# Towards Enhancing Reliability in Hybrid Mobile Ad-Hoc Network

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# Declaration

I, Muhammad Awais Bawazir, declare that this thesis submitted in partial fulfillment of the requirements for the conferral of the degree MS (Telecommunication And Networks), from the Bahria University, Islamabad, is wholly my own work unless otherwise referenced or acknowledged. This document has not been submitted for qualifications at any other academic institution.

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# Abstract


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Mobile Ad-Hoc network (MANET) is a group of multi-hop mobile nodes that communicate with each other without any centralized control infrastructure or fixed infrastructure. Nodes in MANET communicate with each other using wireless channels. Because the nodes have short transmission range in MANET, therefore multiple hops communication may be look for transmitting packets across the network.

In order to make easy communication within the network,the routing protocol is use to find out paths between source node to the destination node. The main goal in MANET is routing for efficient and correct path establishment between couple of nodes, so that data delivery may be in timely manner. In our thesis, we present a hybrid routing protocol named as Dynamic routing protocol (DRP), which uses relay node when destination node is not in Line Of Sight (LOS). Our proposed protocol enforces LOS communication between the nodes. Typically we deal with an environment where we have all of these nodes, which have a very fast, intermediate and slow mobility. In hybrid networks nodes are either in LOS or Non Line Of Sight (NLOS). Fading and shadowing effect the communication more in NLOS as compared to LOS, and also reduces the reliability of communication. In DRP, an intermediate or relay node is used for communication where both source and destination are not in direct LOS. This relay based communication will increase the reliability of communication with dynamic mobility in an urban environment. We have evaluated DRP in Manhattan grid mobility model with heavy traffic loads, experiments reveal that, DRP significantly reduces

packet drop ratio and gives better throughput as compared to Dynamic Source Routing Protocol (DSR) and Ad Hoc On- Demand Distance Vector routing protocol (AODV). Furthermore DRP improves number of packet delivered in fewer time.

# Acknowledgements

I simply bow my heads before Almighty Allah for giving me faith in my abilities and enabling me to accomplish this work and granting me with his Special Mercy, Blessings and unlimited help throughout the phases of the research work.

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Last but not the least, I would like to thank my family: my parents and my siblings, for supporting me spiritually throughout my life.

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# Abbreviations

| | |
|---|---|
| **MANET** | **Mobile Ad-Hoc network** |
| **S** | **Source node** |
| **D** | **Destination node** |
| **RREQ** | **Route request** |
| **RREP** | **Route reply** |
| **RERR** | **Route error** |
| **DRP** | **Dynamic routing protocol** |
| **LOS** | **Line of sight** |
| **NLOS** | **Non line of sight** |
| **AODV** | **Ad hoc on- demand Distance Vector routing** |
| **DSR** | **Dynamic source routing protocol** |
| **DSDV** | **Destination sequenced distance vector** |
| **ARM** | **Adapting to route-demand and mobility** |
| **LDSDV** | **Light destination sequenced distance vector** |
| **DSDV-MC** | **Destination sequenced distance vector- multi channel** |
| **OPR** | **Optimal path routing** |
| **OLSR** | **Optimized link state routing protocol** |
| **MPR** | **Multipoint relays** |
| **FSR** | **Fisheye routing protocol** |
| **GFSR** | **Gateway fisheye routing protocol** |

| | |
|---|---|
| **WRP** | **Wireless routing protocol** |
| **MDSR** | **Modified DSR protocol** |
| **AODV** | **Ad-Hoc On- demand distance vector routing protocol** |
| **MPR** | **Multi point relay algorithm** |
| **RAODV** | **Reverse AODV** |
| **EN-RAODV** | **Enhanced reverse AODV** |
| **AODV-PA** | **AODV-Path accumulation** |
| **MAODV** | **Multicast AODV** |
| **TORA** | **Temporally ordered routing Protocol** |
| **ZRP** | **Zone routing protocol** |
| **BER-ZRP** | **Binary error rate BASED approach of Zone routing protocol** |
| **PDR** | **Packet delivery ratio** |

# Chapter 1

# Introduction

The wireless network have sustained to play very important role in communication. It is extensively use in military applications, personal area network (PAN) and even in industrial applications. In different application it has been extremely popular in view of different attributes which includes reliability, cost, simplicity of installation, bandwidth and network performance. But it is similar to wired network that used fixed infrastructure [1] such as cellular networks, cordless telephone, microwave communication, Wi-Fi, RADAR and satellite communication etc. Figure 1.1 illustrates the concept of wireless network.

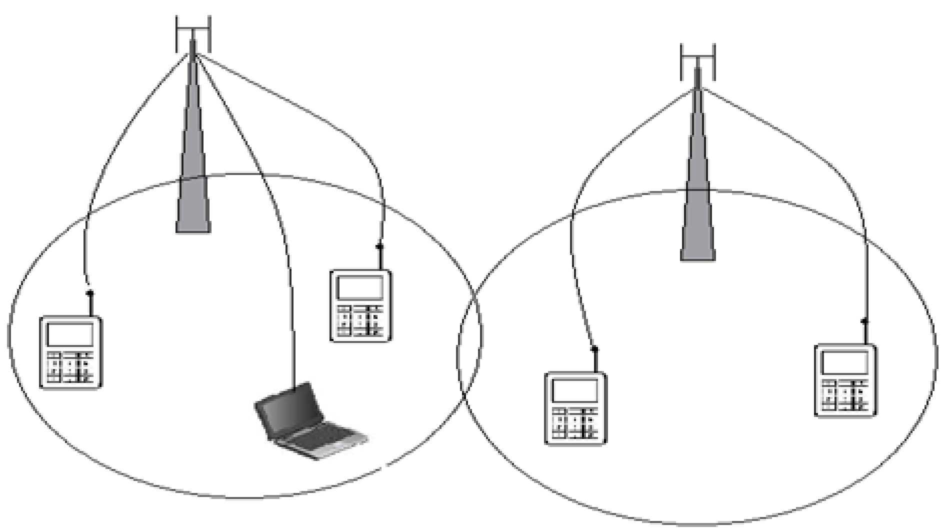

**Figure 1.1: Infrastructure based wireless network**

The next generation wireless Ad-Hoc networks are widely used because users are independent, need for dynamic communication and efficient in rescue/emergency operations, military network and is also used for different application [2,3]. Wireless Ad-Hoc network cover a very large area without any fixed topology and may change unpredictably and dynamically. This type of network improve scalability of network as compared to other infrastructure-based networks because the Ad-Hoc network are decentralized. The critical situations such as military conflicts, natural disasters etc, wireless Ad-Hoc network provide better performance due to the quick operation and minimum configuration [4,5].

Ad-Hoc network can be categorized into three categories depending on their applications: Wireless Sensor Networks (WSN), Wireless Mesh Networks (WMN) and Mobile Ad-Hoc Networks (MANET). A MANET is the collection of independent mobile devices (laptops, smart phones etc) which are connected to each other over a wireless link in a distributed manner [6]. MANET do not have any fixed infrastructure and they provide connectivity in a distributed way. It is possible that one or more than one points of these Ad-Hoc networks are connected to internet to provide connectivity. The main purpose of MANET is to share resources and provide connectivity when there is no fixed infrastructure available. Figure 1.2 illustrates the concept of MANET.

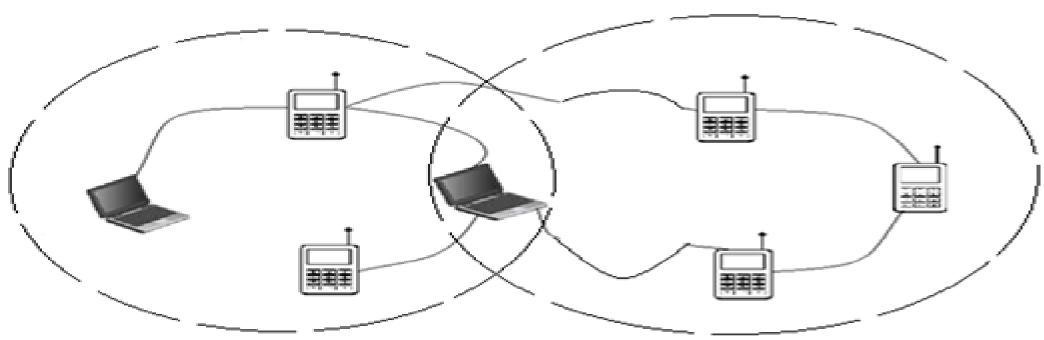

**Figure 1. 2 : Mobile Ad-Hoc network**

The design of most favorable routing protocol for MANET is highly complicated. The dynamic scenarios need to be design a well-organized algorithm which determines the link scheduling and connectivity of network [7]. The routing algorithm efficiency depends on the successful and efficient route calculation. Generally in static networks the shortest path algorithm is an efficient approach to calculate the most favorable route but this idea is very simple and not true always in MANET. Many reason such as path losses, fading, quality of wireless link, extended power and topological changes have to be consider for determining a new route [8]. The network adaptively changes its routing path that depends on the scenario at any occasion to overcome any of these effect [9].

## 1.1 Problem Statement

Typically we deal with an environment where we have all of these nodes, which have a very fast, intermediate and slow mobility. In hybrid networks nodes are either in LOS or NLOS. Fading and shadowing effect the communication more in NLOS compared to LOS, and also reduces the reliability of communication. In our urban environment all these Ad-Hoc network nodes such as VANET (fast), Cyclic (intermediate) and MANET (slow) communicate with each other forming dynamic hybrid mobility. Fading and shadowing reduce the reliability of hybrid Ad-Hoc network. For example figure 1.3 illustrates the concept of LOS and NLOS. Node 1 and node 2 are part of a hybrid network, where they could be mobile pedestrian, cyclic or vehicular node. Node 1 and Node 2 are not in direct LOS because of building.

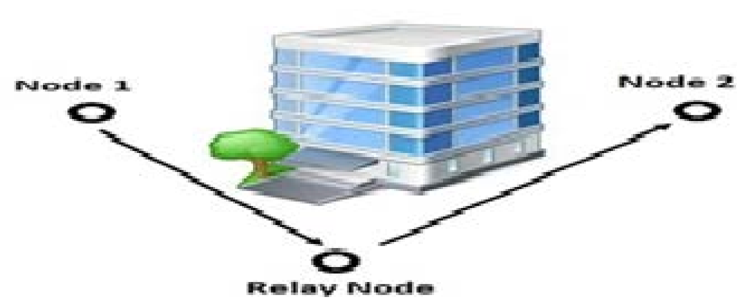


**Figure 1. 3: Relay node concept**

## 1.2 Objective of Research

The objective of this thesis is to use the propagation models described in [10] for the NLOS situation in a simulation environment so that we can produce a routing algorithm with better quality of service in an urban mobility environment. In this thesis we seek the following intensions.

- Force the NLOS transmission to LOS through relays
- Use the concept of multi-hoping
- Increase the reliability of the network

## 1.3 Contribution

In this thesis work, we present a novel hybrid routing protocol DRP for better data delivery from source node S to target node D. We will analyze the network performance of hybrid MANET in an urban environment with LOS communication between nodes. We reduce NLOS and fading margins to achieve the reliability of communication with the help of relay nodes. In our simulation we consider high traffic loads to calculate the performance of DRP in Manhattan grid mobility model. Through the detailed simulation results shows that DRP outperforms AODV and DSR under a wide range of traffic loads including high loads and bursty traffic. DRP experiences significantly low packets drops and high through put as compared to DSR and AODV. Furthermore DRP increases packet delivery ratio as compared to AODV and DSR under high traffic loads and diverse networks.

## 1.4 Organization

The rest of the dissertation is organized as follows: We first summarize the related work in Chapter 2. Classification of routing protocols and some routing protocols are explained in Chapter 2.

In Chapter 3 we describe the design of DRP in detail. Overview of DRP is given in Section 3.1. Route discovery mechanism is described in Section 3.2 Relay node selection in 3.3 and Recovery strategy mechanism in section 3.4.

Simulation environment and evaluation for DRP and Simulation results for Manhattan grid mobility model and setdest are given in Chapter 4. Conclusion and future work is given in Chapter 5.

# Chapter 2

## Background and Related Work

Many routing protocols are proposed in the literature for efficient data delivery. The efficiency of routing protocols highly depends on the environment around. Different approaches are used to increase the performance of these routing protocols. MANET routing protocols can be mainly classified into three categories reactive, proactive and hybrid. Figure 2.1 illustrates the types of routing protocols.

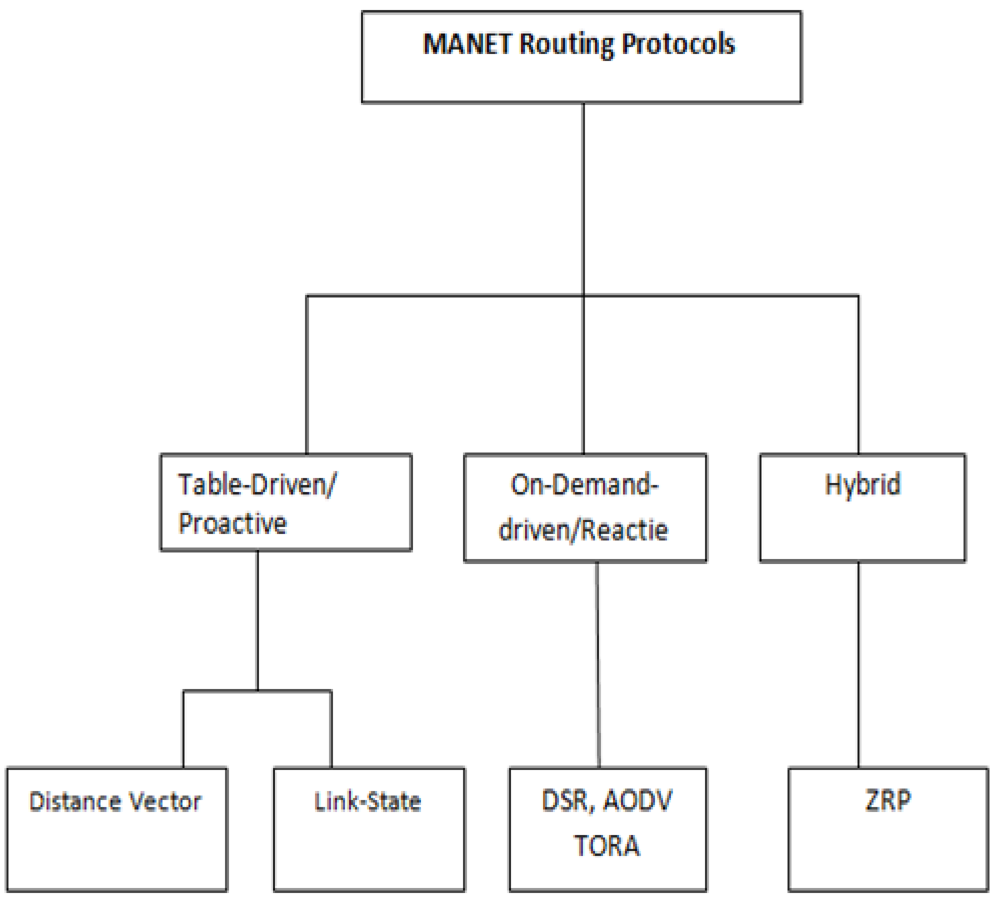


**Figure 2.1: MANET routing protocols categorization**

## 2.1 Table-Driven/ Proactive Protocols

In order to establish connection with other nodes in the network each node contains routing table for the broadcast of data packets. Every node has the routing table which contains the target node address and the number of hop required to reach the destination. A sequence number is generated by the target node which is tagged with every entry of the routing table [11, 12]. Proactive routing protocols are also known as table driven routing protocols [13]. The main benefit of proactive routing protocol is availability of the path from source node to the target node without any delay because they do not depends on traffic profile [14]. As in proactive routing protocols routing table contains entry of all the nodes of network so it is useless to adopt this protocol for a large network. The table driven protocols keep different number of the routing table varying for protocol to protocol. The examples of proactive routing protocols are DSDV, OLSR and WRP etc [15]. Figure 2.2 illustrates the concept of table driven routing protocol node 1 and 4 has routing table with hope count entries and GST (Global Sequence Table).

