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Hybrid Routing Protocol with Broadcast Reply for Mobile Ad hoc Network

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ABSTRACT
ManNet 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 Hybrid 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), HRP-Broadcast Reply. 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-BR is compared with existing routing protocol AODV. The results shows significant reduction in routing overhead, end- to-end delay and increases packet delivery ratio over AODV.

General Terms
Routing Protocol, Manet, Proactive, Reactive, Hybrid

Keywords
Mobile ad hoc network, Hybrid Routing Protocol, AODV, Broadcast Reply (BR), etc

1. INTRODUCTION
ManNet [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 propose Hybrid Routing Protocol which combines the features of proactive and reactive routing protocol approaches [2]. This paper propose Hybrid Routing Protocol (HRP), HRP-BR 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-BR with AODV, a highly used reactive routing protocol in Ad hoc network. The Results shows significant reduction in routing overhead, End-To-End delay as well as increase packet delivery ratio.

2.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 2.1.

Table 2.1: 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

3.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 reactive routing protocol [19] is given in Table 3.1.

Table 3.1: 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

4. HYBRID ROUTING PROTOCOLS

Hybrid Routing Protocols combines the merits of proactive and reactive routing protocols by overcoming their demerits. In this section we put some light on existing hybrid routing protocol.

4.1 Zone Routing Protocol (ZRP)

Zone routing protocol is a hybrid routing protocol which effectively combines the best features of proactive and reactive routing protocol [2, 17]. The key concept is to use a proactive routing scheme within a limited zone in the r-hop neighborhood of every node, and use reactive routing scheme for nodes beyond this zone. An *Intra-zone routing protocol (IARP)* is used in the zone where particular node employs proactive routing whereas *inter-zone routing protocol (IERP)* is used outside the zone. The routing zone of a given nodes is a subset of the network, within which all nodes are reachable within less than or equal to the zone radius hops. The IERP is responsible for finding paths to the nodes which are not within the routing zone. When a node *S* wants to send data to node *D*, it checks whether node *D* is within its zone. If yes packet is delivered directly using IARP. If not then it broadcasts (uses unicast to deliver the packet directly to border nodes) the RREQ packet to its peripherals nodes. If any peripheral nodes find *D* in its zone, it sends RREP packet; otherwise the node re broadcasts the RREQ packet to the peripherals nodes. This procedure is repeated until node *D* is located.

5. HYBRID ROUTING PROTOCOL WITH BROADCAST REPLY

In this paper, we proposed hybrid routing protocol with 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 5.1: 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.

The RREP packet is broadcast by the node along the path. The nodes that are neighbor to the node and not along the path receives the RREP packet, updates their routing table and drop the packet. As a results of broadcasting RREP from destination towards source, node on the active path as well as nodes neighbor to active path node able to gather more routing information.

5.1 Analytic Study of HRP-BR

We consider Figure 5.1 to explain working of protocol. The propos routing protocol, HRP-BR works in two different phases: Route Discovery and Route Maintenance.

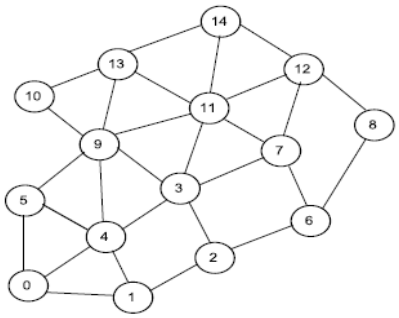

Figure 5.1: Network Topology

5.1.1 Route Discovery in HRP-BR

in HRP-BR, RREP packet is broadcast to all neighbors which are in the coverage area of the replying node. The RREP packet is broadcast to all neighbor nodes along with *intended* node. On receiving RREP packet, neighboring node makes an entry in the routing table about complete path which has received in RREP. If neighboring node is not the *intended* node, it drops RREP packet. If it is *intended* node, it adds own id in the received path and rebroadcast RREP. This process of extracting useful information from RREP packet and updates of RREP packet is carried out until RREP packet is not received by the destination which is source of RREQ packet. Figure 5.2 shows the process of RREP packet transmission.

In the Figure 5.2, 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* is shown in Table 5.2

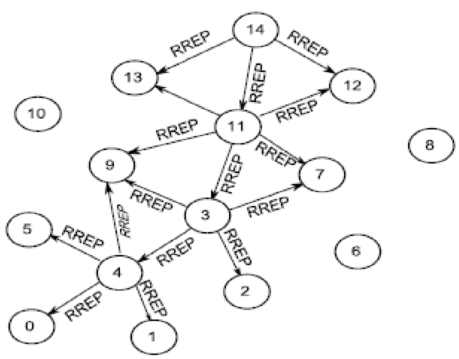

Figure 5.2: RREP Transmission in the Network

Table 5.2: 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 4.1 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 5.3 and 5.4.

Table 5.3 Routing Table at Node 13

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

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 5.5. 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

Table 5.4: Routing Table at Node 12

Dest	Next hop	Hop count
0	11	4
14	14	1
11	11	1
2	7	2

Table 5.5: 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

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 5.2.

Consider few more CBR data traffic as follows

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

The routing table for some of the node for above scenario is given in Tables 5.3, 5.4, 5.8 and 5.6 and 5.5. As the number of CBR data traffic increases, more and more information are added to the routing table. Suppose node *13* want to communicate with node *2*. In the routing table of node *13* as shown in Figure 5.2, there exist a path to node *2*. There is no need for route discovery as it usually happen in reactive protocol. Node *13* can immediately start transmitting data to node *2*.

Table 5.6: Routing Table at Node 5

Dest	Next hop	Hop count
0	0	1
4	4	1
3	4	2
11	4	3
14	4	4
2	4	3
9	9	1
13	9	2

Table 5.7: Routing Table at Node 10

Dest	Next hop	Hop count
0	13	5
2	9	3
13	13	1
9	9	1

Table 5.8: Routing Table at Node 8

Dest	Next hop	Hop count
0	12	5
2	7	2

5.1.2 Route Maintenance in HRP-UR

Usually link failure occurs due to node mobility. A node on detecting link failure send a route error message (RERR). This RERR message is forwarded to the source. Source will start fresh route discovery procedure after receiving RERR message This process is shown in Figure 5.3.

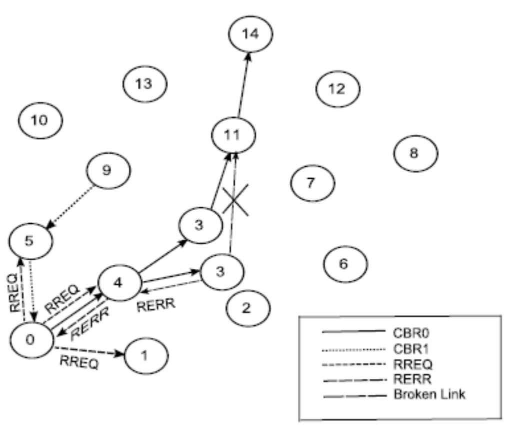

Figure 5.3: Link Failure and Recovery

6. 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 resented in this paper is related with the efficient routing issue, which is most demanding and thrust area of ad hoc network. We have a new Hybrid Routing Protocol with variation in route reply. we have a hybrid routing protocol scheme with Broadcast reply (HRP-BR).

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