SIMULATION AND COMPARISON OF AODV AND DSR ROUTING PROTOCOLS IN MANETs

Thesis submitted in partial fulfillment of the requirements for the award of degree of

Master of Engineering

in

Computer Science & Engineering

By:
VIVEK KUMAR
(80732026)

Under the supervision of:
Mr. SUMIT MIGLANI
(Lecturer)

COMPUTER SCIENCE AND ENGINEERING DEPARTMENT
THAPAR UNIVERSITY
PATIALA – 147004

JULY 2009

Certificate

I hereby certify that the work which is being presented in the thesis entitled, **"Simulation and Comparison of AODV and DSR Routing Protocols in MANETs"**, in partial fulfillment of the requirements for the award of degree of Master of Engineering in Computer Science & Engineering submitted in Computer Science and Engineering Department of Thapar University, Patiala, is an authentic record of my own work carried out under the supervision of ***Mr. Sumit Miglani*** and refers other researcher's works which are duly listed in the reference section.

The matter presented in this thesis has not been submitted for the award of any other degree of this or any other university.

(Vivek Kumar)

This is to certify that the above statement made by the candidate is correct and true to the best of my knowledge.

(Mr. Sumit Miglani)
Lecturer
Computer Science and Engineering Department
Thapar University, Patiala

Countersigned by:

(Head) 14/07/09
Computer Science & Engineering Department
Thapar University,
Patiala

(R.K.SHARMA) 15/7/09
Dean (Academic Affairs)
Thapar University,
Patiala

Acknowledgement

No volume of words is enough to express my gratitude towards my guide, ***Mr. Sumit Miglani***, Lecturer, Computer Science and Engineering Department, Thapar University, who have been very concerned and have aided for all the material essential for the preparation of this seminar report. They helped me to explore this vast topic in an organized manner and provided me with all the ideas on how to work towards a research-oriented venture.

I am also thankful to ***Dr. Rajesh Bhatia***, Assistant Professor & Head Department of Computer Science and engineering, ***Dr. (Mrs.) Seema Bawa,*** Professor and ***Ms. Inderveer Channa***, P.G. Coordinator, for the motivation and inspiration that triggered me for the seminar work.

I would like to say a special thanks to ***Dr. Anil Kumar Verma,*** Assistant Professor, Computer Science and Engineering Department, for providing me required help for the completion of work.

I would also like to thank the staff members and my colleagues who were always there in the need of the hour and provided with all the help and facilities, which I required, for the completion of my seminar.

Most importantly, I would like to thank my parents and the Almighty for showing me the right direction out of the blue, to help me stay calm in the oddest of the times and keep moving even at times when there was no hope.

(Vivek Kumar)
80732026

Abstract

Mobile ad hoc network (MANET) is an autonomous system of mobile nodes connected by wireless links. Each node operates not only as an end system, but also as a router to forward packets. The nodes are free to move about and organize themselves into a network. These nodes change position frequently. The main classes of routing protocols are Proactive, Reactive and Hybrid.

A Reactive (on-demand) routing strategy is a popular routing category for wireless ad hoc routing. It is a relatively new routing philosophy that provides a scalable solution to relatively large network topologies. The design follows the idea that each node tries to reduce routing overhead by sending routing packets whenever a communication is requested.

In this work an attempt has been made to compare the performance of two prominent on-demand reactive routing protocols for MANETs:- Ad hoc On Demand Distance Vector (AODV), Dynamic Source Routing (DSR) protocols. DSR and AODV is a reactive gateway discovery algorithms where a mobile device of MANET connects by gateway only when it is needed. As per our findings the differences in the protocol mechanics lead to significant performance differentials for both of these protocols.

The performance differentials are analyzed using varying simulation time. These simulations are carried out using the ns-2 network simulator. The results presented in this work illustrate the importance in carefully evaluating and implementing routing protocols in an ad hoc environment.

Keywords: MANETS, AODV, DSR.

Table of Contents

List of Figures

List of Tables

Chapter 1
Introduction

1.1 Introduction

Wireless cellular systems have been in use since 1980s. We have seen their evolutions to first, second and third generation's wireless systems. These systems work with the support of a centralized supporting structure such as an access point. The wireless users can be connected with the wireless system by the help of these access points, when they roam from one place to the other.

The adaptability of wireless systems is limited by the presence of a fixed supporting coordinate. It means that the technology can not work efficiently in that places where there is no permanent infrastructure. Easy and fast deployment of wireless networks will be expected by the future generation wireless systems. This fast network deployment is not possible with the existing structure of present wireless systems.