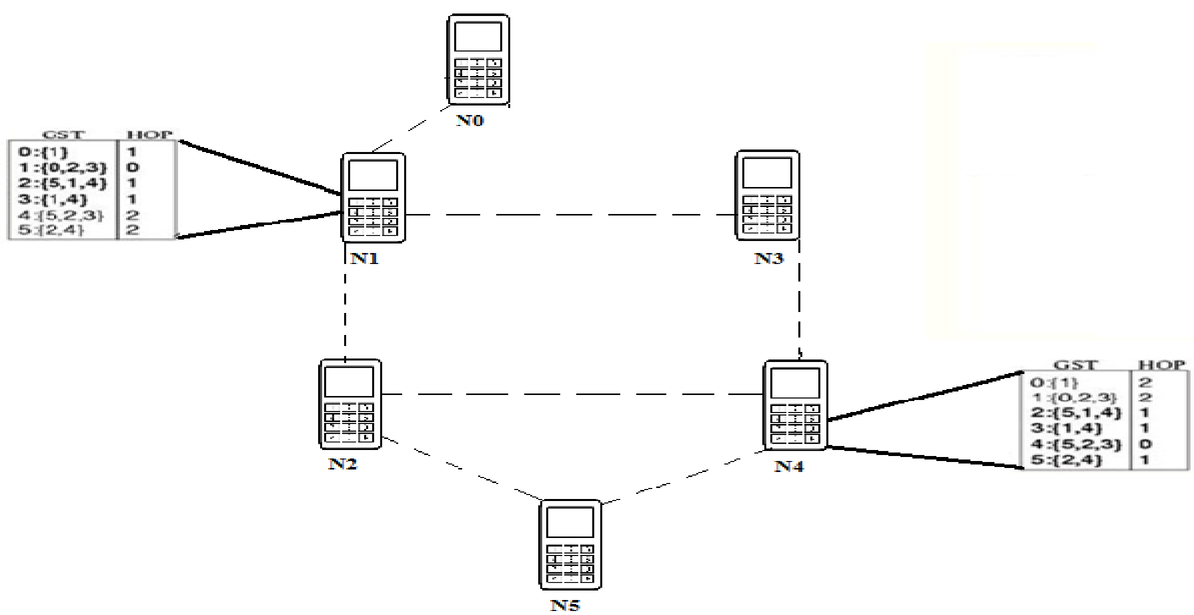


**Figure 2.2: Tables-Driven/ Proactive protocols**

### 2.1.1 Destination Sequenced Distance Vector (DSDV)

In DSDV [16, 17] routing protocol routes are maintained for all nodes of the network. As it depends upon Bellman-Ford routing algorithm, that can not be suitable for MANET due to its prolonged convergence time. Numerous modifications or extensions have been desinged to enhance the performance of DSDV for instance [18-24]. The main problem related with Distance vector routing of wired networks is solved by DSDV (i.e., Count-to-infinity), through destination sequence numbers. In addition to this it also assures, the loop-free paths to every destination.

In DSDV every node sustains routing table that point one path for every target node. Every entry of the routing table consists of the target node (number of nodes to reach the destination node) the sequence number that is initially created by the target node. New routes are distinguished from the old routes through sequence numbers. The routing table are used to broadcast packets involving nodes in the system.

DSDV manages the topology modifications using a certain process which will be based on two types of updates ,They are time-driven and event-driven , in time driven the routing table of the node is periodically transmitted, but in event driven it reacts when link fails. Nodes manage the list of newly recorded channels for instant announcement to the existing neighbor nodes. Routes with an enhanced metric are listed for announcement each time which in turn depends on the ordinary settling time for channels to the certain destination under consideration. To decrease the amount of routing information packets in DSDV ,it uses two different approaches of update packets, an “incremental update" or a "full dump”. A full dump update is the transmitting of every routing table entry to the active neighbors. On the other hand, in an incremental up-date, the node only transmits those entries that are changed since the last full dump.

Figure 2.3 illustrates the concept of DSDV routing protocol. In the following example three steps are explained when a packet is sent from node one to node three (not listed in figure). The figure (2.3 a) shows that source node is node 1 and destination is node 3, the next hope of the packet is node 4. Figure (2.3 b) show that when fourth node receives the packet it first checks the destination address for the node three in its routing table. Figure (2.3c) shows that node 4 sends the packet to next hop which is node 5 as defined in the routing table of node 4. This process is repeated as compulsory until finally the packet reached it target node.

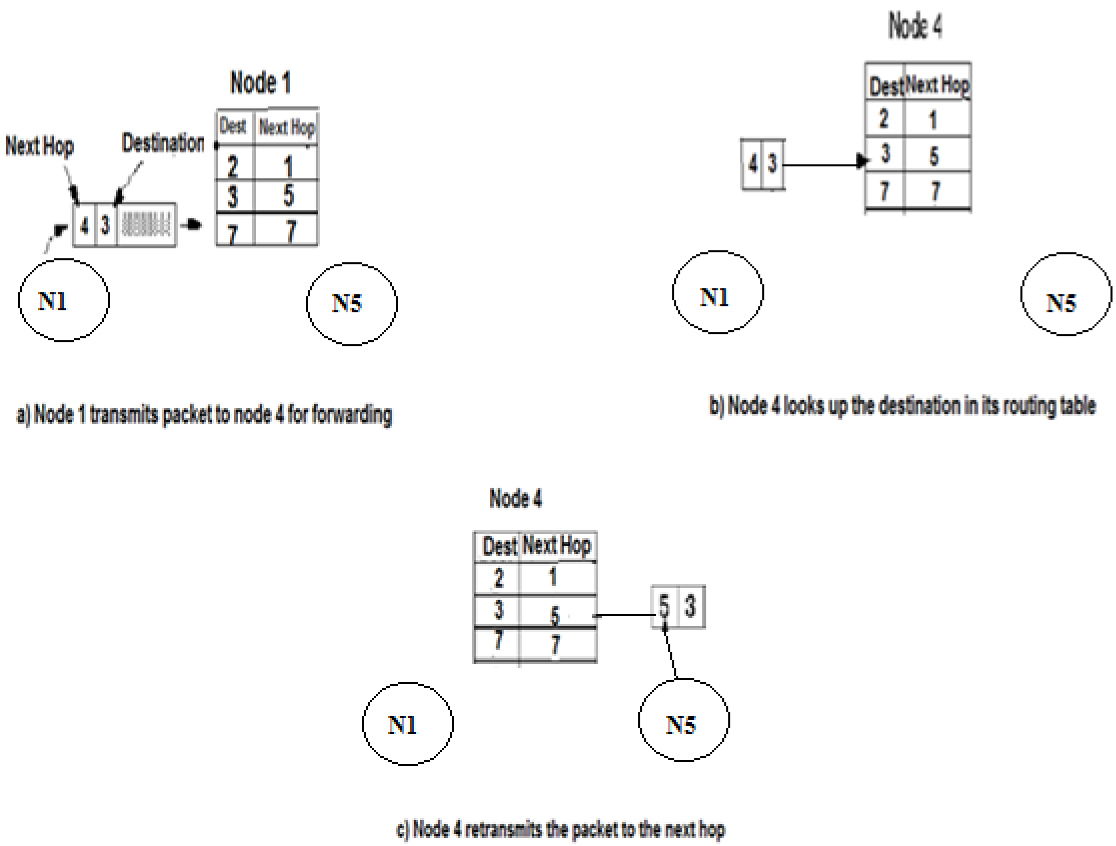


**Figure 2.3: An example of the routing protocol in DSDV**

Ahn et al. [25] have proposed a control method called Adapting to Route-demand and Mobility (ARM). The actual method makes it possible for any kind of proactive routing protocol to be able to adapt to changes with node freedom as well as workload path demands. By using this method, each node maintains a couple of metrics to modify the cycle of routing updates and content: route-demand metric represents which target node is currently transferring data. Mobility metric demonstrates how fast its neighbors are presently changing. The ARM is decentralized therefore each node adapts independently. The writers concluded that comparison of DSDV and ARM –DSDV shows that ARM-DSDV achieves a better data delivery ratio, with a reasonable amount of routing costs.

Chang et al. [26] Present a technique called Light DSDV (LDSDV), to decrease routing overhead in DSDV. The LDSDV technique is better then DSDV, because in this method they choose shortest path for data delivery and also loop-free path. But in LDSDV a problem flooding of control messages occurs when the network topology modify. The spanning trees is main benefit in LDSDV, it maintains the nodes relationship under every spanning tree. When routing message received at any node from the destination node, then it runs a process to verify whether the message should be forwarded or discarded. The writers conclude that LDSDV at leaf nodes filters a large amount of redundant messages, therefore it reduces routing overhead especially for MANET when nodes speed is high.

Lee et al. [27] Proposed Destination Sequenced Distance Vector- multi channel (DSDV-MC) in which expanded DSDV routing protocol with the help of multi-channel version. The DSDV-MC protocol utilizes multiple channels, where useful multiple transmissions can occur at the same time. DSDV-MC protocol separates network layers into data and control planes. Nodes exchange routing updates by using control channel, and data channel for data transmission. The writers concluded that capacity of network is increased by using multiple channels with the help of DSDV-MC protocol. The DSDV-MC protocol improves throughput of the network in both scenarios multiple-hop and single-hop network, packet drop rate is reduced even when we increase the number of channels.

Kumar et al. [28] proposed a protocol Optimal Path Routing (OPR). The OPR is a proactive routing protocol it based on DSDV, OPR works proactively using optimal path routing method. The protocol supposes that every node in network is fitted with GPS receiver for the nodes current location. OPR reduces the routing overhead by maintaining the neighbour and neighbour of the neighbours nodes routing tables, therefore every node stores information up to only one-hop and two-hop nodes. When a node transmits packets to any target node then node select the closest neighbour as the target node and sends packet.

### 2.1.2 Optimized Link State Routing Protocol (OLSR)

It is link-state proactive routing protocol that utilizes hello packets and topology control (TC) to determine and then broadcast link state details throughout MANET. Every single node utilizes information of this topology to calculate the next hop destinations using the shortest hop forwarding paths for every node in network. Paths to all the target nodes surrounded by the network are obvious and sustained before use. Does not contain any provisions for identifying the quality of link [29- 31].

The multipoint relays (MPRs) idea used in the OLSR protocol. During the flooding process MPRs are elected nodes which transmit broadcast messages. This procedure provides two type of optimizations [32]. The First type , it decrease the control packets size on all links and the MPRs selected just a neighboring subset of links. The second type decreases the control traffic of flooding by using method of only the elected nodes to transmit the messages in the network. The broadcast massages are retransmitted only by the MPR nodes. This procedure decrease the overhead of message as compared to the mechanisms of pure flooding where all node retransmits every message when node receive the packet first time. The figure 2.4 illustrates the concept of broadcasting versus multi-point relay in a network of 10 nodes. The concept of broadcasting the source node floods the massages to all nodes within the range as shown in figure 2.4(a). But when it uses the concept of multi-point relay then the source node broadcast the massages only to the elected nodes called MPR.

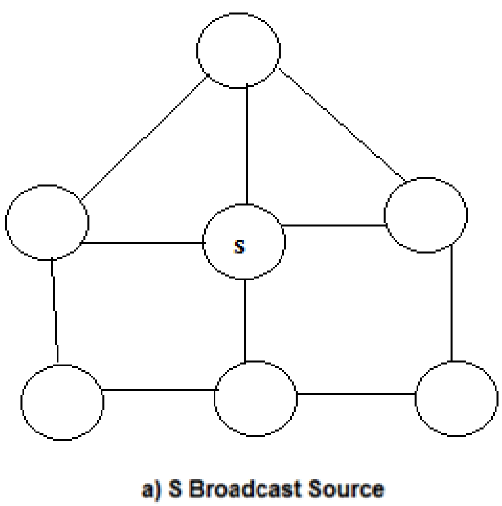


**Figure 2.4: Example of multipoint relay**

Y. Ge et al. [33] Proposed a new idea for MPR selection method. It is based on the bandwidth of route in order to offer quality of service with OLSR. At last [34] explore the influence of the fractional information of topology available for OLSR while increasing MPR redundant topology information and coverage. While increasing the redundant topology information illustrate high delivery data rates under moderate mobility.

Reza Fotohi et al. [35] enhanced the OLSR in MANET by removing the redundant Loops. The authors conclude that throughput is improved in OLSR by reducing the redundant loops in the network.

The synchronization assumption in [36] is difficult to realize in MANET. T. Sanguankotchakorn et al. [37] proposed a new idea CIDQ which overcomes the delay with realistic route. A Connectivity Index (CI) new metric is developed to cover the connectivity of a link and capacity. Increased 6.25% throughput by using this method as compared to OLSR.

### 2.1.3 Fisheye State Routing (FSR)

The FSR routing protocol is based on link state routing algorithm and it is also proactive routing protocol [38]. As the name of FSR point out uses a function like fish eyes, where the eyes capture the pixel with high details close to the focal point. As the detail decreases when the focal point distance increases. FSR sustains immediate neighboring nodes information about accurate path quality and distance. FSR to decrease the overhead of routing update in large network uses the concept of fisheye scope at multi-level. The scope is defined as a number of nodes which can be reached within a specified number of hops. The number of levels and the radius of every scope depend on the size of the network.

