data packets at the intermediate nodes can be costly. Likewise, if the session is a best effort, TCP connection, packet drops may lead to slow start, timeout, and throughput degradation. This paper proposes Hybrid Routing Protocol which combines the features of proactive and reactive routing protocol approaches [2]. This paper propose Hybrid Routing Protocol (HRP), The propose protocol creates route only when desired by the source node as in case of reactive routing protocols. The propose protocols maintain routing table at each node as in case of proactive routing protocols. Hence called hybrid routing protocol. The proposed protocol takes advantage of broadcast nature of MaNet which is used to gain maximum routing information at the nodes in the network. HRP-UR and HRP-BR with AODV, a highly used reactive routing protocol in Ad hoc network. The simulation Results of Control Packet analysis as well as Data packets sent and dropped in the Network shows significant reduction in routing overhead, Average End-To-End delay analysis.

II. PROACTIVE ROUTING PROTOCOLS

In Proactive [3, 5, 19] i.e. Table-driven routing protocols attempt to maintain consistent, up-to-date routing information from each node to every other node in the network. These protocols require each node to maintain one or more tables to store routing information, and they respond to changes in network topology by propagating hello messages [20] throughout the network in order to maintain a consistent network view.

2.1 Destination-Sequenced-Distance-Vector Routing

Destination- Sequenced-Distance-Vector Routing [5] is the table driven routing based on classical Bellman-ford routing mechanism. Every mobile node in the network maintains routing table in which all of the possible destinations within the network and the number of hops to each destination are recorded. Each entry is marked with the sequence number assigned by the destination node which is used to avoid formation of routing loops. Routing table updates are periodically transmitted in order to maintain consistency. The main disadvantage is that the DSDV protocol suffers from excessive control overhead that is proportional to the number of nodes in the network and therefore is not scalable in ad hoc wireless network. Another disadvantage is that the node has to wait for a table update message initiated by the same destination node, in order to obtain information about a particular node.

2.2 Cluster Head Gateway Switch Routing

Cluster head gateway switch routing [21] uses hierarchical network topology. The nodes are organized into small clusters. Each cluster is having cluster-head which coordinate the communication among members of each cluster head. Cluster-head also handles issues like channel access ,bandwidth allocation in the network. The main advantage of this protocol is the better bandwidth utilization. The disadvantage of this routing protocol is that frequent cluster head changes can adversely affect routing. This also degrades the performance as the system is busy in cluster head selection rather than data transmission. Another disadvantage is the power consumption, which occurs more at the cluster-head as compared to other nodes.

2.3 Wireless Routing Protocol

Wireless Routing Protocol is one of the table driven routing protocol [22]. Each node is responsible for maintaining four tables i.e. Distance table(DT), Routing table(RT), Link cost table(LCT) and Message Transmission List table(MRL). The DT contains network view of the neighbors of a node. RT contains the up-to-date view of the network for all known destinations. The LCT contains the cost of relaying each message through each link. The MRL contains an entry for every update message that is to be retransmitted and maintains a counter for each entry. WRP belongs to class of path finding algorithm. WRP has same advantages as that of DSDV. In addition, it has faster convergence and involves fewer tables updates. But as it involves maintaining and processing various tables, it requires larger memory and more processing power at each node.

The comparison of proactive routing protocol [19] is summarized in Table I.

Table I : Comparison of Proactive Routing Protocol

Parameter	**DSDV**	**CGSR**	**WRP**
Time Complexity (Link Addition/Failure)	O(d)	O(d)	O(h)
Communication complexity (Link Addition/Failure)	O(x=N)	O(x=N)	O(x=N)
Routing Philosophy	Flat	Hierarchical	Flat
Loop Free	Yes	Yes	Yes but not instantaneous
Multicast Capability	No	No	No
Number of Required Tables	Two	Two	Four
Frequency of Update Transmission	Periodically & as Needed	Periodically	Periodically & as Needed
Updates Transmission to	Neighbor	Neighbor and Cluster Head	Neighbor
Utilizes Sequence Numbers	Yes	Yes	Yes but not instantaneous
Utilizes "Hello" messages	Yes	No	Yes but not instantaneous
Routing Metric	Shortest Path	Shortest Path	Shortest Path

