# A Novel Hybrid Routing Protocol for Mobile Adhoc Network

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## *Abstract*

Mobile ad hoc networks (MANET) play an important role in connecting devices in pervasive environments. Each node in MANET can act as source and router. In this paper, we propose a hybrid routing protocol with Broadcast Reply (HRP-BR) which combines the merits of both proactive and reactive approach. Like proactive approach, it maintains routing table at every node. However, it differs from proactive approach; that the routing table is not built prior to communication. Routing table is built in incremental steps during route discovery. Route discovery takes place like reactive approach only on demand. HRP-BR takes advantage of broadcast nature in MANET for route discovery and store maximum information in the routing tables at each node. Broadcast natures avoid handshaking of RTS and CTS and effectively utilize trans-receiver antennas which reduce power consumption and effectively utilize bandwidth. HRP-BR is compared with existing AODV routing protocol which shows significant reduction in routing overhead, end-to-end delay and increases packet delivery ratio.

***Keywords:*** *Hybrid Routing Protocol. MANET, proactive, reactive, hybrid, RTS, CTS, HRP-BR.*

## 1. Introduction

MANET has emerged as one of the most focused and thrust research areas in the Field of wireless networks and mobile computing [1]. MANET consists of hosts communicating one another with portable radios. These networks can be deployed impromptu without any wired base station or infrastructure support. In MANET, routes are mainly multi hop because of the limited radio propagation range, topology changes frequently and unpredictably since each network host moves randomly. Because of unpredictable topology, routing has attracted the attention of many re searchers. The protocols proposed for MANET are broadly classified into *three* categories such as: Proactive, Reactive and Hybrid [2, 3, 4]. Proactive routing protocols [5, 3, 7] attempt to maintain consistent, up-to-date routing information from each node to every other node in the network. On the other hand reactive routing protocol [2, 3, 9] creates routes only when desired by the source node. 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) [2, 9, 10] and Dynamic Source Routing (DSR) [10, 3, 4] protocols belong to the category of reactive routing protocol. That has received the most attention; however, they do not utilize multiple paths. This paper proposes a hybrid routing protocol with broadcast reply scheme (HRP-BR) which combines the features of both proactive and reactive routing protocol [6, 12, 13, 14]. The propose protocol creates route only when desired by the source node as in case of reactive routing protocols. It broadcast route request message and wait for route reply message. Node receiving route request message keeps the routing information about source node in routing table. Node rebroadcast the route request message if it has not broadcast it previously. Destination node on receiving route request message sends a route reply message. This route reply message is broadcast to the neighboring nodes. The nodes which are on active path keeps the routing information about the destination as well as the nodes which are involve in forwarding route reply message. A node on receiving route request or route reply message enters necessary information in its routing table. In this way the protocol maintains routing table at each node as a proactive routing protocols. The routing table building process starts only when any node called source node want to transmit data to other node destination. The propose protocol takes advantage of broadcast nature of MANET to gain maximum routing information at the nodes in the network. The rest of the paper is organized as follows: Section 2 briefly describes the related to routing protocol in MANET. Section 3 proposed a hybrid routing protocol with broad- cast reply. Section 4 compares the proposed protocol with AODV and presents the simulation results. Finally, some conclusions are drawn in Section 5.

## 2. Related Works

Our focus is on three goals:

(i) To decrease routing over Head
(ii) To increase packet delivery ratio and
(iii) To Increase Average End-to-End Delay

MANETs are comprised of mobile devices communicating via their wireless interfaces, and their topology is continuously changing. Several routing protocols have been proposed for such environment that is resilient to these conditions and is efficient in establishing and maintaining routes. Many routing protocols are proposed for MANET. The protocols are mainly classified into three types, Proactive, Reactive and Hybrid [6, 15, 12]. In Proactive [16, 6] i.e. Table-driven routing protocols attempt to maintain consistent, up-to-date routing information from each node to every other node in the net- work. 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.eg. DSDV, CGSR, WRP. Reactive routing protocol [2, 8, 9] 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 de- sired. The Ad hoc On-demand Distance Vector (AODV) [2, 9, 10] 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 every new 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 in- stance), 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. E.g. AODV, DSR.

In this paper, we focus on hybrid routing protocol with broadcast reply scheme, which do not maintain any a priori network topology information as explained in next section.