FSR is likely to many other Link-State routing protocols in which every node sustains a topology map. The major difference of FSR from other link-state routing protocols routing is information propagation throughout the network. In its place of link-state flooding information into the overall network, every node in FSR maintains table according to received information from their neighbors and update routing table, as well as exchange the information only with neighboring nodes. This exchange of information is based on the sequence number. Every node updated routing table and in ascending order such as the routing table holds the smaller sequence number entries first and than large sequence number entries.

G. Pei et al. [39] conclude that in MANTE the correct routes maintanince is a challenge task but FSR provide a flexible solution, if it properly selected the radius size and the number of scope levels. The Figure 2.5 illustrates the concept scope of fisheye for the centered (Black) node.

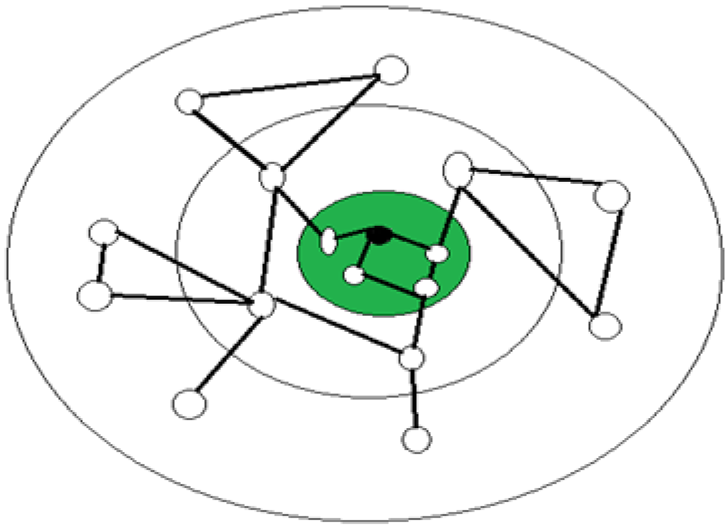

**Figure 2.5: Concept scope of FSR**

The scope is defined regarding to the nodes that could be reached within a specific number of hops. The most correct information regarding all nodes has center node in the green surround and so on. While the node does not have exact details regarding distant nodes, the correctly routed are packets because the information of route more correct when the packet moves nearer to the target node. Fisheye state routing scales well to huge networks as the controlled is overhead in this method.

S. Nithya Rekha et al. [40] enhanced the FSR by using the idea of gateway node. In GFSR routing protocol a gateway is selected in each grid. Gateway nodes are the only nodes in grid which are used to exchange data packets and control messages with other grids. The GFSR improves the packet delivery ratio and has lower delay compare to the FSR.

## 2.1.4 Wireless Routing Protocol (WRP)

WRP utilizes an improved mechanism of the DSDV path planning algorithm that utilizes Bellman-Ford algorithm in order to compute paths. Due to transient nature of edges in

MANET, the algorithm introduces a method that guarantees reliable communication and reduces path loops [41].

Just as DSDV, WRP retains the current prospect of network; each edge has readily reachable paths to every target node within network. The difference between DSDV and WRP is in the update mechanism and table maintenance. As DSDV retains only one topology record where as WRP utilizes a group of records to retain more precise information. Tables that are retained by any edge are following, routing table (RT), message retransmission list (MRL), distance table (DT) and a link cost table (LCT). The network prospects of the neighbor nodes are contained by DT. It has a matrix in which every component have a penultimate edge and distance informed through neighbor for a specific target edge. The RT has a current prospect of network for every known target edge. It retains the predecessor edge, shortest distance, the next edge to reach the target edge, and a flag that indicates the status of route. The route status possibly a loop (error), the target edge not marked (null) or simple path (correct). LCT retains the cost (number of edges to reach the target) of transmitting messages via every link. The link failure cost is infinity. It also has periodic updates (time spam among two consecutive updates) passed while the ultimate update was received from that connection. In order to find links failures. For each update message MRL contains a record which is to be rebroadcasted and retains counter for every record. After the retransmission of every update message the counter is decremented. Every edge which has responded to update message it broadcasts is marked in RT of node. When the counter counts to zero, the records in update message for which no response is received are rebroadcasted and update message is removed. So, an edge detects a link failure through the number of periodic updates missed since the last successful communication. Convergence is greatly faster than DSDV because after getting an update message, an edge not updates the distance for broadcast neighbors only but also checks the distance of other neighbors [42, 43].

The main disadvantage of WRP is that it maintains many tables so enormous memory storage is used. Moreover, WRP is a proactive routing protocol, so is not suitable for large network due to limited scalability [44].

## 2.2 Reactive or On-Demand Routing Protocols

Reactive routing protocols are also known as on-demand routing protocols. These routing protocols try to use network bandwidth with making paths only when required through S node. When path is recognized, it is sustained through various path maintenance mechanisms as long as this is desired with S node. When S node desires to transmit data to several destinations, it checks the routing table to find whether it has reachable routes. Whenever there is no path for target node, it executes a path discovery process to determine a route to target node. This technique of routing is called on-demand routing protocols. The examples of on-demand routing protocols are DSR, AODV and ABR etc [45- 47].

In MANET the On-Demand routing protocols have very low control overhead as compared to Table-Driven routing protocols. Therefore scalability of proactive routing protocols is not better as compared to reactive routing protocols. In MANET when source node forward data packets using reactive routing protocols, it gets long delay due to route discovery process. Figure 2.6 illustrates the concept of reactive routing protocols in MANET. When source node send data to any node in network it first find the path to destination node. The given network has 7 nodes when source node send data then it first flood the RREQ to all nodes in range. This flooding will chock the network performance when numbers of nodes are increased.

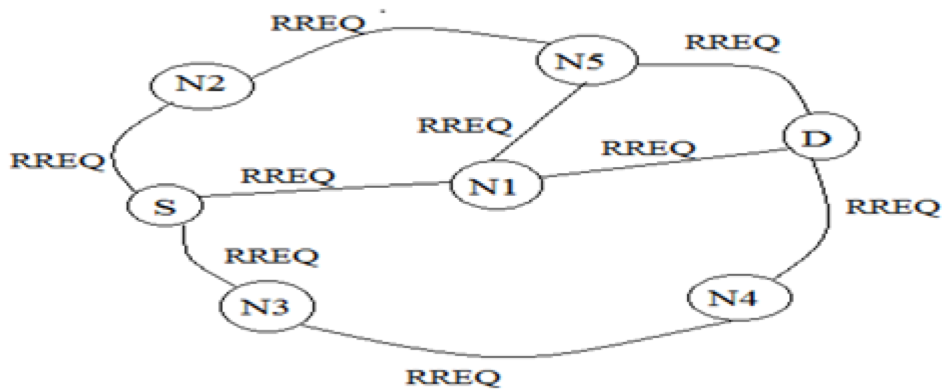


**Figure 2.6: Reactive or On-Demand Routing Protocols**

## 2.2.1 Dynamic Source Routing Protocol (DSR)

Dynamic source routing protocol (DSR) is a reactive routing protocol [48]. The idea is based upon the source routing. It use the idea of route cache to store complete paths of the known destinations without maintaining the routing table therefore it is different from other unicast routing protocols. The DSR does not need periodic packets and periodic routing advertisements. Control overhead may decreased by the lack of control packet activity. The Route Maintenance and Route discovery are two methods in DSR protocol to maintain and discover the desired routes.

The first step is route discovery , when any node has data packets and are ready to transmit, node checks the route cache for path to the target node. If node found the active route entry in cache towards the destination, it use the route for data packet transmission. If node does not fond the path towards destination then the source node start broadcasting a packet called Route Request (RREQ) for route discovery. The address of S node , th address of D node , and a unique id request is included in route request packet. Also, every RREQ packet includes a record listing of address every middle nodes to forward the packet. Every middle node after receiving the RREQ packet first checks if it has the path to target node. If the any middle node does not have rote then it first add its own address on path record and then broadcast to the neighbors.

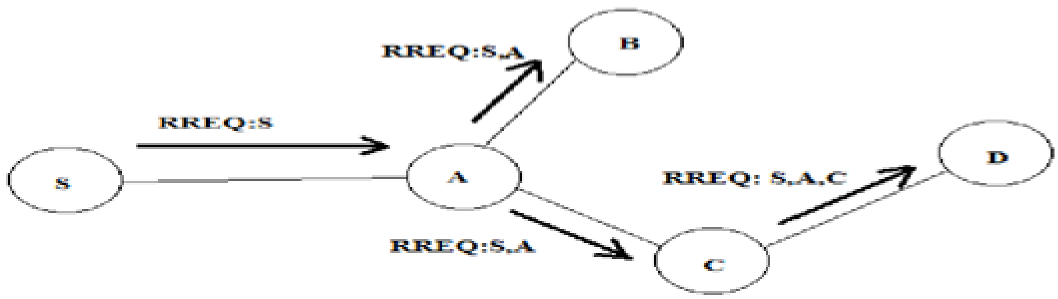


**Figure2.7: DSR route discovery**

And generated the RREP, when a route request received to the middle or an destination node that has route unexpired to target node. If the receiving node is the target node, it puts the path record contained in the RREQ into the RREP. If the RREQ received at the middle node, it adds its cache route and then create a RREP. If there are supported the symmetric links, then reacting node may reverse path in the route record. If they are no supported symmetric links, then node commence its own discovery of path and piggybacks the route reply RREP packets on a new RREQ.

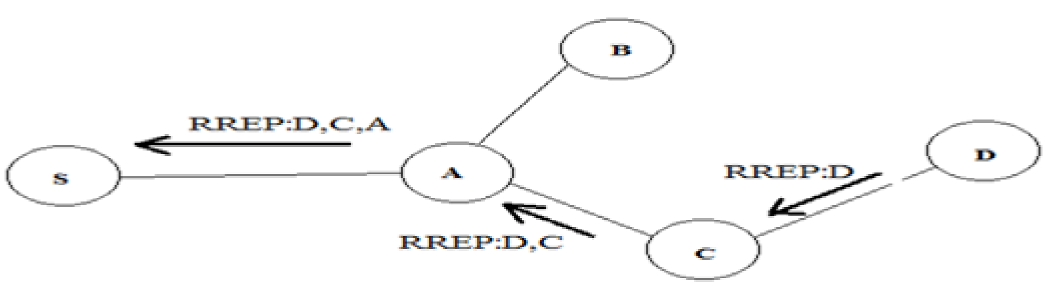


**Figure 2.8: DSR route reply**

The route maintenance in DSR does not introduce the periodic hello messages. Each node along the route is liable for the downstream link validity connecting itself with the next node. Path maintenance is invoked if damaged link is found. This particular stage is completed using RERR packets along with the acknowledgements. Any node that determine a link failure then it generates RERR packet and transmitt to the S node. When RERR packet is received at S node, then path discovery process is re-initiated for alternate path.

Sourish Mitra et al. [49] proposed a new approach with the help of improved strategy of link repairing on a link failure. The algorithm is based on the DSR, which take decision on basis of relay node location (where link failure is detected) in source route. According to proposed work route maintenance algorithm detects the relay node location when link failure occur on source route . After detection within a specific zone it execute the maintenance algorithm to transmitt the data packets to the target node. The algorithm decrease the end to end delay and improve PDR. The relay based DSR algorithm also improves the scalability of MANET as well as route maintenance and also decrease the number of error message inside the Ad-Hoc network.

Sharmin Sultana et al. [50] Proposed a new approach enhanced the DSR mechanism to E-DSR with the two new ideas: short length of packet header in DSR and reduce the route request. E-DSR Performance is elevated in some simulations metrics such as control packet overhead and packet delivery ratio and Route Request . The E-DSR adapt quickly to route change by decrease in sending the route request packets as well as shorten the length of packet when the network size is large.

ABDULLAH GANI et al. [51] Proposed a new approach, enhanced DSR mechanism to MDSR. The MDSR using ACK paths as the backup routes when the original path no longer exists. This mechanism reduces the waiting time for data delivery before path is reestablished.MDSR also improves the PDR and reduces the end to end packet delay.

## 2.2.2 Ad-Hoc On- demand Distance Vector routing protocol (AODV)

The AODV is a unicast reactive routing protocol in which paths are maintained only when required. AODV only maintain the active routes in routing table [52-54]. AODV routing protocol use four different control packets: Hello message, Route Request (RREQ), Route Reply (RREP), and Route Error (RERR). All nodes maintain routing table which contain: Next Hop, Sequence number, Destination address, Number of hop (metric), Expiration time of the route entry and Active neighbour for this route.

In distance vector protocols a sequence number is used for freedom of loops. Both RREP and RREQ are send with sequence number and stored in routing table. The greater the sequence number the newer the path information. If new route is available, then sequence number of the existing route and new route are compared. The path with the larger sequence number is utilized. If the sequence number is same, then the path with fewer number of hops is selected .

AODV is organized of two mechanisms: Path Discovery and Path Maintenance:

First mechanism is Route Discovery: When any node wants to transmit data to target node, then firstly it make sure for an appropriate route exists for destination in its routing table. If any path exists in routing table, then node starts transmitting data to next node. Or else, start path discovery process. In the process of path discovery, it uses two types of packets RREQ and RREP to constitute a path for target node. The RREQ is broadcast in the network. Upon receiving of RREQ, the node establishes an invert routing record towards S that could be used to send replies afterward. An intermediate node or a destination node, responds with RREP packet, which has valid path for the destination.

Figure 2.9 illustrates the concept of route discovery in AODV routing protocol. Node S needs a path to D node for data delivery. It than generates a RREQ which has different entries such as entire target node IP address, sequence number, source node IP address, and hop count(=0). Then source node S broadcast the RREQ to all neighbors. Node A receive the RREQ packet and makes a reverse path towards source node S. If A node has no path for destination node D then it rebroadcast the RREQ. When node receives the RREQ it makes reverse path entry towards source node.