Abbreviations:
N=No. of nodes in the network h=Height of Routing Tree
d=Network Diameter x=No. of nodes affected by topological change

III. REACTIVE ROUTING PROTOCOLS

Another approach used for routing is reactive approach [6,7]. This type of routing creates routes only when desired by the source node. When a node requires a route to a destination, it initiates a route discovery process within the network. This process is completed once a route is found or all possible route permutations have been examined. Once a route has been established, it is maintained by a route maintenance procedure until either the destination becomes inaccessible along every path from the source or until the route is no longer desired.

3.1 Ad hoc On-Demand Distance Vector (AODV)

The Ad hoc On-demand Distance Vector (AODV) [6, 8, 9] protocol, one of the on-demand routing algorithms that has receive the most attention, however, does not utilize multiple paths. It joins the mechanisms of DSDV and DSR. The periodic beacons, hop-by-hop routing and the sequence numbers of DSDV and the pure on-demand mechanism of Route Discovery and Route Maintenance of DSR are combined. In AODV [6], at Every instance, route discovery is done for fresh communication which consumes more bandwidth and causes more routing over-head. The source prepares RREQ packet which is broadcast to it's neighboring nodes. If neighboring node will keep backward path towards source. As soon as destination receives the RREQ packet, it sends RREP packet on received path.

This RREP packet is unicast to the next node on RREP path. The intermediate node on receiving the RREP packet make reversal of path set by the RREQ packet. As soon as RREP packet is received by the source, it starts data transmission on the forward path set by RREP packet. Sometimes while data transmission is going on, if path break occurs due to mobility of node out of coverage area of nodes on the active path, data packets will be lost. When the network traffic requires real time delivery (voice, for instance), dropping data packets at the intermediate nodes can be costly. Likewise, if the session is a best effort, TCP connection, packet drops may lead to slow start, timeout, and throughput degradation.

3.2 Dynamic Source Routing (DSR)

Dynamic Source Routing, DSR [2,14,16], is a reactive routing protocol that uses source routing to send packets. It is reactive protocol like AODV which means that it only requests a route when it needs one and does not require that the nodes maintain routes to destinations that are not communicating. It uses source routing which means that the source must know the complete hop sequence to the destination. Each node maintains a route cache, where all routes it knows are stored. The route discovery process is initiated only if the desired route cannot be found in the route cache. to limit the number of route requests propagated, a node processes the route request message only if it has not already received the message and its address is not present in the route record of the message. As mentioned before, DSR [9] uses source routing, i.e. the source determines the complete sequence of hops that each packet should traverse. This requires that the sequence of hops is included in each packet header. A negative consequence of this is the routing overhead every packet has to carry. However, one big advantage is that intermediate nodes can learn routes from the source routes in the packets they receive. Since finding a route is generally a costly operation in terms of time, bandwidth and energy, this is a strong argument for using source routing. Another advantage of source routing is that it avoids the need for up to-date routing information in the intermediate nodes through which the packets are forwarded since all necessary routing information is included in the packets. Finally, it avoids routing loops easily because the complete route is determined by a single node instead of making the decision hop-by-hop.
The comparison of proactive routing protocol [19] is summarized in Table II.

Table II: Comparison of Reactive Routing Protocol

Parameter	AODV	DSR
Routing Metric	Freshest & Shortest Path	Shortest Path
Route Maintained in	Route Table	Route Cache
Route Reconfiguration Methodology	Erase Route; Notify Short	Erase Route; Notify Short
Loop Free	Yes	Yes
Multicast Capability	Yes	No
Routing Philosophy	Flat	Flat
Communication Complexity	O(2N)	O(2N)
Time Complexity	O(2d)	O(2d)
Beaconing Requirement	No	No

Abbreviations:
N=No. of nodes in the network h=Height of Routing Tree
d=Network Diameter x=No. of nodes affected by topological change

IV. HYBRID ROUTING PROTOCOL WITH UNICAST REPLY AND BROADCAST REPLY

In this paper, we proposed hybrid routing protocol with unicast reply scheme (HRP-UR) and broadcast reply scheme (HRP-BR). The proposed protocol takes the advantages of both proactive and reactive routing protocol hence called Hybrid Routing Protocol(HRP).