## 3. Proposed Hybrid Routing Protocol

Hybrid Routing Protocol with broadcast reply (HRP-BR) proposed in the paper takes the advantage of both proactive and reactive routing protocol. Like proactive protocols, it maintains a routing table at each node. However, it differs from it in the way the routing table is constructed and maintained. Unlike proactive routing protocol, it does not exchange the routing table information among the nodes. The routing table at each node is built in incremental steps. Like reactive routing protocol, the source initiates route discovery only on-demand. It uses the route request (RREQ) and route reply (RREP) packet of reactive routing protocol. Routing table in our propose protocol is built during the route discovery phase and is not exchanged along the nodes.

To build routing table, it extracts necessary information from the RREQ and RREP packets. Propose protocol does not require exchange of hello message required in proactive routing protocol, needed to maintain up-to-date information. It uses the route error message of reactive routing protocol in case of link failure. A node having packet to transmit, first checks its routing table for an existence of path to destination. If an entry exists to the destination, then the packet is forwarded to the next node along the path to destination. For non existence of path, it initiates a route discovery to the destination.

The structure of routing table is shown in Table 1. It consists of following three entries:

- Dest: Destination node of packet,
- Next hop: Next hop on the path to destination,
- Hop Count: Hop distance to destination from the current node,
- Bid: Broad Cast ID

**Table 1: Structure of Routing Table**

| Dest | Next Hop | Hop count | Bid |
|---|---|---|---|
| ------ | ------ | ------ | ------ |

The format of RREQ packet is shown in Figure 1. Meaning of each Field of the RREQ/RREP packet is explained below:

- Src - Source of packet.
- Dest - Destination of the packet.
- Prev node - Previous node address.
- Hop count - Noumber of hops traversed by the packet.
- Bdid - Broadcast id.

| Src | Dest | Prev Node | Hop Count | B id |
|---|---|---|---|---|

**Figure 1: Format of RREQ/RREP Packet**

The process of route discovery and routing table updates in HRP are explained below.

### *3.1 Route Discovery in HRP-BR*

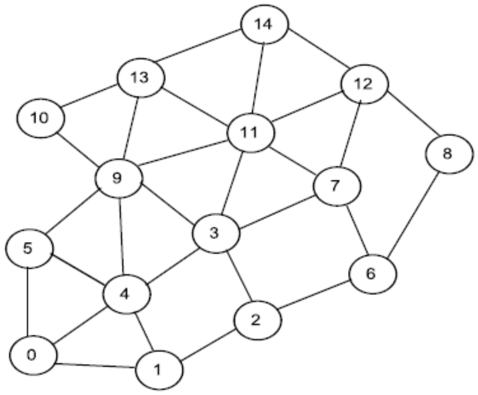

**Figure 2: Network Topology**

To explain the mechanism of route discovery and routing table updates we consider Network Topology shown in Figure 2. Assume that node *0* has some packet to transmit to node *14*. Initially, routing table maintained at each node is empty. A node on receiving RREQ/RREP packet extracts necessary information and enters into the routing table. Since node *0* has no path to node *14*, a route discovery process is initiated. Node *0* broadcast RREQ packet. As shown in Figure 4.

| | | | | |
|---|---|---|---|---|
| 0 | 14 | 5 | 2 | 1 |

| | | | | |
|---|---|---|---|---|
| 0 | 14 | 4 | 2 | 1 |

| | | | | |
|---|---|---|---|---|
| **0** | **14** | **1** | **2** | **1** |

**Figure 3: Rebroadcast of RREQ Packet from node 0 by (a) Node 5, (b) Node 4 and (c) Node 1.**

Nodes within the transmission range of node *0* i.e. node *5, 4* and *1* receives the packet shown in Figure 3 and start building their routing table. The routing table at node and *5, 4* after processing RREQ is as shown in Table 2 and 3.