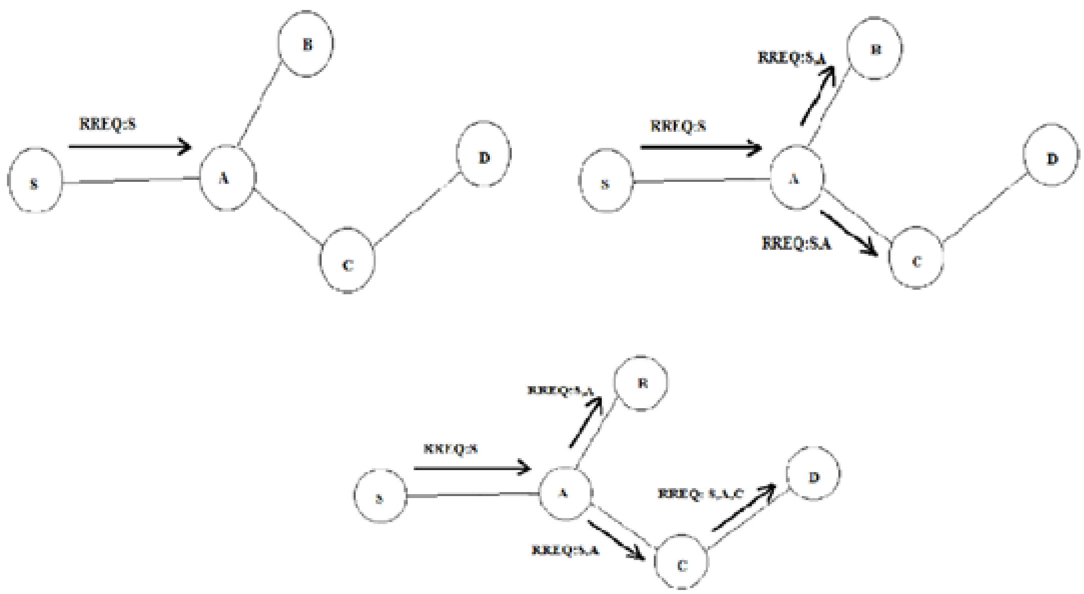


**Figure 2.9: AODV route discovery**

Figure 2.10 illustrates the concept of route reply in AODV routing protocol. When node D receives the RREQ it retransmits the RREP using the reverse path of RREQ. Node D generates a RREP which includes entire destination D IP address, sequence number, source node IP address, hop count to D (=1). When D node informs the source node for path then it unicast RREP to C.

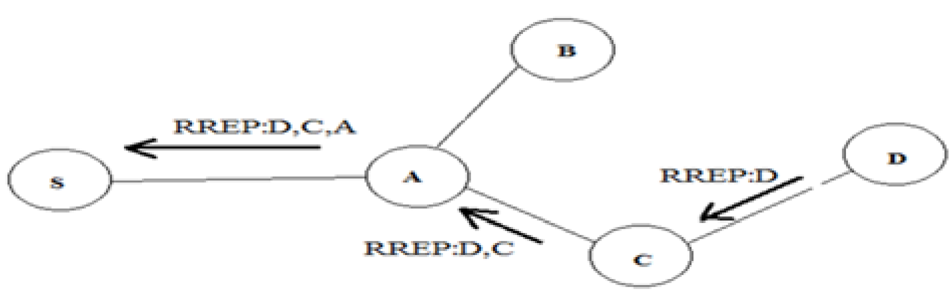


**Figure2.10: Route reply in AODV**

Second is Path Maintenance: each node along with active routes periodically broadcast hello message to its neighbours. If the node not receive a data packet  or a hello message from a neighboring node for a certain time, the link is consider to be broken. In case of the target node with this neighbor as the next hop is not far away from the invalid routing entry, a local repair method may be started to reconstruct the path towards the target node; otherwise, a RERR is send to the neighbors, which in turn propagates the RERR packet towards nodes whose paths may be affected by the broken link. Then, the affected source can re-initiate a path discovery process if the path is still needed.

Vivekanandha et al. [55] proposed a new approach enhanced AODV for MANET and introduce a new mechanism called Multi Point Relay Algorithm (MPR). In high density network MPRAODV perform better then AODV routing protocol. When nodes speed is fast in network then MPRAODV operate better than AODV. The main problem in current AODV is overhead caused by packets flooding of route query. The MPRAODV increase the performance of AODV; decrease the overhead of routing by using method of multipoint relay. This method only selects nodes that transmit only flooding query packets.

M. Sanabani et al. [56] proposed a new mechanism to enhance RAODV routing protocol. The RAODV routing method provides the top services and is a reactive routing protocol. RAODV organized routing path whenever begin delivering the data packets, and it also developed run out time to maintain the path planning table. Thus, if any node moves away during run out time, the routing paths do not alter.  If it finds a new shortest  path for routing, an already developed path during run out time is used instead of using the shortest path. Therefore, Enhanced RAODV to EN-RAODV routing protocol for a fresh shortest path  selection  during transmitting of  packets. Results shows that EN-RAODV betters the performance of RAODV in most metrics, as the average delay, routing packet sent, routing overhead, packet delivery ratio and average throughput.

Sumit Gwalani et al. [57] Proposed a new approach to modify AODV routing protocol. The AODV-PA protocol integrates path accumulation throughout the process of discovery route in AODV to achieve more information about routing. The AODV-PA improves the performance with high load, high mobility and in larger network as compared to AODV. AODV-PA routing protocol provides low delay and higher PDR than DSR, with slightly higher routing loads than that of DSR routing protocol.

Sridhar Subramanian et al. [58] proposed a new mechanism to enhanced AODV routing protocol. The trust base reliable protocol TBRAODV to evaluate the misbehave nodes during routing. If any node misbehaves during transmission of data then it changes its routing path for reliable routing. This approach improves the performance of PDR and decrease the end to end delay.

J. Mackeret al. [59] proposed a new approach MAODV to enhance the unicast protocol AODV. The AODV normal process is applied on MAODV. The MAODV use the same process of rote discovery as AODV to find out a route to the multicast sharing tree. The sharing tree is maintained for every multicast group, and first member of multicast group is the leader of group. The leader of groups maintains the sequence number and sends hello massage to maintain the group forwarding tree. Apart from discovering and incorporate an additional node into the group, the multicast tree is sustained in two further approaches: pruning the tree as soon as a node leaves the group, and reinstating a busted link. A node could actively eradicate itself from the group by informing its active neighbor, with a special Multicast Activation Message.

P. Wannawilai, C. Sathitwiriyawong et al. [60] proposed a new AODV approach with sufficient bandwidth aware (AODV-SBA) routing protocol . The AODV-SBA improves the performance of network by reducing the routing overhead and better route to avoid congestion. The algorithm utilizes light weight mechanism to ascertain network congestion. The MAC layer information is used for measuring the local network congestion. Therefore, blocking the discovery of paths over which it is undesirable to carry extra data and routing traffic over those hops that are already busy. The channel free time is used as a metric for route establishment stage. AODV-SBA thus maintain the necessary features of AODV while considerably increasing the performance of network by avoiding the routes with high congestion.

### 2.2.3 Temporally Ordered Routing Protocol (TORA)

The TORA is highly efficient, adaptive and scalable distributed mechanism of routing based on the idea of link reversal [61]. The temporally ordered routing Protocol is proposed for multi-hop wireless network and highly dynamic mobile. It is on-demand source initiated routing protocol. It finds out many paths form S node to D node. The main characteristic of TORA is that control massages for a very small set of nodes. The protocol has three basic tasks: path formation, path maintenance and path removal. TORA has a unique characteristic of sustaining many paths to the target node so that topological changes do not need any reaction at all. The TORA routing protocol react only when all paths to the target node fails. In the incident of network partitions the protocol is capable to detect the partition and remove all void paths.

## 2.3 Hybrid Routing Protocols

These routing protocols take the benefits of both Table-Driven and On-Demand routing protocols. Hybrid routing protocol is initially recognized by some proactively prospected paths and also serves the need from additionally stimulated nodes with reactive flooding. The examples of hybrid routing protocols are ZRP, DHAR and HSLS [62].

### 2.3.1 Zone Routing Protocol (ZRP)

Haas and Pearlman introduced Zone Routing Protocol. It is a hybrid routing protocol for MANET that divides the edges into zones (sub- networks). It integrates the merits of proactive and on-demand routing protocols. In every zone, in order to boost up communication between the neighbors proactive routing is used. In order to decrease redundant communication within inter-zone communication it uses on-demand routing. Distance between mobile nodes is used to divided the network into different routing zones. Given a hop dissociate D and edge N, all edges within hop distance not more than D from N be the member of routing zone of N. Tangential edges of N are N's neighboring edges in its routing zone that are accurately D hops far from N. the significant problem of zone routing is to decide the size of zone. An improved ZRP, Independent Zone Routing (IZR) is proposed in [63], that permits distributed and adaptive reconfiguration of the enhanced zone size. Moreover, scalability of MANET is improved by adaptive nature of IZR. Each edge periodically requires to update routing information within a zone [64]. Also, several local path optimizations are carried out at every node, that have the subsequent actions.

- Redundant routes removal
- Route shortening
- Link failure detecting

The figure 2.11 illustrates the concept of route discover in ZRP. For example node S need to transmit data to D node . Firstly node S confirm that D Node is not available in its zone. Then S node send a request to all node in its zone (C,G, and H). After receiving the query all node check that D node is available in their zone or not. If D node is not in zone then nodes again broadcast the request to their peripheral nodes. In example when query receive at node H and it sends query again to node B. when node B receive the query and recognize that D node is in the routing zone.B Node react to the query, indicate that the forward route is S-H-B-D.

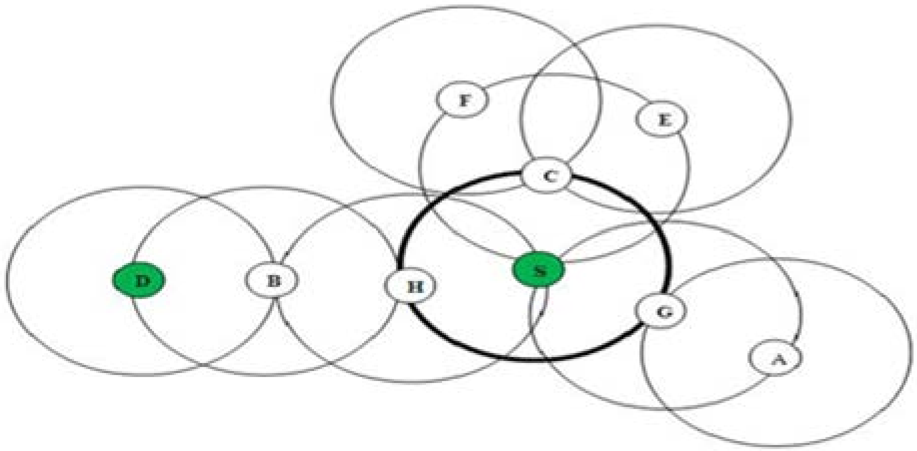


**Figure2.11: Example of ZRP**

Anup Kumar Sahu et al. [65] proposed a new ZRP approach for MANETs is called zone multicast routing Protocol (ZMRP). ZMRP decrease the load of network by reducing the control packet. When protocol find the new route for data delivery. Therefore ZMRP has high packet delivery ratio and better throughput as compared to ZRP.

M.N Sree Ranga Raju et al. [66] update the existing ZRP model with an improvement of ZRP to achieve better performance. In MDVZRP the node start the discovery of route process for target node, only when any node transmit the data and route is not available in routing table. Therefore MDVZRP reduce the discovery packets for route 3 times as compared to reactive routing protocols. When a link failure is detected in active routes, then MDVZRP use a different route selection process. MDVZRP use the full dump method; in which novel node receive its nearby neighbor's path planning table while joining the network and transmit a beacon for creating its own path planning table. This method provide the new nodes capability to view the complete network rather than its own zone only.

P. Dhivya et al. [67] Proposed a new ZRP approach that each zone selects a relay node base on GPSR routing.This approach will not suggest the consistent route to transmit the data transmission. The selection of the relay node is base on the node weight. The node weight is based on the two metric such as remaining power and mobility of the node . The proposed approach show that the GPRS is better for selecting a relay node in ZRP. The proposed approach reduces the end to end delay and maximizes PDR.

TiguianeY el emouxz et al. [68] Proposed a algorithm of Binary Error Rate based approach of Zone Routing Protocol (BER-ZRP) for improved utilization of network. By BER-ZRP, every stage of link state entry and path planning table's computation were under QOS control with the intention that better routes in terms of BER were preferred. This approach reduces the overhead and enhanced the process of route discovery. The BER-ZRP Normalized Oversize Load and enhance the PDR.

## 2.4 Summary

The proactive routing protocols always maintain and propagate the routing information. Therefore a path to each other nodes in the network is always reachable. The proactive routing protocols maintain the routes that are needed or not. Proactive routing protocols are classified as hierarchically routed global protocols and flat routed global protocols. Flat routing global protocols uses updating procedures that waste important amount of bandwidth of network. In this type of protocols, when the network grows in size then the overhead increases. The hierarchically protocols can better scale than most of flat routing protocols due controled overhead of network. This is attained by only allowing the selected nodes to retransmit the information.

In reactive routing protocols the path is establish only when it is required. When a node is ready to transmit data, it starts route discovery process for path to the destination. The majority of reactive routing protocols in worst-case scenarios have the same cost of routing. The reactive protocols have low overhead because they do not use the periodic updates.

The hybrid routing protocol is combination of proactive and reactive routing protocols, and it also reduces the deficiency of these protocols. It increases the scalability of the network by permitting the nodes to work simultaneously in a close propinquity in order to decrease the overheads in route discovery. This can be achieved by proactively maintaining routes to near nodes, and reactively determining routes to far away nodes. Many hybrid routing protocols are zone-based, where the network is partitioned or can be seen as a number of zones by every node. Some hybrid routing protocols groups the nodes into trees or clusters.

# Chapter 3

# Design of DRP

In this Chapter we will describe the design of DRP in detail. After an overview of DRP we will explain, route discovery mechanism in the Section 3.2, relay node selection mechanism in the Section 3.3 and recovery strategy mechanism in the Section 3.4.

## 3.1 Overview

DRP is an enhancement of AODV protocol to develop an optimized protocol for an environment of nodes with dynamic mobility. DRP is hybrid protocol which utilizes reactive as well as proactive approach for routing information. It only contains the information of nodes up to 2-hops that are in its neighborhood range through proactive approach. The nodes that are not in 2-hops neighborhood range are not maintained in routing table, it uses reactive approach in such situation. As in MANETS nodes are either in LOS or NLOS, when nodes are in LOS so the communication is direct we do not need a third party for communication. When nodes are in NLOS we need a node that makes the communication channel for sender and destination node. The node that is used for communication in NLOS nodes is relay node which holds the data and control packets. The relay node selection is done on the basis of mobility, direction and distance of nodes. The problem of node mobility, direction and distance is solved using packet forwarding mechanism. Note that we assume, each node has a map of network design in which it is communicating and all nodes are equipped with GPS receivers. This implies that each source node knows the location of its destination through map.

## 3.2 Route discovery

Unlike AODV, DRP is not entirely a reactive protocol, it maintains the routing table up to 2-hops in order to reduce the routing overhead. DRP uses intelligent packet forwarding mechanism to route the packets to destination. There are two phases of route discovery, named as Route Request and Route Reply.