Table III: Structure of Routing Table

Dest	Next hop	Hop count

- Dest : Source address on received packet.
- Next Hop : Next hop address on the path towards source node.
- Hop Count : Hop distance to reach to source node.

4.1 Analytic Study of HRP-UR and HRP-BR

Hybrid Routing Protocol with unicast reply scheme and broadcast reply scheme, HRP combines the features of proactive and reactive routing protocols, overcoming their demerits. The propos protocol maintains routing table as that of table driven (proactive) routing protocol scheme. Initially, all the nodes in the network will have empty routing table. The structure of routing table is as shown in Table IV. Updating in routing table takes place in on demand manner (reactive). The proposed routing protocol, HRP-UR operates in two different phases: Route Discovery and Route Maintenance.

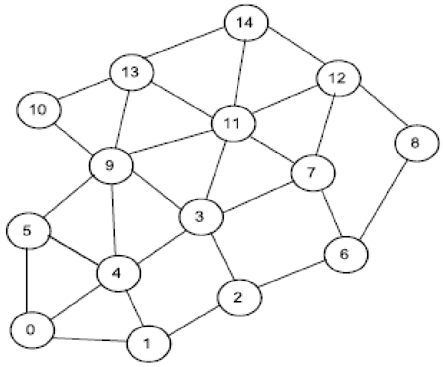

Figure 1: Network Topology

Table IV: Structure of Routing Table

Dest	Next hop	Hop count

4.1.1 Route Discovery in HRP-UR and HRP-BR

A source, on receiving a data packet first checks, whether route to the destination exists in it's routing table. If route exists then it sends data packets to the destination. If no route exists then source node first stores the data packet in queue, prepares route request packet(RREQ) and broadcast it. The source generate broadcast id. Broadcast id is the unique id which will identify the unique communication over the network. The hop count field is set to one. After sending RREQ packet, the source waits for a route reply packet (RREP). If it did not receive within a certain time called *request timeout* , it broadcast another RREQ packet. If the maximum number of retries has been reached, all data packets for this destination are dropped since destination is unreachable. Destination on receiving the RREQ packet, sends RREP packet to the source on the same path RREQ packet has followed. In the propose HRP-UR scheme, the destination set hop count field of RREP packet to 1. In HRP-UR and HRP-BR, RREP packet contain id of the node from which it has received RREQ packet hereafter it is named as *intended node*. This RREP packet is received by *intended node*. On receiving, *intended node fi*rst make an entry in its own routing table for destination in received RREP packet. Then *intended node* search its own routing table for the destination. If found then *intended node* retrieves next hop information from routing table and unicast and broadcast RREP packet. It then dequeues all the data packets one by one from QUEUE and sends to the next hop. Next hop will search destination in its routing table and repeat the same procedure.

Consider the example of network given in Figure 1. The process of route discovery is shown in Figure 2. Source node(say *0*) having Constant Bit Rate (CBR) traffic, want to communicate with destination node (say *14*). Let us assume this CBR traffic as CBR0 which starts at time *1.0* and ends at time *3.0*. Initially no route is available at any of the node in the network, so routing tables at all the nodes are empty. Source node 0 search destination node 14 in its own routing table. Route is absent, so node 0 prepares RREQ packet and fill up the necessary information and broadcast it. This RREQ packet is received by immediate neighbors i.e. node 5,1 and 4 . On receiving RREQ, they first store route information for source node 0 in there own routing table. So node 5,1 and 4 will enter route to node 0 in there routing table along with corresponding hop count which is 1. The details of routing table entries is summarized in Tables V, VI and VII.

Table V: Routing Table at Node 5

Dest	Next hop	Hop count
0	0	1

Table VI : Routing Table at Node 4

Dest	Next hop	Hop count
0	0	1

Table VII : Routing Table at Node 1

Dest	Next hop	Hop count
0	0	1

After making an entry for node *0* , node *5*,*1* and *4* search their routing table for destination node *14*. If any of them will find the entry in their own routing table, it creates RREP packet and sends back to the source node *0*. If not then increase the hop count received in RREQ packet by 1 and rebroadcast it. This process is repeated till destination node *14* is reached or TTL field of RREQ packet becomes 0.