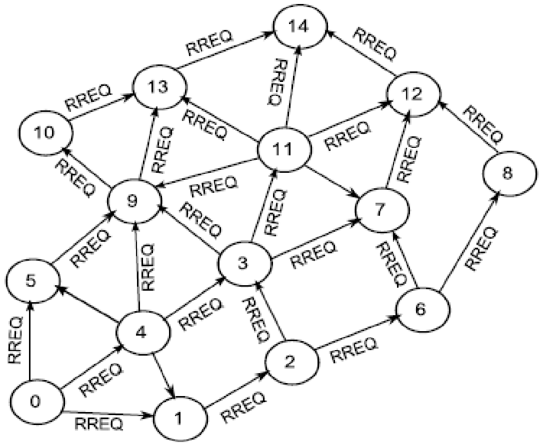

**Figure 4: Process of Broadcasting RREQ packet**

**Table 2: Routing Table at Node 5**

| Dest | Next Hop | Hop count | Bid |
|---|---|---|---|
| 0 | 0 | 1 | 1 |

**Table 3: Routing Table at Node 4**

| Dest | Next Hop | Hop count | Bid |
|---|---|---|---|
| 0 | 0 | 1 | 1 |

After processing the RREQ packet node *5* , *4* and *1* rebroadcast it updating the *Prev node* and *Hop Count* field of packet as shown in Figure 3. Intermediate nodes on receiving the RREQ packet make an entry in their routing table for the source and the neighboring nodes from which it has received the RREQ packet. The entry for the neighboring nodes has a hop count of *one* only. Table 4 and 5 shows the routing table at node *11* and *14* respectively after processing received RREQ packet which is flooded in the network due to broadcasting. Figure 4 shows the propagation of RREQ packet from Node *0* to Node *14*.

**Table 4: Routing Table at Node 11**

| **Dest** | **Next Hop** | **Hop count** | **Bid** |
|---|---|---|---|
| 0 | 3 | 3 | 1 |
| 3 | 3 | 1 | 1 |

| | | | |
|---|---|---|---|
| 9 | 9 | 1 | 1 |
| 7 | 7 | 1 | 1 |
| 13 | 13 | 1 | 1 |
| 12 | 12 | 1 | 1 |

**Table 5: Routing Table at Node 14**

| Dest | Next Hop | Hop count | Bid |
|---|---|---|---|
| 0 | 11 | 4 | 1 |
| 11 | 11 | 1 | 1 |
| 13 | 13 | 1 | 1 |
| 12 | 12 | 1 | 1 |

Having a route (entry in its routing table) to the destination. There are two ways in which a destination can send the RREP packet. Destination node can either broadcast or unicast the RREP packet. In this paper we are concentrating on Broadcasting of Reply packet hence the name Hybrid Routing Protocol with Broadcast Reply.

### *3.1 Hybrid Routing Protocol with Broadcast Reply (HRP-BR)*

In, Hybrid Routing Protocol with Broadcast Reply (HRP-BR), destination node broadcast the RREP packet to its neighboring nodes which are within its transmission range. These nodes, update their routing table by making an entry for the source and forwarding node of RREP packet. Node which is on the active path of the RREP packet rebroadcast it to its neighboring nodes where as other node simply drops the received reply packet(REEP) after making necessary entries in corresponding routing table. In our example, node 14 broadcast the RREP packet which is received by its neighboring node *11, 12* and *13*. Nodes 12 and 13 are not on the active path of the RREP packet. Therefore, the RREP packet is dropped at node 12 and 13 after updating the routing table as shown in table 7 & 6 respectively. Node 11 rebroadcast it which will be again processed by the neighboring nodes. During the propagation of RREP packet, the next hop field of RREP packet is updated to the next hop node on the path. This process of routing table updating and rebroadcast of RREP continues until it reaches the destination node 0. Routing table at node 0 after processing the RREP packet is shown in table 8. Thereafter, node 0 updates it routing table and start sending data packets to the next hop node 4 on the path to node 14.This next hope information is retrieved from routing table of node *0*. In the example, we have assumed that node *0* called source node has data packets to transmit to destination node 14. The process of RREP transmission is shown in Figure 5.

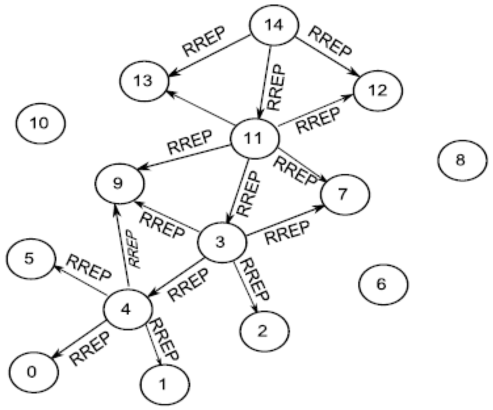

Figure 5: Process of RREP Transmission in the Network

Table 6: Routing Table at Node 13 after processing RREP Packet

| Dest | Next Hop | Hop count | Bid |
|---|---|---|---|
| 0 | 9 | 3 | 1 |
| 10 | 10 | 1 | 1 |
| 9 | 9 | 1 | 1 |
| 11 | 11 | 1 | 1 |
| 14 | 14 | 1 | 1 |