### 3.2.1 Route Request

First phase in route discovery is Route Request, As shown in figure 3.1 if source node S wants to transmit data to any target node D then the S node creates a RREQ [69,70] only if source node has no information about D in its routing table. As DRP is hybrid routing protocol therefore it first checks the route for D in its routing table. S node sends the RREQ only to the nodes which have 2-hops in its neighborhood. The S node sends the RREQ packets to N2, N10 and N11 because these nodes are in the transmission range of S node. The N2, N10 and N11 first check the route for D in their routing table if not found then initiate the route request to the next node. As N10 and N11 have no further nodes so they discard the RREQ packet.  When node N3 receives the RREQ packet it also checks the route for D in its routing table. The N3 node knows about the D node, because it has 2-hops neighborhood information and sends the RREP to the source node.

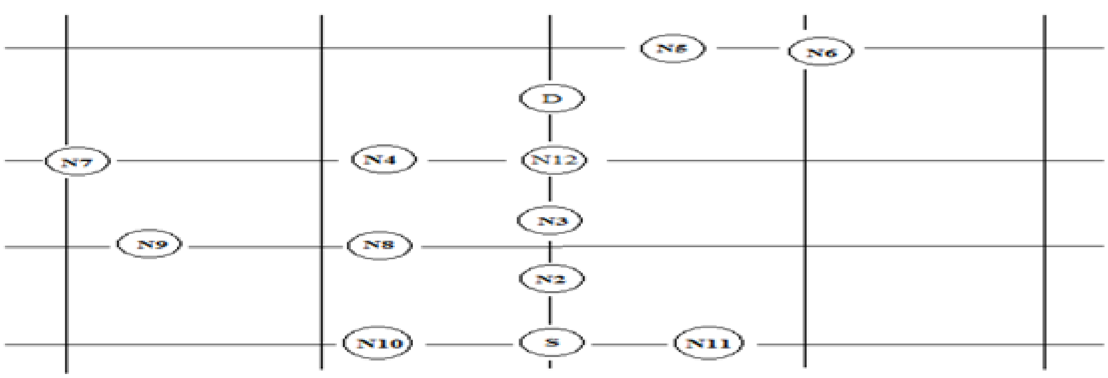


**Figure 3.1: Concept of RREQ in DRP**

**Algorithm 1**: 2-hops neighborhood routing information

1. If A 2-hops tuple exists (Node X, Node Y) with:
2. N-address =originator address of (Node X ,Node Y)and
3. N-2hops-address= the address of the 2-hops (Node X, Node Y) neighborhood and send to nodes within range
4. Else
5. If A 2-hops tuple (Node 1, Node 2) do not exists
6. N-address= not originator address because no nodes in transmission range.

### 3.2.2. Route reply

Second phase of route discovery is Route Reply. Once the route for the D node is found then node sends RREP using the same path as for RREQ [71, 72]. The figure 3.2 illustrates the concept of RREP using reverse path of RREQ to inform the source node. After receiving the RREP at S node, it transmits the data packets to the D node.

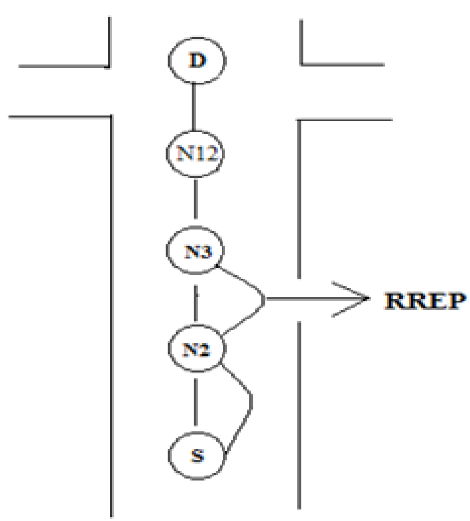


**Figure 3.2: Concept of RREP**

### 3.2.3. Route maintenance

If link fail between any two nodes then node selects another relay node for data. As shown in figure 3.3(a) the S node forward data using the path (N1-N2-D). If node N2 moves away then current route will fail. In this case the carrier node automatically selects the next relay node by looking up in its routing table. As shown in figure 3.3(b) if N2 move away then N1 select the N3 node for data communication because N1 node has information about the N3 node in its routing record. On the other hand AODV sends the path error message to the sender node about the route failure [72].

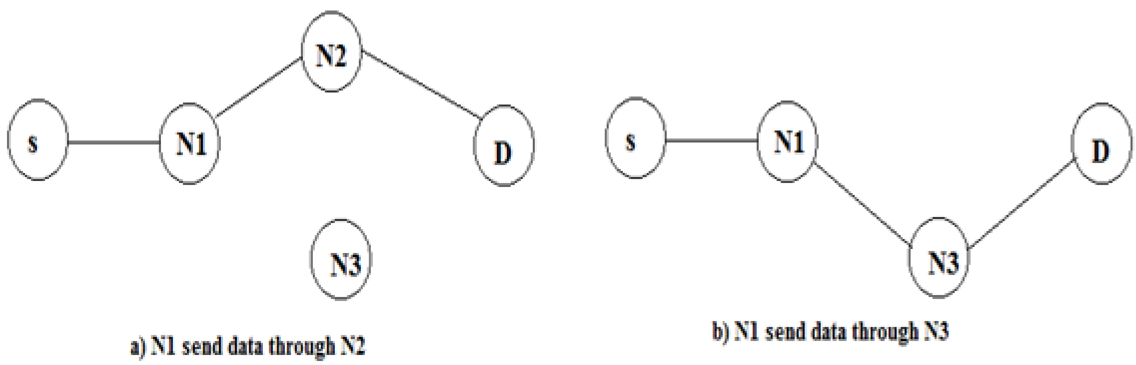


**Figure 3.3: Concept of other relay node for data delivery**

The RAODV routing method provides the top services and is a reactive routing protocol [56]. RAODV organized routing path whenever begin delivering the data packets, and it also developed run out time to maintain the path planning table. Thus, if any node moves away during run out time, the routing paths do not alter. If it finds a new shortest path for routing, an already developed path during run out time is used instead of using the shortest path. The RAODV do not maintains the routing table therefore it again sends a RREQ packet for path. But in DRP node do not broadcast the RREQ when any node moves its looks on the routing table.

**Algorithm 2**: Rote maintenance

1. If route exist from source node to target node:
2. S-Node = Use the same path for data delivery to the target node
3. Else
4. If any node moves and path break between source and target node then
5. S-node= looks up routing table for route and do not generate the REE packet for source node.

## 3.3 Relay node selection

The relay node selection depends on the different parameters distance, direction and speed of the node. The S node first checks these parameters then select a node as a relay for data delivery. Each hello message contains the information of nodes current speed and direction, so every node knows the speed and direction of its neighboring node up to 2-hops.

### 3.3.1 Distance

If any source node S wants to transmit data to target node D. It firstly checks the routing table for route to node D. If S has no entry for D in its routing table then RREQ packet is transmitted to the neighbors N1 and N2. These nodes also checks for route to D in their routing table and retransmit the RREQ to their neighboring nodes. Node N6 and N18 has the entry of D in their routing table so these nodes send RREP packets to their prospective nodes. The N2 is nearest to the node D with the help of relay nodes (N4, N5, N6, and N7) and RREP packet reached early at node S as compared to the RREP packet from the node N18. The green line indicated the shortest path for S node to the D node. The S node selects the shortest path for data delivery to D node. After some time when node N1 sends RREP to the S node it discarded the route but stores the information in its routing table. As in MANET nodes are constantly moving so when nodes in L1 street moves and there is no node for data delivery from S to D than L2 street is selected that is stored in routing table. So if we have multiple paths for S to D than all of these are stored in routing table for future communication. The selection of street is done on the number of nodes in the street for data delivery.

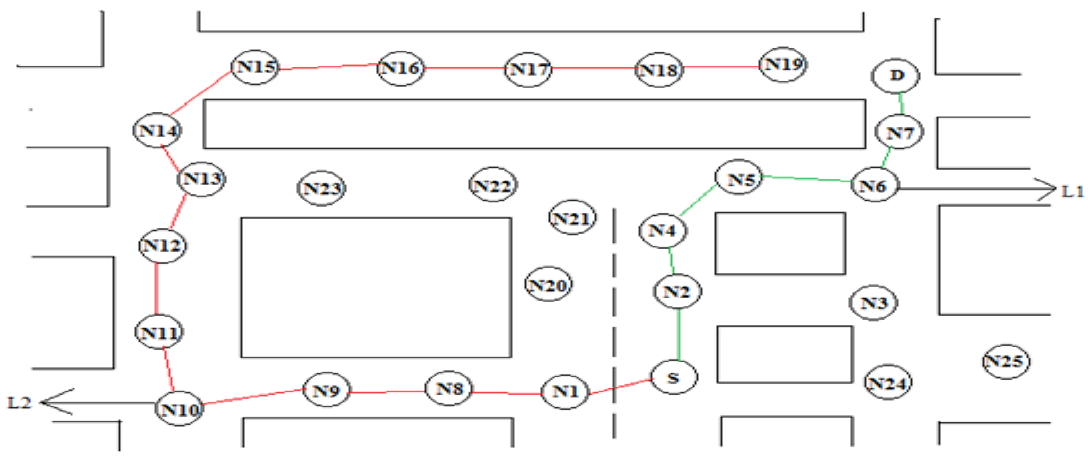


**Figure 3.4: Distance mechanism in DRP**

### 3.3.2 Direction and speed

Each node maintains a neighbor table in which direction and speed up to 2-hops neighboring nodes is recorded. This table is updated through periodically exchange of hello packets by all nodes. Thus, when a hello packet is received, the forwarding node computes the new position of every neighbor using the recorded information (newest known position and the direction).This technique is illustrated in figure 3.5, where N1 and N2 are moving in the same direction towards node D. N3 is moving in the direction opposite to node D. In this case N2 will receive the forwarded packet, as it is closest among the nodes moving towards the destination node D. However, without using direction information S would choose N3 as the next hop instead of N2 since it was the closest to the destination, but it is moving in opposite direction.

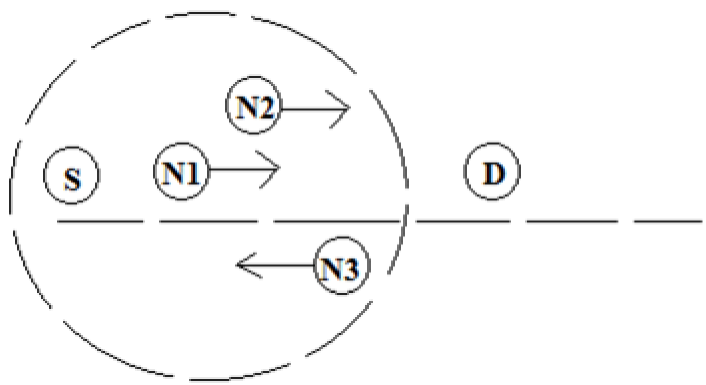


**Figure 3.5: Hello massages exchange**

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**Algorithm 3**: Speed and Direction

---

1. If A 2-hops tuple exists (Node A, Node B) with:
2. Speed and direction of (Node A ,Node B) is predicted using coordinates(x,y) then:
3. N-2hops- coordinates information = send packet of the 2-hops neighborhood to the node within range.

---

## 3.4 Recovery strategy

Despite the improved DRP routing strategy, the risk remains that a packet gets stuck in a local optimum. Hence, a recovery strategy is required. The repair strategy of DRP is based on the idea of "carry and forward”. The forwarding node in a recovery mode will carry the packet in two cases. In first case the forwarding node will carry the packet until it moves away from the path to destination D as shown in figure 3.6(a). In second case when forwarding node is moving away from the destination, it will carry the packet until, the next node with high speed and direction towards the destination is not found.

As shown in figure 3.6(b) N1 forwards the data packet to N2 because it is moving in direction of D.

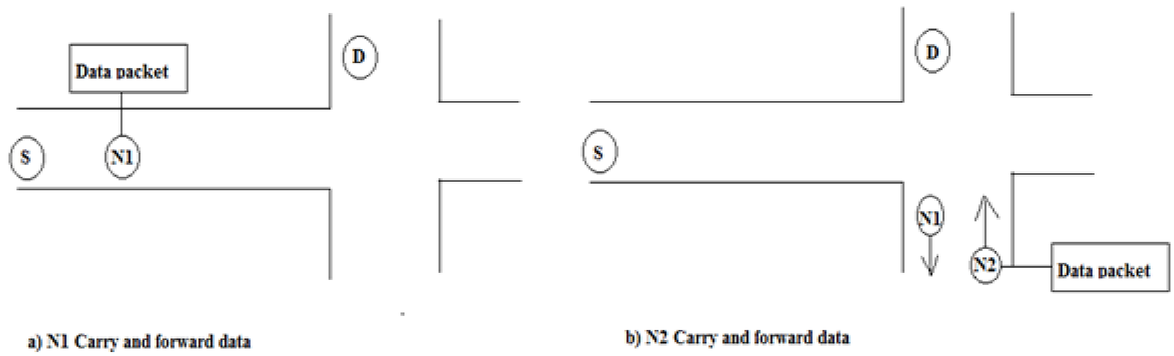


**Figure 3.6: Concept of carry and forward**

## 3.5 Comparison of DRP with other Enhanced AODV routing protocols

Different routing protocols use different approaches to achieve some common goals, such as reducing packet delivering latency and increasing through-put of the network. The main purpose of a routing protocol is to minimize end to end delay and increase the PDR from source to destination. A comparison of parameters is given between DRP and some other existing routing protocols in the table 3.1. DRP routing protocol performs better in different nodes mobility and route selection criteria on the basis of different parameters. But other routing protocols select the shortest route for data delivery. We compared DRP with AODV because we modified the AODV and present a new protocol named as DRP. It out performs as compared to based protocol AODV.

**Table 3.1: Comparison of DRP with other Enhanced routing protocols**

| Sr No. | Protocols | Type | Route Selection Criteria | Route Discovery | Nodes Mobility |
|---|---|---|---|---|---|
| 1 | MPRAODV | Reactive | Shortest path | Global | Fast |
| 2 | EN-RAODV | Reactive | Shortest path | Global | Slow |
| 3 | AODV-PA | Reactive | Shortest path | Global | Fast |
| 4 | MAODV | Reactive | Tree Based | Global | Slow |
| 5 | AODV-PA | Reactive | Shortest path | Global | Slow |
| 6 | DRP | Hybrid | Distance, Direction And Speed | Global And Local | Slow, Intermediate And Fast |

## 3.6 Summary

A novel Hybrid protocol is presented in this chapter called Dynamic Routing Protocol. It only contains the information of nodes up to 2-hops that are in its neighborhood range through proactive approach. Route discovery has two phases route request and route reply. It uses a relay node for NLOS communication. Relay node is selected on the basis of three parameters (distance, speed and direction) through exchange of hello messages. Its takes the advantage over AODV through route recovery mechanism. In route recovery mode node carry and forward the data packets. Node will not inform the sender node about the link failure where as in AODV route error message is send to the sender node, DRP enforces data delivery.