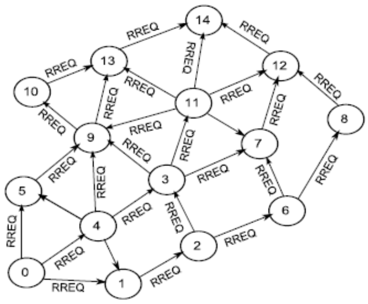

Figure 2: RREQ Transmission in the Network

As soon as node *14* receives the RREQ packet, it sends RREP packet. Assume that the node *14* received RREQ packet from node *11*. So node *14 fi*nds entry for node *0* in its own routing table. Node *14* retrieves the next hop towards node *0* which is node *11*. So node *11* becomes *intended node*. On receiving RREQ by node *11*, it searches node *0* in its own routing table, finds next node towards source node *0* which is node *3* called new *intended node*. Then new *intended node 3* unicast RREP packet to node *4*. This process is repeated until RREP packet is reached to destination node *0* which is source of RREQ packet. The process of RREP transmission is summarized in the Figure 3.

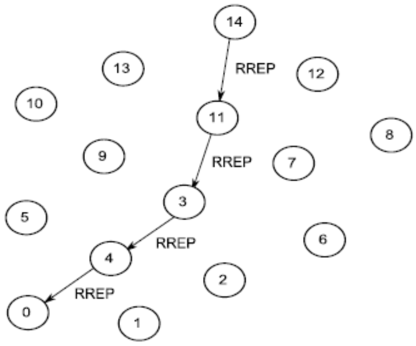

Figure 3: RREP Transmission in the Network

As soon as node *0* receives RREP packet, it first make an entry for node *14* in it's routing table. Then node search its routing table for node *14* and finds next hop towards destination node *14* which is node *4*. Then node *0 fi*rst dequeues all data packets from queue one by one, which were enqueued during route discovery process and sends to the destination node *14*. Then source node *0* starts receiving data packets from higher layers and send it to the destination node*14*. The Data packets are unicast to next hop from routing table i.e. node *4*. Node *4* search it's own routing table and finds the next hop towards node *14* which is node *3*. This procedure is repeated until data is successfully received at destination node *14*. The higher layer at destination node *14* will send acknowledgment of data received at destination node*14*. The updated routing table along active path (0-4-3-11-14) is given in Tables VIII, IX, X, XI, XII.

Table VIII : Routing Table at Node 0

Dest	Next hop	Hop count
14	4	4

Table IX : Routing Table at Node 4

Dest	Next hop	Hop count
0	0	1
14	3	3
11	3	2
3	3	1

Table X : Routing Table at Node 3

Dest	Next hop	Hop count
0	4	2
14	11	2
11	11	1

Table XI : Routing Table at Node 11

Dest	Next hop	Hop count
0	3	3
14	14	1

Table XII : Routing Table at Node 14

Dest	Next hop	Hop count
0	14	4

In the Figure 4, node *14* is sending a RREP packet is response to RREQ from node *0*. Routing table at node *14* after processing RREQ packet from node *0*

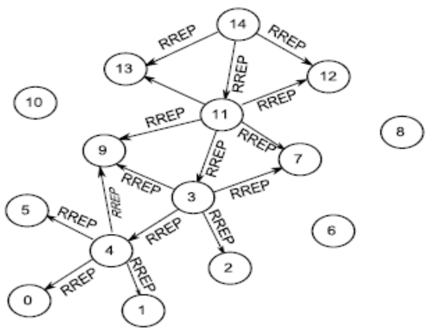

Figure 4: RREP Transmission in the Network

Table XIII: Routing Table at Node 14

Dest	Next hop	Hop count
0	11	4

At node *14* the next hop towards node *0* is node *11* shown in Table XIII with node *11* as *intended node*. It prepares RREP packet and broadcast with node *11* as the intended node. Neighboring node *11,12,13* will receives the RREP packet.