Recent advancements such as Bluetooth introduced a fresh type of wireless systems which is frequently known as mobile ad-hoc networks. Mobile ad-hoc networks or "short live" networks control in the nonexistence of permanent infrastructure. Mobile ad hoc network offers quick and horizontal network deployment in conditions where it is not possible otherwise. Ad-hoc is a Latin word, which means "for this or for this only." Mobile ad hoc network is an autonomous system of mobile nodes connected by wireless links; each node operates as an end system and a router for all other nodes in the network.

A wireless network is a growing new technology that will allow users to access services and information electronically, irrespective of their geographic position. Wireless networks can be classified in two types: - infrastructured network and infrastructure less (ad hoc) networks. Infrastructured network consists of a network with fixed and wired gateways. A mobile host interacts with a bridge in the network (called base station) within its communication radius. The mobile unit can move geographically while it is communicating. When it goes out of range of one base station, it connects with new base station and starts communicating through it. This is called handoff. In this approach the base stations are fixed.

A Mobile ad hoc network is a group of wireless mobile computers (or nodes); in which nodes collaborate by forwarding packets for each other to allow them to communicate outside range of direct wireless transmission. Ad hoc networks require no centralized administration or fixed network infrastructure such as base stations or access points, and can be quickly and inexpensively set up as needed [4].

A MANET is an autonomous group of mobile users that communicate over reasonably slow wireless links. The network topology may vary rapidly and unpredictably over time, because the nodes are mobile. The network is decentralized, where all network activity, including discovering the topology and delivering messages must be executed by the nodes themselves. Hence routing functionality will have to be incorporated into the mobile nodes.

MANET is a kind of wireless ad-hoc network and it is a self-configuring network of mobile routers (and associated hosts) connected by wireless links – the union of which forms an arbitrary topology. The routers, the participating nodes act as router, are free to move randomly and manage themselves arbitrarily; thus, the network's wireless topology may change rapidly and unpredictably. Such a network may operate in a standalone fashion, or may be connected to the larger Internet [1].

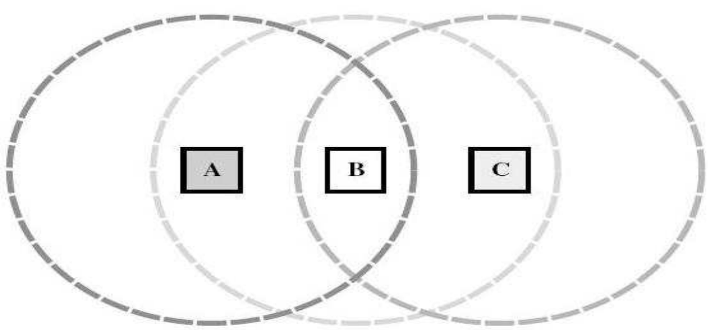


Figure 1.1 Example of a simple ad-hoc network with three participating nodes

Mobile ad hoc network is a collection of independent mobile nodes that can communicate to each other via radio waves. The mobile nodes can directly communicate to those nodes that are in radio range of each other, whereas others nodes need the help of intermediate nodes to route their packets. These networks are fully distributed, and can work at any place without the aid of any infrastructure. This property makes these networks highly robust.

In Figure 1.1 nodes A and C must discover the route through B in order to communicate. The circles indicate the nominal range of each node’s radio transceiver. Nodes A and C are not in direct transmission range of each other, since A’s circle does not cover C [1].

1.2 Characteristics of MANET

Mobile ad hoc network nodes are furnished with wireless transmitters and receivers using antennas, which may be highly directional (point-to-point), omnidirectional (broadcast), probably steerable, or some combination there of [1]. At a given point in time, depending on positions of nodes, their transmitter and receiver coverage patterns, communication power levels and co-channel interference levels, a wireless connectivity in the form of a random, multihop graph or "ad hoc" network exists among the nodes. This ad hoc topology may modify with time as the nodes move or adjust their transmission and reception parameters.

The characteristics of these networks are summarized as follows:

- Communication via wireless means.
- Nodes can perform the roles of both hosts and routers.
- Bandwidth-constrained, variable capacity links.
- Energy-constrained Operation.
- Limited Physical Security.
- Dynamic network topology.
- Frequent routing updates.

1.3 Advantages of MANET

The following are the advantages of MANET:

- They provide access to information and services regardless of geographic position.

- These networks can be set up at any place and time.