# Chapter 4

# Simulation and Evaluation

We evaluated DRP, AODV and DSR in NS-2.35. We have used simulations to compare the performance of DRP with AODV, DSR, under dynamic traffic loads. We have used gnuplot to represent results in the form of graphs.

## 4.1 Simulation

We have used Two Ray-Ground propagation model and simple LL link layer type. We have used cbr traffic for all experiments. We have used Manhattan Grid mobility model and sedest emulator in NS-2.35 directory to emulate random network scenarios. Cbrgen tool in NS-2.35 directory is used in order to emulate random cbr traffic events. Other simulation parameters are given in the Table 4.1.

**Table 4.1: Simulation parameters**

| Parameter | Value |
|---|---|
| Simulator | NS-2.35 |
| Number of nodes | 5,10,15,20,25,30,35,40,45,50 |
| Traffic type | CBR |
| Packet size | 512 kb |
| Bandwidth | 2 Mb/s |
| Media Access Control Layer | IEEE 802.11 |
| Transmission range | 250m |
| Model | Manhattan Grid Model |
| Protocols | AODV, DSR, DRP |
| Speed of Nodes | 5m/s-80m/s |

| | |
|---|---|
| Simulation Time | 100s |
| Model map size | 1000m by 1000m |

## 4.2 Simulation Environment

Simulations are a talent which is commonly use in the area of engineering science research. In this research work, simulation package NS 2.35 is use and carry out the necessary simulation to calculate the performance of DRP, AODV and DSR.We have used Manhattan grid mobility model scenarios to evaluate the performance of different routing protocols. We proposed a new routing protocol named DRP which uses relay node to reduce the effect of NLOS in hybrid networks. Manhattan gird model as explain by M.M Javadi [75] is used to reproduce the movement patterns of nodes on vertical and horizontal street define by map. The nodes freely move along the grid of vertical and horizontal street on the map therefore it's named Manhattan Grid Model. The node movements in Manhattan Grid Model show in figure 4.1.

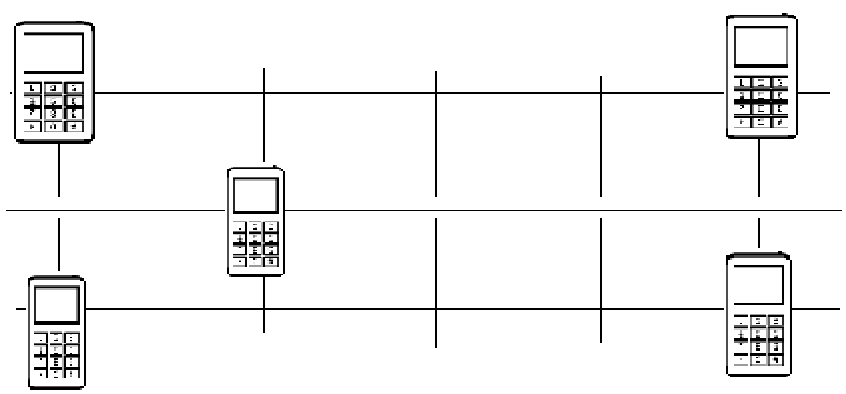

**Figure 4.1: Manhattan grid model**

We used 1000m by 1000m as simulation area. By using Manhattan Grid Model we create different number of nodes e.g 5, 10,15,20,30,35,40,45 and 50 with pause time of 0,25,35,55,75 and 95 seconds. Each node has minimum speed of 5m/s and maximum speed of 80m/s when moving across the streets. The nodes speed varies with the type of node e.g vehicular speed, walking speed and cyclic speed. Vehicular speed is between 70m/s to 80m/s, walking speed is between 5m/s to 10m/s and cyclic speed 20m/s to 40m/s. At the junction of a vertical and a horizontal streets, the nodes can turn right, head straight or left. The movement at the junction is probabilistic : probability of the turning left side is 0.25 , probability of the turning right side is 0.25 and probability of the moving nodes on the same streets is 0.5.

We have used different mobility scenario for Manhattan Grid Mobility Model by using the tool of BONNMOTION. Then these scenarios change in to the TCL scripts format for NS2. The following command shows an example of mobility scenario creates in Manhattan Grid Model.

bm -f manhattan1 Manhattan Grid -x 300 -y 300 -c 0.7 -e 6 -m 12 -o 80 -p 0.46 -t 0.25
-u 8-v 8-n 50 -d 350 -i 3500

**Table 4.2: Manhattan grid Parameters**

| Parameters | Use for |
|---|---|
| -v | no. of blocks along x-axis |
| -u | no. of blocks along x-axis |
| -c | speed change probability |
| -e | min. speed |
| -m | mean speed |
| -o | max. pause |
| -q | update distance |
| -t | turn probability |
| -p | pause probability |
| -s | speed standard deviation |
| -x,-y | Grid size |

## 4.3 Result Evaluation

The performance of DRP is compared with AODV and DSR graphically on the basis of different parameters e.g, number of nodes and packets size.

### 4.3.1 Packet Delivery Ratio

Figure 4.2 illustrate the average PDR attained by DRP, AODV and DSR with increasing the number of nodes from 5 to 50. The figure shows that PDR of DRP routing protocol increases with an increase in the number of nodes. We can observe that the performance of DSR and AODV reduce with an increase of number nodes as compare to DRP. AODV and DSR have sharp decline in average delivery ratio after increasing the number of nodes up to 10. The DRP achieved better PDR as compare to AODV and DSR because DRP is combination of proactive and reactive protocol that utilizes a relay node when the destination node is in NLOS. Results show that average PDR with DRP remains 99% on average indicating higher throughput with an increase in the number of nodes in the network. DRP has steady Packet delivery ratio with an increase in the number of nodes compared to AODV and DSR.

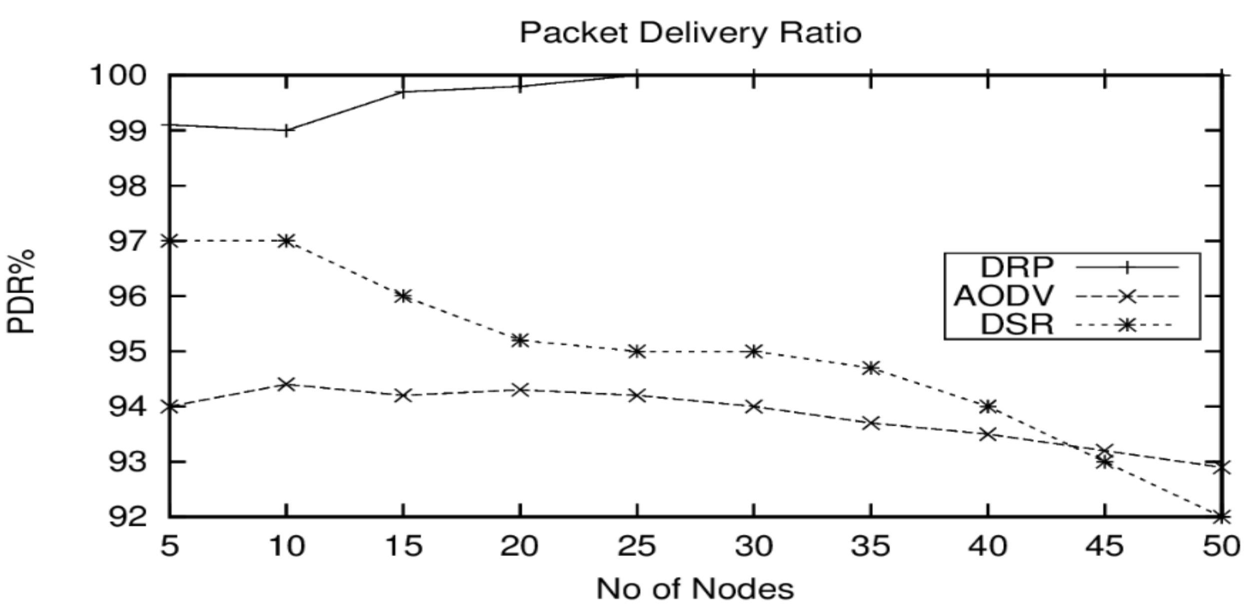


**Figure 4.2: Packet Delivery Ratio**

Table 4.3 shows Packet delivery ratio for different nodes. We see that when we increase the number of nodes then PDR increase in DRP as compared to AODV and DSR.

**Table 4.3: Packets delivery effectiveness**

| Parameter | No. of packets send [Bytes ] | | | No. of packets received [Bytes] | | |
|---|---|---|---|---|---|---|
| No. of nodes | AODV | DSR | Dynamic Routing Protocol | AODV | DSR | Dynamic Routing Protocol |
| 5 | 39424 | 40960 | 40448 | 38912 | 40860 | 40399 |
| 10 | 38912 | 38912 | 37376 | 38400 | 38400 | 37340 |
| 15 | 38912 | 38400 | 39936 | 38400 | 34816 | 39936 |
| 20 | 38912 | 39936 | 40960 | 38400 | 39424 | 40890 |
| 25 | 38912 | 38912 | 40448 | 38400 | 37376 | 39936 |
| 30 | 38912 | 37888 | 37888 | 38400 | 37688 | 37888 |
| 35 | 40960 | 40448 | 40448 | 38400 | 40348 | 40448 |
| 40 | 39936 | 40960 | 40960 | 39329 | 40860 | 40960 |
| 45 | 36864 | 38400 | 38400 | 36264 | 38200 | 38400 |
| 50 | 39936 | 40448 | 40448 | 39236 | 40248 | 40448 |

### 4.3.2 End-To-End Delay

Figure 4.3 illustrates that AODV and DRP achieves lower end to end delay as compare to DSR. When increas the mobile node speed then DSR suffers high delay, on the other hand DRP has lower end to end delay as compare to DSR and AODV. AODV has lower end to end delay as compare to DSR because periodic activities in AODV (HELLO messages exchange) and does not store the routes in cache. On-Demand source routing protocol is a DSR, the main cause for it have a larger End-to-End Delay. Where path is looked only when required and there is a path discovery mechanism happening each time and it also has to carry a large overhead every time. DRP less end to end delay because nodes carry data for D or next node. DRP not create RERR packet when link break it select another relay node for data delivery. But in DSR and AODV when link fail then create a RERR packet and send to S node for find new path to D.

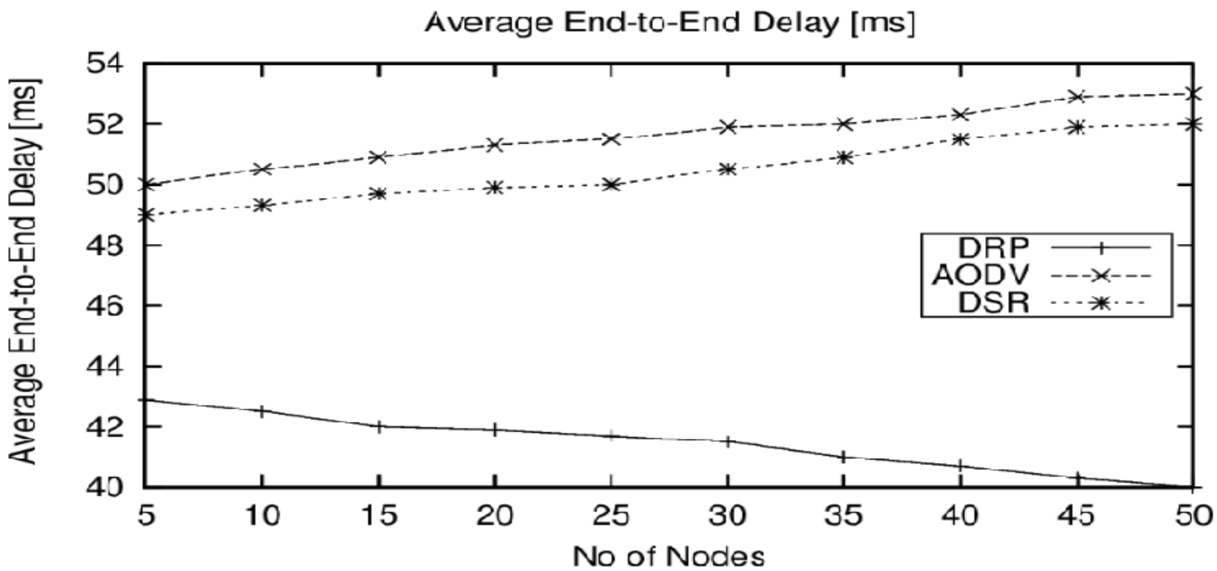


**Figure 4.3: Average End-to-End Delay**

## 4.3.3 Normalized Routing Overhead

Figure 4.4 illustrates that normalized routing overhead is greater in DRP as compare to DSR and AODV. The DRP is hybrid therefore use both techniques reactive and proactive. DSR and AODV are performing equally in terms of routing Overhead factor. Because both DSR and AODV are reactive protocols and only looked the routes when it required.

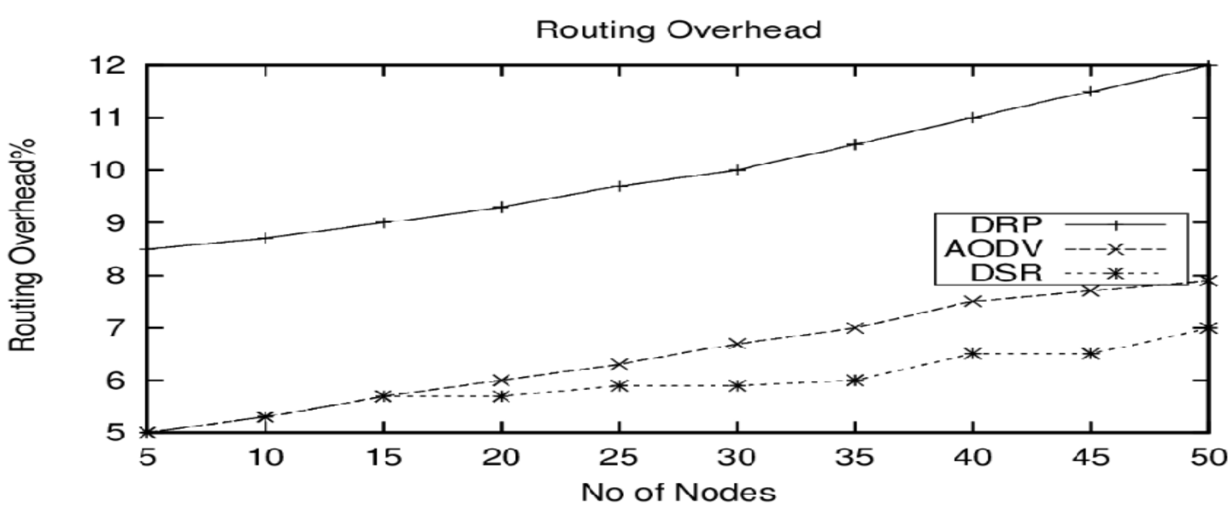


**Figure 4.4: Routing Overhead**

## 4.3.4 Throughput

Figure 4.5 shows that DRP has higher throughput as compare to AODV and DSR. AODV and DSR has more packets drop ratio as compare to DRP because DRP avoids freshness of routes and loops but DSR use stale route and do not use relay node when in NLOS.