The nodes which are not intended node will drop the RREP packet after updating there routing table as shown in Table XIV and XV

Table XIV : Routing Table at Node 13

Dest	Next hop	Hop count
0	11	4
14	14	1
11	11	1
2	9	3

Table XV : Routing Table at Node 12

Dest	Next hop	Hop count
0	11	4
14	14	1

11	11	1
2	7	2

After receiving RREQ by *intended* node *11*, it searches node *0* in own routing table and finds next node towards source node *0* which is node *3* called new *intended* node as shown in Table XVI. It then add it's own address in the received RREP packet. So modified reply path in RREP packet is *14-11*. Then it searches node *0* in its own routing table and finds next hop towards source node *0*, which is termed as new *intended* node. After modification of RREP packet, *intended* node *11* will broadcast modified RREP packet to all its neighboring nodes i.e. node *13*,*14*,*12*,*7*,*3* and *9*. Then new *intended* node *3* rebroadcast modified RREP packet to all neighbors. This process is repeated until RREP packet is reached to the destination node *0* which is source of RREQ packet. The process of RREP packet transmission is as shown in the Figure 4.

Table XVI : Routing Table at Node 11

Dest	Next hop	Hop count
0	3	3
14	14	1
3	3	1
2	7	2
9	9	1

4.1 Simulation Result of HRP-UR and HRP-BR

In this section, we evaluate the performance of HRP-UR and HRP-BR. We select parameters to evaluate the performance

We consider 14 node network examples shown in Figure 1. We simulate the new propose routing protocol, HRP-UR using NS2. We considered 5 CBR data traffic running in the network as explained in Section V. Total simulation time for the following scenario is considered to be 12 seconds. The details of data traffic running in the network are as follows:

CBR 0: node *0* to node *14* starts at 1.0 ends at 3.0
CBR 1: node *9* to node *0* starts at 4.0 ends at 6.0
CBR 2: node *1* to node *11* starts at 5.0 ends at 7.0
CBR 3: node *5* to node *14* starts at 8.0 ends at 9.0
CBR 4: node *2* to node *13* starts at 10.0 ends at 12.0

4.2.1 Control Packets Analysis

We compare proposed protocol HRP-BR with our propose protocol HRP-UR and AODV. We compute some of the parameters given in Table XVII.

Table XVII: Control Packet Analysis

Parameters	HRP-BR	HRP-UR	AODV
Total no. of Control packets in the network	323	247	876
Total no. of Control packets sent in the network	57	63	216
Total no. of Control packets received in the network	266	184	660
Node id, sending max no. of control packet in the network	node 3(6)	node 9(6)	node 9(21)
Node id, receiving max no. of control packet in the network	node 7(26)	node 5,9,11(18)	node 11(72)

We compute the number of send and receive packets at each node in the network topology. We plot the graph of send and receive packets versus the nodes in the network as shown in Figure 5. The results show that the least number of control packets are flooded in the network in HRP-BR as compared to HRP-UR and AODV protocol. Initially in HRP-BR, the no. of control packets flooded in the network is more as compared to AODV and HRP-UR. But as the number of source-destination pair which are interested to communicate get increased, the number of control packets flooded in the network reduces significantly compare to HRP-UR and AODV. In propose HRP-BR, building of routing table is started in reactive manner as that of AODV. So, Initially the number of control packet flooded in the network is same as that of AODV and HRP-UR. But as the number of source-destination pair which are interested to communicate get increased, the number of control packets flooded in the network reduces significantly. Due to the maintenance of routing table as that of proactive routing protocol, source node can able to get route information from own routing table and reduces frequent route request broadcasting for every new source-destination pair which is always initiated in AODV routing protocol.