Table 7: Routing Table at Node 12 after processing RREP Packet

| Dest | Next Hop | Hop count | Bid |
|---|---|---|---|
| 0 | 11 | 4 | 1 |
| 7 | 7 | 1 | 1 |
| 8 | 8 | 1 | 1 |
| 11 | 11 | 1 | 1 |
| 14 | 14 | 1 | 1 |

Table 8: Routing Table at Node 0 after processing RREP Packet

| Dest | Next Hop | Hop count | Bid |
|---|---|---|---|
| 5 | 5 | 1 | 1 |
| 4 | 4 | 1 | 1 |
| 1 | 1 | 1 | 1 |
| 14 | 4 | 4 | 1 |

### *3.3 Route Maintenance in HRP-BR*

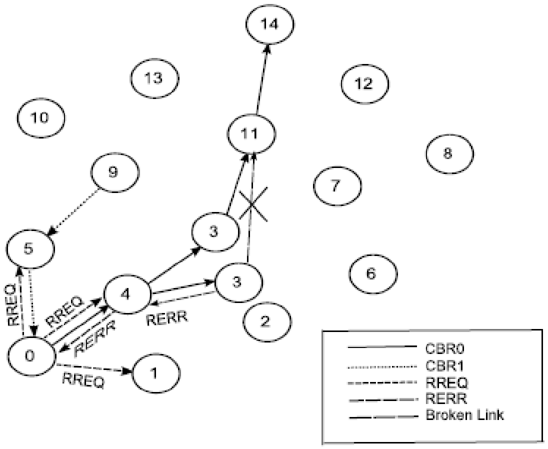

Figure 6: Route Maintenance in HRP-BR

To explain route maintenance in HRP, consider network topology shown in Figure 6. Suppose node *3* has moved out of the communication range of node *4*, while data packets are transmitted from node *0* to node *14*. Node *4* on receiving data packet from node 0, send RTS packet to next hop node *3* on the path to destination node *14* and waits for a CTS packet.

Since node *3* has moved out of transmission range of node *4*, the RTS packet fails to reach node *3*; hence no CTS reply from node *3*. Non-receive of CTS reply from node *3* is detected as link failure by node *4*. So, a route error message(RERR), is sent from node *4* to node *0*.After receiving RERR message, node *0* invalidate the route entry for node *14* in its routing table and initiates a new route discovery for node *14* with a the next broadcast id. Intermediate nodes, that have an entry for node *0* in their routing table, update it accordingly when they receive the new RREQ packet. For example, node *11* receives the RREQ packet from node *0* with a higher broadcast id. Let this RREQ packet has followed the path 0 / 4/ 9 / 11. In the routing table for node *11*, there exists an entry with node *3* as the next hop node for destination node *0*; shown in Table 4. Since, the broadcast id is higher than that exist in the routing table, node *11* update the entry for node *0* as shown in Table 6. Here we assume that, when a node re-initiates a route discovery process, it increments the current broadcast id in its routing table by *one*, which becomes the new broadcast id for the RREQ packet. Intermediate nodes, update their routing table based on the value of broadcast id.

## 4. Simulation Results

We use Ns2.31 network simulator on Linux platform having operating system Fedora 8. For simulation, we consider *node* network as shown in Figure 2 and Five CBR traffics are considered as given below.

- CBR 0: From Node *0* to Node *14*, start time is *1.0* and end time *3.0*.
- CBR 1: From Node *9* to Node *0*, start time is *4.0* and end time is *6.0*.
- CBR 2: From Node *1* to Node *11*, start time is *5.0* and end time is *7.0*.
- CBR 3: From Node *5* to Node *14*, start time is *8.0* and end time is *9.0*.
- CBR 4: From Node *2* to Node *13*, start time is *10.0* and end time is *12.0*.

**Table 9: Simulation Parameters**

| Parameter | Value |
|---|---|
| Transmission range | 250 m |
| Propagation Model | Two ray ground |
| Antenna | OmniAntenna |
| Interface Queue | Droptail/Priority Queue |
| Simulation time | 15 s |
| Topology size | 800m x 800m |
| Number of mobile nodes | 15 |
| Data Traffic type | constant bit rate |
| Packet size | 512 bytes |

The proposed HRP-BR is compared with existing Adhoc On-demand Distance Vector Routing Protocol (AODV) . Metrics consider for comparison are: (i) Over head in terms of number of control packet flooded in the network, (ii) Packet delivery ratio and (iii) Average end-end delay.