1.4 Disadvantages of MANET

Some of the disadvantages of MANETs are as follows:

- Limited resources and physical security.
- Intrinsic mutual trust vulnerable to attacks.
- Lack of authorization facilities.
- Volatile network topology makes it hard to detect malicious nodes.
- Security protocols for wired networks cannot work for ad hoc networks.

1.5 Applications of MANET

Some of the applications of MANETs are as follows:

- Military or police exercises.
- Disaster relief operations.
- Mine cite operations.
- Urgent Business meetings.

1.6 Related work

Many routing protocols have been proposed, but few comparisons between the different protocols have been made. Of the work that has been done in this field, only the work done by the Monarch1 project at Carnegie Mellon University (CMU) [32] has compared some of the different proposed routing protocols and evaluated them based on the same quantitative metrics. The result was presented in the article -“A performance comparison of multi-hop ad hoc wireless network routing protocols” [13] [26] that were released in the foundation of October 1998. There exist some other simulation results that have been done on individual protocols. These simulations have however not used the same metrics and are therefore not comparable with each other.

1.7 Organization of Thesis

This thesis consists of 7 chapters and these chapters are organized as follows:

Chapter 1 and Chapter 2 explain the concept of ad-hoc networks and routing in general. Chapter 3 describes and analyzes the different routing protocols, mainly AODV and DSR. Chapter 4 presents problem statement that could analyses the problem statement that we are going deal. Chapters 5 describe the simulator and the scenarios that were considered. Chapters 6 describe results and finally Chapter 7 concludes the report by describing various observations and scope of future work.

Chapter 2
Routing Protocols

2.1 Routing

Routing is the act of moving information from a source to a destination in an internetwork. At least one intermediate node within the internetwork is encountered during the transfer of information. Basically two activities are involved in this concept: determining optimal routing paths and transferring the packets through an internetwork. The transferring of packets through an internetwork is called as packet switching which is straight forward, and the path determination could be very complex.

Routing protocols use several metrics as a standard measurement to calculate the best path for routing the packets to its destination that could be number of hops, which are used by the routing algorithm to determine the optimal path for the packet to its destination. The process of path determination is that, routing algorithms find out and maintain routing tables, which contain the total route information for the packet. The information of route varies from one routing algorithm to another. The routing tables are filled with entries in the routing table are ip-address prefix and the next hop. Destination/next hop associations of routing table tell the router that a particular destination can be reached optimally by sending the packet to a router representing the "next hop" on its way to the final destination and ip-address prefix specifies a set of destinations for which the routing entry is valid.

Routing is mainly classified into static routing and dynamic routing. Static routing refers to the routing strategy being stated manually or statically, in the router. Static routing maintains a routing table usually written by a networks administrator. The routing table doesn't depend on the state of the network status, i.e., whether the destination is active or not [3]. Dynamic routing refers to the routing strategy that is being learnt by an interior or exterior routing protocol. This routing primarily depends on the state of the network i.e., the routing table is affected by the activeness of the destination.

2.2 Routing in Mobile Ad hoc Networks

Mobile Ad-hoc networks are self-organizing and self-configuring multihop wireless networks, where the structure of the network changes dynamically. This is mainly due to the mobility of the nodes [3]. Nodes in these networks utilize the same random access wireless channel, cooperating in an intimate manner to engaging themselves in multihop forwarding. The node in the network not only acts as hosts but also as routers that route data to/from other nodes in network [6]. In mobile ad-hoc networks there is no infrastructure support as is the case with wireless networks, and since a destination node might be out of range of a source node transferring packets; so there is need of a routing procedure. This is always ready to find a path so as to forward the packets appropriately between the source and the destination. Within a cell, a base station can reach all mobile nodes without routing via broadcast in common wireless networks. In the case of ad-hoc networks, each node must be able to forward data for other nodes. This creates additional problems along with the problems of dynamic topology which is unpredictable connectivity changes [8].