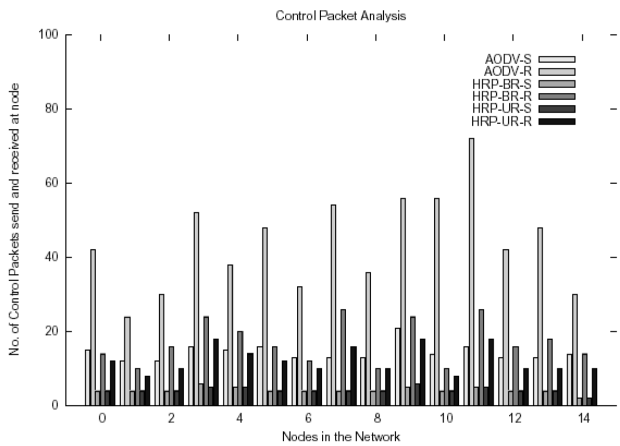

Figure 5: Control Packets Flooded in the Network

4.2.2 Data Packet Sent and Dropped

We plot the graph of number of packets sent and dropped versus CBR traffic in the network as shown in Figure 6 from the graph; the number of packet dropped in CBR0 between node *0* to node *14* is greater in HRP-BR than HRP-UR and AODV protocol. But it is decreasing for CBR1, CBR2 and CBR4 gradually as compared to HRP-UR and AODV. For CBR3 it is same in HRP-BR, HRP-UR and AODV.

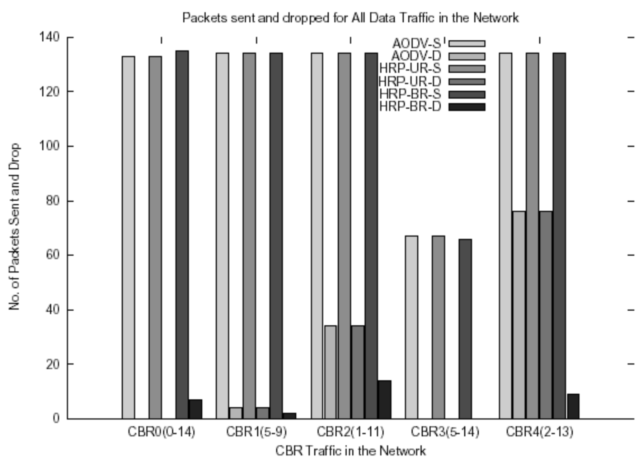

Figure 6: Data Packets Sent and Dropped in the Network

4.2.3 Average End-To-End Delay Analysis

We plot the graph of average delay versus CBR traffic in the network as shown in Figure7. From the graph, the average delay for CBR 0 between node *0* to node *14* is less in HRP-BR than HRP-UR and AODV. Since we are using broadcasting RREP, so it reduces end-to-end delay as explained in pervious Section For CBR 1, CBR 2 and CBR 3 there is no need to broadcast route request as the routing information is available in there respective source. This will help to start data transmission. But in AODV and HRP-UR, it has to setup route by route discovery process. As a result average end-to-end delay is less in HRP-BR.

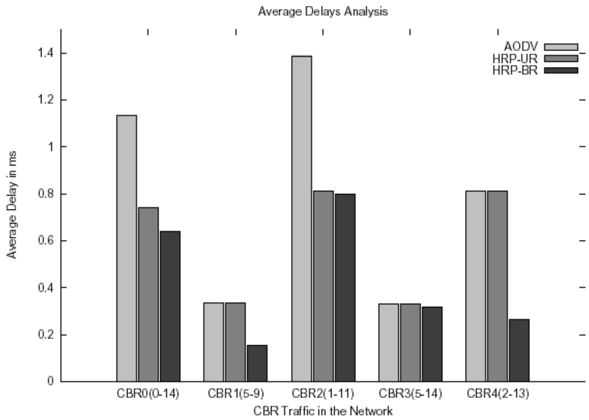

Figure 7: Average End-to-End Delay Analysis

V. CONCLUSION

The Proactive and Reactive approach for routing in ad hoc network have their merits and demerits. The Proposed routing protocol will have an advantage of both proactive and reactive approach. Backup routing in proposed scheme will helpful in path break up to some extent. Here we want to conclude by saying that the analytic study of the new hybrid approach will result in less routing overhead than most of the routing algorithm such as AODV and DSDV. The simulation results of control packets flooded in the network, data packets sent an dropped and average end-to-end delay analysis are related with the efficient routing issue, which is most demanding and thrust area of ad hoc network. We have a hybrid routing protocol scheme with unicast reply and Broadcast reply.

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