### *4.1 Control Packet analysis*

Number of control packets flooded in the network is computed as the sum of control packets send and receive at each node in the network. From the control packet analysis it is observed that the number of control packet flooded is minimum for HRP-BR In our proposed HRP-BR. In HRP-BR, routing table is built at every node that are taking part during route discovery phase and the number of entries in the routing table proportionately increases with increase in source-destination pairs involved in successive communication.

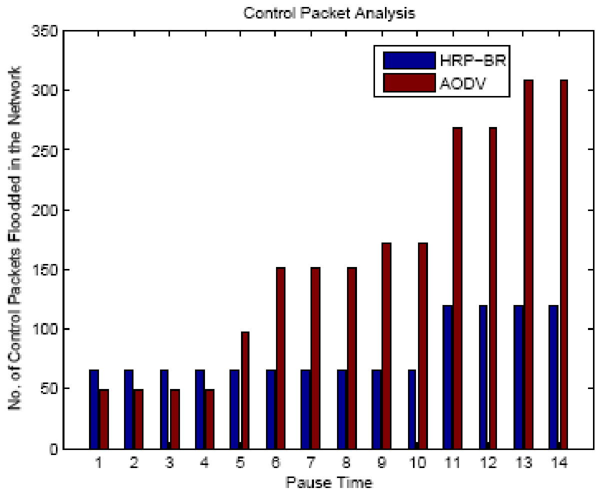

Figure 7: Control Packets Flooded in the Network

So, for some source-destination pair a node may find an entry in its routing table, which does not, necessitates the route discovery phase. Thus, reduction in routing overhead.

### 4.2 Packet Delivery Ratio

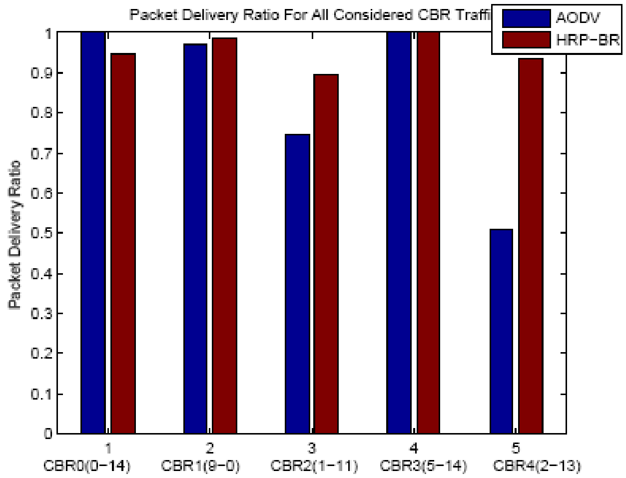

Figure 8: Packet Delivery Ratio for All CBR Traffic in the Network

We plot the graph of CBR traffic versus packet delivery ratio as shown in Figure 8. From the graph, it can be seen that the packet delivery ratio is less initially when single data transmission is considered between node *0* to node *14* in HRP-BR as compared to AODV. But as the traffic increases, the packet delivery ratio increases in HRP-BR as compared to AODV.

### 4.3 Average End-to-End Delay Analysis

End-to-End delay is the time difference between the times at which packet is transmitted from source node and the time at which it is received at destination node. We plot the graph for average end-to-end delay *vs.* CBR traffic in Figure 9. For the Figure it is observed that the end-to- end delay in HRP-BR is less than AODV. This is because, the source node in HRP-BR receive the RREP packet earlier than AODV and HRP-UR. Thus, the delay at the source is reduced as the nodes do not require RTS/CTS transmission. But in AODV every time it is required to setup route by using route discovery process. As a result average end-to-end delay is less in HRP-BR.