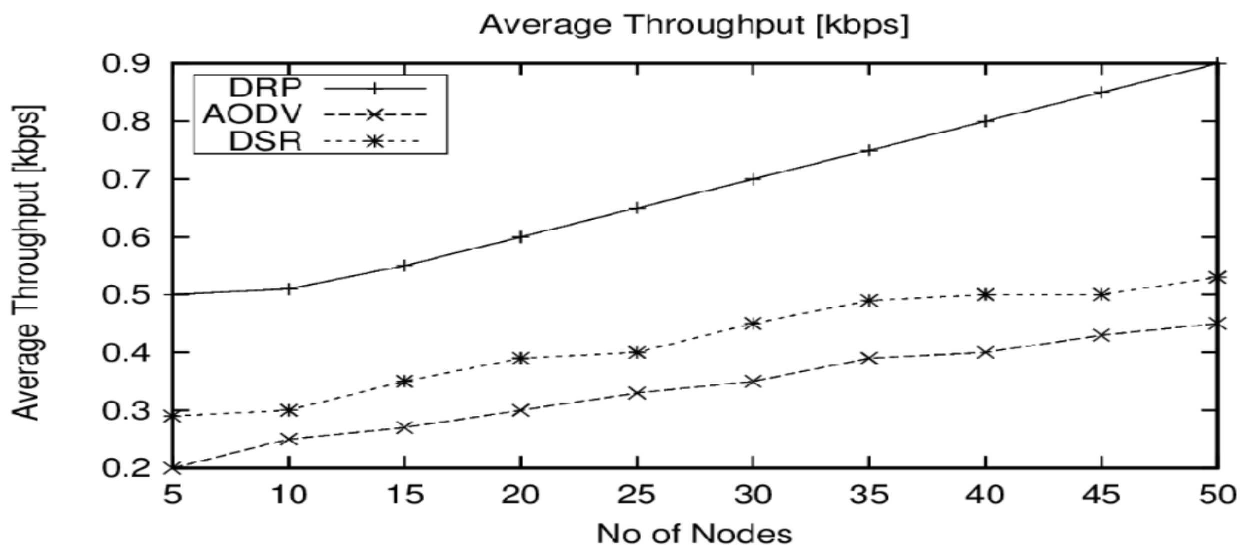


**Figure 4.5: Average Throughput**

## 4.4 Summary

Simulation environment and evaluation results are presented in this chapter. Simulation Parameters used in the experiments are given in Table 4.1. Performance of Dynamic Routing Protocol is evaluated in dynamic and wide range of traffic. Evaluation results show that Dynamic Routing Protocol outperforms AODV and DSR in dynamic network scenarios. Especially Dynamic Routing Protocol has higher PDR on multi-hop path. Results are quantized in the explanation of the graphs.

# Chapter 5

## Conclusion and Future work

MANET is normally used for urgent situation, such as military conflicts, natural disasters and different applications, with a better performance due to the quick operation and minimum configuration. Majority of routing protocols for path at the rate of improve in packet delivery ratio, which is not suitable for time critical applications.

In this thesis we have presented a new hybrid routing protocol called DRP. DRP uses relay node for data delivery when any node is not in range or NLOS in order to decrease the packet delivery ratio on multi-hop route. Moreover, DRP utilize metrics (direction, distance and speed) for selection of relay node. DRP enhances number of transmissions by maintain 2-hops neighborhood information in routing table.

We have simulated DRP for performance evaluation in Manhattan grid mobility model and we used heavy traffic loads to evaluate the performance of DRP. Evaluation of DRP through NS-2 simulator shows that DRP has low packet delivery ratio and it preserves more end to end delay, furthermore DRP has better packet delivery ratio as compared to AODV and DSR. Results show that DRP outperforms AODV and DSR in diverse networks, under wide range of traffic loads.

In future we will use fix relay node in the corner of streets or at any place for data delivery. The fix node is also connected with the internet and it maintains all information about nodes in that street. All fix nodes are connected and they can exchange the routing information with other relay nodes. If S node wants to send data to any destination node D which is not in rage of S and there are no other nodes in the street than S sends the address of D to the fixed rely node in range. The fix relay node has information about the D location and sends the whole route to S node.

# Bibliography


**[1].** A. K. Pandey, and H. Fujinoki. Study of MANET routing protocols by GloMoSim simulator. Intl of network management NT, Wiley InterScience 15:393–410, Intl. Journal Network Management 2005.

**[2].** S. Ali, and A. Ali. Performance analysis of AODV, DSR and OLSR in MANET. In Global telecommunications conference (GLOBECOM), pages 1-5, 2010.

**[3].** N. Qasim, F. Said, H. Aghvami. Mobile Ad-Hoc Networks Simulations Using Routing Protocols for Performance Comparisons. Proceedings of the World Congress on Engineering, Vol. 1, WCE 2008, UK, 2008.

**[4].** S. Ahmed, M. Bilal, U. Farooq, F. Hadi. Performance Analysis of various routing strategies in Mobile Ad-Hoc Network using QualNet simulator. Int. Conf. on Emerging Technologies, ICET, Islamabad, 2007.

**[5].** Haas, Zygmunt J., Pearlman, Marc R. A New Routing Protocol for the Reconfigurable Wireless Networks. Proc. of 6th IEEE Intl. Conf. on Universal Personal Comm., IEEE ICUPC_97, San Diego, California , USA, 1997.

**[6].** MoermanHoebeke and Demeester. An overview of mobile Ad-Hoc networks: applications and challenges, 2006.

**[7].** N Vetrivelan, and A.V. Reddy. Performance Analysis of three routing protocols for varying MANET size. Proceedings of International M. Conference of Eng. & Computer Scientists, Hong Kong, Vol. II IMECS 2008.

**[8].** V. D. Park, and M. S.Corson. A highly Adaptive Distributed Routing Algorithm for Mobile Wireless Networks. 16th IEEE Comp. and Comm. Societies. Proc, vol.3 pages 1405–1413, 1997.

**[9].** S.Bilal, F. Hadi , U.Farooq. Performance Analysis of various routing strategies in Mobile Ad-Hoc network using QualNet simulator. Int. Conf. on Emerging Technologies, 2007.

**[10].** San-Yuan Wang, Jia-Yu Liu, Chun-Chien Huang, Mao-Yuan Kao and Yi-Ho Li. signal Strength-based Routing Protocol for Mobile Ad-Hoc Networks. Proceedings of the 19$^{th}$ International Conference on Advance Information Networking and Applications, IEEE, 2005.

**[11].** Basu Dev Shivahare ,Charu Wahi , Shalini Shivhare. Comparison Of Proactive And Reactive Routing Protocols In Mobile Ad-Hoc network Using Routing Protocol Property. International Journal of Emerging Technology and Advanced Engineering (ISSN 2250-2459, Volume 2).

**[12].** Narendra Singh Yadav, R.P.Yadav. Performance Comparison and Analysis of Table-Driven and On-Demand Routing Protocols for Mobile Ad-Hoc networks. International Journal of Information Technology Volume 4 Number 2.

**[13].**Kaur, Robinpreet, and Mritunjay Kumar Rai. A Novel Review on Routing Protocols in MANET. Undergraduate Academic Research Journal (UARJ), ISSN (2012): 2278-1129.

**[14].** Royer, Elizabeth M., and Chai-KeongToh. A review of current routing protocols for Ad-Hoc mobile wireless networks. Personal Communications, IEEE 6, no. 2 (1999): 46-55.

**[15].**Gorantala, Krishna. Routing protocols in mobile ad-hoc networks. A Master'thesis in computer science, pp-1-36 (2006).

**[16].** C.E. Perkins and P. Bhagwat. Highly dynamic destination-sequenced distancevector routing (DSDV) for mobile computers. ACM SIGCOMM Computer Communication Review, 24(4):234–244, 1994.

**[17].** G.He. Destination-sequenced distance vector (DSDV) protocol. Technical report, Networking Laboratory, Helsinki University of Technology, Finland, 2002 .

**[18].** A. Boukerche and S.K. Das. Congestion control performance of R-DSDV protocol in multihop wireless ad hoc networks. Wireless Networks, 9(3):261– 270, 2003.

**[19].** K.U.R. Khan, R.U. Zaman, A.V. Reddy, K.A. Reddy, and T. Harsha. An Efficient DSDV Routing Protocol for Wireless Mobile Ad-Hoc networks and its Performance Comparison. In Proceedings of the 2nd UKSIM European Symposium on Computer Modeling and Simulation, pages 506–511, Liverpool, United kingdom, 2008.

**[20].** U. Lee, S.F. Midkiff, and J.S. Park. A proactive routing protocol for multichannel wireless Ad-Hoc networks (DSDV-MC). In Proceedings of IEEE International Conference on Information Technology: Coding and Computing (ITCC 2005), volume 2, pages 710–715, Las Vegas, NV, United states, 2005.

**[21].** T. Liu and K. Liu. Improvements on DSDV in mobile Ad-Hoc networks. In Proceedings of International Conference on Wireless Communications, Networking and Mobile Computing (WiCom 2007), pages 1637–1640, Shanghai, China.

**[22].** T.T. Luong, B.S. Lee, and C.K. Yeo. Dual-interface multiple channels dsdv protocol. In Proceedings of 5th IEEE International Conference on Wireless and Mobile Computing Networking and Communication, WiMob 2009, pages 104–109, Marrakech, Morocco, 2009.

**[23].** T.T. Luong, B.S. Lee, and C.K. Yeo. Channel allocation for multiple channels multiple interfaces communication in wireless ad hoc networks. In Proceedings of the 7th international IFIP-TC6 networking conference on AdHoc and sensor networks, pages 87–98, Singapore, May 2008.

**[24].** T. Wan, E. Kranakis, and P.C. van Oorschot. Securing the Destination- Sequenced Distance Vector Routing Protocol (S-DSDV). In Proceedings of the 6th International Conference on Information and Communications Security (ICICS04), volume 3269, pages 358–374, Malaga, Spain, 2004.

**[25].** S. Ahn and A.U. Shankar. Adapting to route-demand and mobility in Ad-Hoc network routing. Computer Networks, 38(6):745–764, 2002.

**[26].** S. Chang, W. Ting, and J. Chen. Method for Reducing Routing Overhead for Mobile Ad-Hoc Network. In Proceedings of IEEE International Conference on Wireless Communications and Signal Processing (WCSP 2010), Suzhou, China, 2010.

**[27].** U. Lee, S.F. Midkiff, and J.S. Park. A proactive routing protocol for multichannel wireless ad-hoc networks (DSDV-MC). In Proceedings of IEEE International Conference on Information Technology: Coding and Computing (ITCC 2005), volume 2, pages 710–715, Las Vegas, NV, United states, April 2005.

**[28].** S. Kumar, RK Rathy, and D. Pandey. OPR: DSDV Based New Proactive Routing Protocol for Ad-Hoc Networks. In International Association of Computer Science and Information Technology - Spring Conference (IACSIT-SC 2009), pages 204–207, Singapore, 2009.

**[29].** Miyahara, Hideo, and Taichi Yuki. A Study on Data Link Layer Control Methods for Performance Improvement of TCP over an Ad Hoc Network. International Conference on Wireless Communications, 2004.

**[30].** Tie, Tai Hieng, Chong Eng Tan, and Sei Ping Lau. Alternate link maximum energy level ad hoc distance vector scheme for energy efficient ad hoc networks routing. In Computer and Communication Engineering (ICCCE), 2010 International Conference on, pp. 1-6. IEEE, 2010.

**[31].** Gupta, Radha Rani, Mahendra Ku Mishra, and Manish Shrivastava. Energy Efficient Routing Protocol for Mobile Ad-Hoc networks based on AODV. International Journal of Information Technology Volume 7 Number 5.

**[32].** P. Jacquet, P. Muhlethaler, T. Clausen, A. Laouiti, A. Qayyum and L. Viennot. Optimized Link State Routing Protocol for Ad Hoc Networks. IEEE INMIC, pp. 62–68, Dec 2001, last accessed on Oct 2005.

**[33].** Y. Ge, T. Kunz, L. Lamont, .Proactive QoS Routing in Ad-Hoc Networks., The 2nd International Conference on Ad-Hoc networks and Wireless, Montreal, Canada, 2003.

**[34].** T. Clausen, P. Jacquet, L. Viennot,. Investigating the Impact of Partial Topology in Proactive MANET Routing Protocols. The 5th International Symposium on Wireless Personal Multimedia Communications, 2002.

**[35].** Bezad S, Fotohi R. Improvement over the OLSR Routing Protocol in Mobile Ad-Hoc networks by Eliminating the Unnecessary Loops. I.J. Information Technology and Computer Science, 2013, 06, 16-22.

**[36].** A. Munaretto et al. A Link-state QoS Routing Protocol for Ad-Hoc networks, In Proceedings of IEEE MWCN2002, 2002.

**[37].** K. Kunavut and T. Sanguankotchakorn. QoS-aware routing for mobile Ad-Hoc networks basedon multiple metrics: Connectivity Index (CI) and delay. in Proceedings of ECTICON2010, 2010, pp.46-50.

**[38].** G. Pei, M. Gerla, and T.W. Chen. Fisheye state routing in mobile ad hoc networks. In Proceedings of the 2000 ICDCS Workshop on Wireless Networks and Mobile Computing, pages D71–D78, Taiwan, 2000.

**[39].** G. Pei, M. Gerla, and T.W. Chen. Fisheye state routing: A routing scheme for Ad –Hoc wireless networks. In Proceedings of IEEE International Conference on Communications, volume 1, pages 70–74, New orleans, LA, USA, 2000.