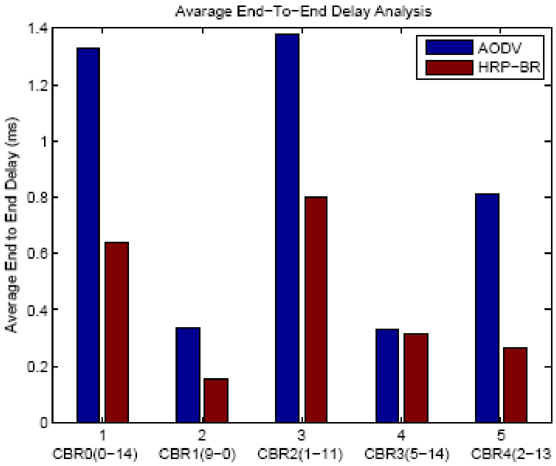

Figure 9: Average End-to-End Delay in the Network

## 5. Conclusions

In this paper, we proposed a new Hybrid Routing Protocol with Broadcast Reply scheme. The existing proactive routing protocol approach will results in wastage of bandwidth by continuously exchanging routing information among nodes in the network. The reactive routing protocol approach unnecessary increases routing overhead. In HRP-BR, the route request and route reply message are broadcasted. The advantage of broadcasting route reply message within the transmission range of the node is that the routing information is collected about source as well as destination at the nodes which are neighbors to intended node. Another advantage is that there is no RTS-CTS transmission for broadcast packets. This is because; we use IEEE 802.11 DCF-MAC protocol which does not require RTS/CTS/DATA/ACK pattern for broadcast packet. This also helps in saving energy level of nodes since the transmitter and receiver antennas will not waste their energy in RTS-CTS signaling as in case of AODV and HRP-UR. The proposed protocol able to reduce the number of control packets broadcasted in the network and average End-To-End delay.

## References

[1] Mobile Ad hoc Network (MANET). http://www.ietf.org/html.charters/MANETcharter.html.

[2] E. Royer C. Perkins and S. Das, "Adhoc On-demand Distance Vector (AODV) routing," (RFC 3561), July 2003.

[3] Francisco J. Ros and Pedro M. Rui, "Implementing a New MANET Unicast Routing Protocol in NS2," December 2004.

[4] Ankur Khetrapal, "Routing Techniques for Mobile Adhoc Networks Classification Qualitative/Quantitative Analysis," *Proceedings of ICWN*, pp. 251-257, 2006.

[5] P. K. Pattanaik and R. Mall, "Challenges in Ad hoc networks," in *Journal of Sidhanth*, pp. 153-160, 2007.

[6] S. Murthy and J.J. Garcia-Luna-Aceves, "An Efficient Routing Protocol for Wireless Networks," P*roceeding of ACM Mobile Networks and Applications*, pp. 183-197, October 1996.

[7] Cenker Demir and Cristina Comanicia, "An Auction Based AODV Protocol for Mobile Ad hoc Network with Selfish Nodes," P*roceeding of IEEE International Conference ICC'07*, pp. 3351-3356, June 2007.

[8] Rendong Bai and M. Singhal, "DOA: DSR over AODV protocol for mobile ad hoc network," *IEEE Transaction on Mobile Computing*, pp.1403-1416, October 2006.

[9] C. Siva Ram Murthy and B.S. Manoj. *Ad Hoc Wireless Networks Architectures and Protocol*, volume ISBN: 81-297-0945-7. Pearson Education, First Indian reprint, 2005 edition, 2005.

[10] Y. Zhang V. Kawadia and B. Gupta, "System Services for Implementing Ad hoc Routing: Architecture, Implementation & Experiments," P*roceeding of First International Conference on Mobile System, Application and Services (Mobisys)*, pp. 99-114. San Francisco, CA. June 2003.

[11] J. H. Chang and L. Tassiulas, "Energy Conserving Routing in Wireless Adhoc Network," P*roceedings of IEEE Conference on Computer Communications INFOCOM*, pp. 22-31, Tel Aviv Israel, March 2000.

[12] AODV code 1997,1998 Carnegie Mellon University.

[13] Santa Barbara Elizabeth M. Royer and Chai Keong Toh, "A Review of Current Routing Protocols for Adhoc Mobile Wireless Networks", P*roceedings of IEEE Personal Communications*, pp. 46-55, April 1999.

[14] C. P. P. Bhagwat, "Highly Dynamic Destination Sequenced Distance Vector DSDV Routing for Mobile Computers," *Proceeding of ACM SIGCOM*, pp. 234 -244, September 1994.

[15] C. K. Toh., "*Ad Hoc Mobile Wireless Networks Protocols and Systems,"* Chapter 6, pages 79{94. Prentice Hall, 2002.