**[40].** S. Nithya Rekha1, C. Chandrasekar and R. Kaniezhil. Efficient Routing Algorithm for MANET using Grid FSR. 2011 International Conference on Advancements in Information Technology With workshop of ICBMG 2011.

**[41].** Wang, Jianping, EseosaOsagie, ParimalaThulasiraman, and Ruppa K. Thulasiram. HOPNET: A hybrid ant colony optimization routing algorithm for mobile ad hoc network. Ad Hoc Networks 7, no. 4 (2009): 690-705.

**[42].** RupérezCañas, D., A. L. Sandoval Orozco, Luis Javier GarcíaVillalba, and P-S.Hong. Hybrid ACO Routing Protocol for Mobile Ad Hoc Networks. International Journal of Distributed Sensor Networks 2013.

**[43].** Taneja, Kavita, and R. B. Patel. Mobile Ad hoc Networks: Challenges and Future. In Proceedings National Conference on Challenges and Opportu-nities in Information Technology, RIMT-IET, MandiGobindgarh, pp. 133-135. 2007.

**[44].** C. Liu and J. Kaiser. A survey of mobile ad hoc network routing protocols. Technical report No. 2003-08, University of Magdeburg, Germany, 2005.

**[45]** Baby, Cisil, and S. Ranjitha2 Dr HN Suresh. A New Techniques for Power Aware Routing Algorithm for Mobile Ad Hoc Networks.

**[46]** Al-Maashri, Ahmed, and Mohamed Ould-Khaoua. Performance analysis of MANET routing protocols in the presence of self-similar traffic. In Local Computer Networks, Proceedings 2006 31st IEEE Conference on, pp. 801-807.IEEE, 2006.

**[47]** Prasanthi, Sanneboina, I. Balavenkateswarlu, and S. AmarnathBabu. Implementing ODMRP (on Demand Multicast Routing Protocol) in Mantes Using Stable Link Approach.

**[48].** D.B. Johnson, D.A. Maltz, J. Broch, et al. DSR: The dynamic source routing protocol for multi-hop wireless ad hoc networks. Ad hoc networking, 5:139– 172, 2001.

**[49].** Sourish Mitra, Mounita Das, Rupa Mitra, Priyanka Maity, Alolika Banerjee. Route maintenance and Scalability improvement of DSR, based on Relay node identification after locating Link-failure over MANET. IOSR Journal of Computer Engineering (IOSR-JCE) Volume 16, Issue 3, Ver. III (2014), PP 21-27.

**[50].** Sharmin Sultana, Salma Begum, Nazma Tara. Enhanced-DSR: A New Approach to Improve Performance of DSR Algorithm. International Journal of Computer Science and Information Technology, Volume 2, Number 2, 2010.

**[51].** Abdullah Gani, Qi Han, Nor Badrul Anuar. Enhancing DSR Protocol Performance in Mobile Ad-Hoc network Using ACK Reply. International Journal of Computer Science and Information Technology.

**[52].** G. Pei, M. Gerla, and T.W. Chen. Fisheye state routing: A routing scheme for ad hoc wireless networks. In Proceedings of IEEE International Conference on Communications, volume 1, pages 70–74, New orleans, LA, USA, 2000.

**[53].** C. Perkins, E. Belding-Royer, and S. Das. RFC3561: Ad hoc on-demand distance vector (AODV) routing. July 2003.

**[54].** C.E. Perkins and E.M. Royer. Ad-Hoc on-demand distance vector routing. In proceedings of 2nd IEEE Workshop on Mobile Computing Systems and Applications (WMCSA'99), pages 90–100, New Orleans, LA, United states, 1999.

**[55].** Assistant Professor., Vivekanandha College of Arts and Sciences for Women, Triuchengodu. An Overview of Multi Point Relay AODV in Mobile Ad hoc Network. International Journal of Technology And Engineering System(IJTES): 2011- Vol2.No1.

**[56].** M. Sanabani, R. Alsaqour2 and S. Kurkushi. A reverse and enhanced aodv routing protocol for manets. ARPN Journal of Engineering and Applied Sciences VOL. 9, NO. 2, 2014.

**[57].** Sumit Gwalani Elizabeth M. Belding-Royer. AODV-PA: AODV with Path Accumulation. In Proceedings of IEEE International Conference on Communications.

**[58].** Sridhar Subramanian and Baskaran Ramachandran " Trust Based Scheme for QoS Assurance in Mobile Ad-Hoc Networks" International Journal of Computer Science and Information Technology.

**[59]** J. Macker, I. Downard, J. Dean, and B. Adamson. Evaluation of distributed cover set algorithms in mobile ad hoc network for simplified multicast forwarding. SIGMOBILE Mob. Comput. Commun. Rev., vol. 11, no. 3, pp. 1–11, 2007.

**[60].** P. Wannawilai, C. Sathitwiriyawong. AODV with Sufficient Bandwidth AwareRouting Protocol. IWCMC'10: Proceedings of the 6th International Wireless Communications and Mobile Computing Conference, pg 281-285.

**[61].** Anuj K. Gupta, Member, IACSIT, Dr. Harsh Sadawarti, Dr. Anil K. Verma. Performance analysis of AODV, DSR & TORA Routing Protocols. IACSIT International Journal of Engineering and Technology, Vol.2, No.2, 2010.

**[62].** Mittal, Shaily, and PrabhjotKaur. Performance Comparison of AODV, DSR and ZRP Routing Protocols in MANET.In Advances in Computing, Control, & Telecommunication Technologies, 2009.ACT'09. International Conference on, pp. 165-168. IEEE, 2009.

**[63].** Tseng, Yu-Chee, and Chih-Sun Hsu. Location-aware routing and applications of mobile Ad-Hoc networks. In The handbook of ad hoc wireless networks, pp. 315-327. CRC Press, Inc., 2003.

**[64].** Broustis, Ioannis, Gentian Jakllari, Thomas Repantis, and Mart Molle. A performance comparison of routing protocols for large-scale wireless mobile Ad Hoc networks. In IEEE International Workshop on Wireless Ad Hoc and Sensor Networks (in conjunction with SECON), New York, USA. 2006.

**[65].** Anup Kumar Sahu, Jajati Mallick, Chinmayee Behera ZMRP: A Performance Analysis of Zone Multicast Routing Protocol in MANETs. International Journal of Computer Applications (0975 – 8887) International Conference on Microelectronics, Circuits and Systems (MICRO-2014).

**[66].** M.N Sree Ranga Raju , Dr. Jitendranath Mungara Ph.D. Enhanced ZRP Protocol for Mobile Ad-hoc Networks. International Journal of Wireless & Mobile Networks (IJWMN) Vol. 3, No. 4, 2011.

**[67].** P. Dhivya,R.M. Bhavadharini,Dr. T. Kalaikumaran. Weight Based Inter Zone Routing Protocol in MANET. ustralian Journal of Basic and Applied Sciences, 8(9) Pages: 418-421, 2014 .

**[68].** TiguianeY el emouxz, Philippe Meseure x, Anne-Marie Poussardx. Improving ZRP performance by taking into account quality of links. 2012 IEEE wireless communication and networking conference Mobile and Wireless Networks.

**[70].** Rahman, M.A. ; Dept. of ECE, Int. Islamic Univ. Malaysia (IIUM), Kula Lumpur, Malaysia. A simulation based performance comparison of routing protocol on Mobile Ad-Hoc network (proactive, reactive and hybrid). Computer and Communication Engineering (ICCCE), 2010 International Conference, IEEE 2010.

**[72].** Hua Yang ; Dept. of Inf. Eng., Guilin Coll. of Aerosp. Technol., Guilin, China ; Zhi-yuan Li. Simulation and analysis of a modified AODV routing protocols. Computer Science and Network Technology (ICCSNT), 2011 International Conference, IEEE 2011.

**[73].** Yang Hua ; Dept. of Inf. Eng., Guilin Coll. of Aerosp. Technol., Guilin, China ; Li Zhiyuan. Simulation and analysis of a stability reverse AODV routing protocol. Consumer Electronics, Communications and Networks (CECNet), 2012 2nd International Conference,IEEE.

**[74].** Sari, R.F. ; Dept. of Electr. Eng., Indonesia Univ., Depok, Indonesia ; Syarif, A. ; Ramli, K. ; Budiardjo, B. Performance evaluation AODV routing protocol on ad hoc hybrid network testbed using PDAs. Networks, 2005. Jointly held with the 2005 IEEE 7th Malaysia International Conference on Communication., 2005 13th IEEE International Conference on (Volume:1 ).

**[75].** M. M. Javadi, Mobility Simulator Manhattan, Available at: http://www.masoudmoshref.com/old/myworks/documentpages/mobisim/manhattan.html, 2007.

# Appendix

```
# ==========================================================================
# Define options
# ============================================================================
set opt(chan) Channel/WirelessChannel
set opt(prop) Propagation/TwoRayGround
set opt(netif) Phy/WirelessPhy
set opt(mac)  Mac/802_11
#set opt(ifq)  Queue/DropTail/PriQueue
set opt(ifq)    CMUPriQueue
set opt(ll)             LL
set opt(ant)       Antenna/OmniAntenna
set opt(x)              780   ;# X dimension of the topography
set opt(y)              780   ;# Y dimension of the topography
set opt(ifqlen)         50          ;# max packet in ifq
set opt(seed) 0.0
set opt(tr)             dsr-25-0-5.tr    ;# trace file
set opt(adhocRouting)   AODV
set opt(rpr)    1        ;#1 for DSR and anything else for AODV
set opt(nn)             50        ;# how many nodes are simulated
set opt(scen)           "scen-25-5"
set opt(tfc)            "cbr-25-50"
set opt(stop)           100.0           ;# simulation time

# ============================================================================
# Main Program
# ============================================================================

if { $argc != 8 } {
      puts "Wrong no. of cmdline args."
         puts "Usage: ns compare.tcl -scen <scen> -tfc <tfc> -tr <tr> -rpr <rpr>"
      exit 0
}


# proc getopt {argc argv} {

      for {set i 0} {$i < $argc} {incr i} {
            set arg [lindex $argv $i]
            if {[string range $arg 0 0] != "-"} continue
```

```
            set name [string range $arg 1 end]
#                   puts $name
            set opt($name) [lindex $argv [expr $i+1]]
      }
         set opt(scen) [lindex $argv 1]
         set opt(tfc) [lindex $argv 3]

      if {$opt(rpr) == 1} {
         set opt(adhocRouting)   DSR
         set opt(ifq)    CMUPriQueue
#        set opt(ifq)    Queue/DropTail/PriQueue
      } else {
         set opt(adhocRouting)   AODV
         set opt(ifq) Queue/DropTail/PriQueue
      }

#        set val(mov) $opt(scen)
#        set val(traf) $opt(tfc)
#        set opt(trace) $opt(tr)

         puts $opt(scen)
         puts $opt(tfc)
         puts $opt(tr)
# }


# getopt $argc $argv


         puts $opt(adhocRouting)
#        puts $val(mov)
#        puts $val(traf)
#        puts $opt(trace)

# Initialize Global Variables
# create simulator instance
set ns_                  [new Simulator]
$ns_ use-scheduler Heap
```

```
Antenna/OmniAntenna set X_ 0
Antenna/OmniAntenna set Y_ 0
Antenna/OmniAntenna set Z_ 1.5
Antenna/OmniAntenna set Gt_ 1.0
Antenna/OmniAntenna set Gr_ 1.0

Phy/WirelessPhy set CPThresh_ 10.0
Phy/WirelessPhy set CSThresh_ 3.162e-12
Phy/WirelessPhy set RXThresh_ 3.16269e-12
Phy/WirelessPhy set bandwidth_ 2e6
Phy/WirelessPhy set Pt_ 0.07214
Propagation/Shadowing set pathlossExp_ 2.7;
Propagation/Shadowing set std_db_ 4.0;
Propagation/Shadowing set dist0_ 1.0;
Propagation/Shadowing set seed_ 0;

Phy/WirelessPhy set freq_ 2412e+6
Phy/WirelessPhy set L_ 1.0

# set wireless channel, radio-model and topography objects
set wtopo      [new Topography]

# create trace object for ns and nam
set tracefd     [open $opt(tr) w]
$ns_ trace-all $tracefd
# use new trace file format
$ns_ use-newtrace

# define topology
$wtopo load_flatgrid $opt(x) $opt(y)

# Create God
set god_ [create-god $opt(nn)]

#set chan_1_ [new $opt(chan)]
#set chan_2_ [new $opt(chan)]

# define how node should be created
#global node setting
$ns_ node-config -adhocRouting $opt(adhocRouting) \
```

```
                    -llType $opt(ll) \
                    -macType $opt(mac) \
                    -ifqType $opt(ifq) \
                    -ifqLen $opt(ifqlen) \
                    -antType $opt(ant) \
                    -propType $opt(prop) \
                    -phyType $opt(netif) \
                    -channelType $opt(chan) \
                    -topoInstance $wtopo \
                    -agentTrace ON \
               -routerTrace ON \
               -macTrace ON \
               -phyTrace ON \
               -movementTrace ON
#         -channel $chan_1_

#  Create the specified number of nodes [$opt(nn)] and "attach" them
#  to the channel.
for {set i 0} {$i < $opt(nn) } {incr i} {
          set node_($i) [$ns_ node]
          $node_($i) random-motion 0                    ;# disable random motion
}

#for {set i 0} {$i < 10} {incr i} {
 #   set a($i) [new Agent/MessagePassing/Flooding]
  #  $n($i) attach  $a($i) $MESSAGE_PORT
   # $a($i) set messages_seen {}

    #set if_($i) [$n($i) set netif_(0)]

#}

#for {set i 0} {$node_($i) < 10} {incr i} {

 #  if {$node_($i) < 5} {
  #$if_($node_($i)) set Pt_0.02818
  #} else {
 #$if_($node_($i)) set Pt_0.00316
 #}
#}
```

```
# Define node movement model
puts "Loading connection pattern..."
source $opt(scen)

# Define traffic model
puts "Loading traffic file..."
source $opt(tfc)

# Define node initial position in nam
for {set i 0} {$i < $opt(nn)} {incr i} {

    # 20 defines the node size in nam, must adjust it according to your scenario
    # The function must be called after mobility model is defined
   $ns_ initial_node_pos $node_($i) 20
}

# Tell nodes when the simulation ends
for {set i 0} {$i < $opt(nn) } {incr i} {
    $ns_ at $opt(stop).000000001 "$node_($i) reset";
}

# tell nam the simulation stop time
#$ns_ at  $opt(stop) "$ns_ nam-end-wireless $opt(stop)"
$ns_ at  $opt(stop).000000001 "puts \"NS EXITING...\" ; $ns_ halt"
puts "Starting Simulation..."
$ns_ run
```