2.3 Properties of Ad-Hoc Routing protocols

The properties that are desirable in Ad-Hoc Routing protocols are [4]:

i). **Distributed operation:** The protocol should be distributed. It should not be dependent on a centralized controlling node. This is the case even for stationary networks. The dissimilarity is that the nodes in an ad-hoc network can enter or leave the network very easily and because of mobility the network can be partitioned.

ii). **Loop free:** To improve the overall performance, the routing protocol should assurance that the routes supplied are loop free. This avoids any misuse of bandwidth or CPU consumption.

iii). **Demand based operation:** To minimize the control overhead in the network and thus not misuse the network resources the protocol should be reactive. This means that the protocol should react only when needed and should not periodically broadcast control information.

iv). **Unidirectional link support:** The radio environment can cause the formation of unidirectional links. Utilization of these links and not only the bi-directional links improves the routing protocol performance.

v). **Security:** The radio environment is especially vulnerable to impersonation attacks so to ensure the wanted behavior of the routing protocol we need some sort of security measures. Authentication and encryption is the way to go and problem here lies within distributing the keys among the nodes in the ad-hoc network.

vi). **Power conservation:** The nodes in the ad-hoc network can be laptops and thin clients such as PDA's that are limited in battery power and therefore uses some standby mode to save the power. It is therefore very important that the routing protocol has support for these sleep modes.

vii). **Multiple routes:** To reduce the number of reactions to topological changes and congestion multiple routes can be used. If one route becomes invalid, it is possible that another stored route could still be valid and thus saving the routing protocol from initiating another route discovery procedure.

viii). **Quality of Service Support:** Some sort of Quality of service is necessary to incorporate into the routing protocol. This helps to find what these networks will be used for. It could be for instance real time traffic support.

2.4 Problems in routing with Mobile Ad hoc Networks

i). **Asymmetric links:** Most of the wired networks rely on the symmetric links which are always fixed. But this is not a case with ad-hoc networks as the nodes are mobile and constantly changing their position within network

ii). **Routing Overhead:** In wireless ad hoc networks, nodes often change their location within network. So, some stale routes are generated in the routing table which leads to unnecessary routing overhead.

iii). **Interference:** This is the major problem with mobile ad-hoc networks as links come and go depending on the transmission characteristics, one transmission might interfere with another one and node might overhear transmissions of other nodes and can corrupt the total transmission.

iv). **Dynamic Topology:** Since the topology is not constant; so the mobile node might move or medium characteristics might change. In ad-hoc networks, routing tables must somehow reflect these changes in topology and routing algorithms have to be adapted. For example in a fixed network routing table updating takes place for every 30sec. This updating frequency might be very low for ad-hoc networks.

2.5 Classification of Routing Protocols

Classification of routing protocols in mobile ad hoc network can be done in many ways, but most of these are done depending on routing strategy and network structure [2] [3] [10]. The routing protocols can be categorized as flat routing, hierarchical routing and geographic position assisted routing while depending on the network structure. According to the routing strategy routing protocols can be classified as Table-driven and source initiated. The classification of routing protocols is shown in the Figure 2.1.

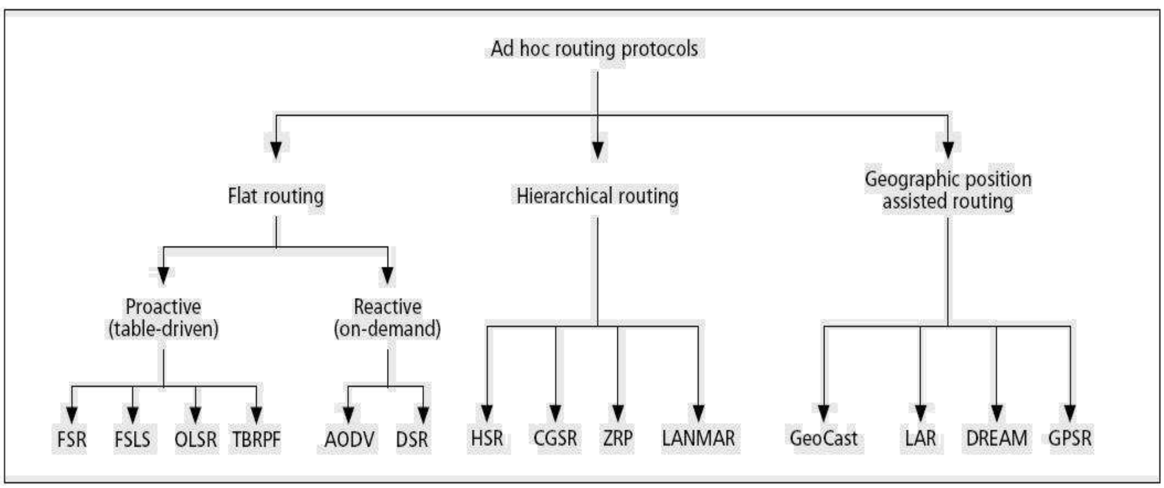


Figure 2.1: Classification of Routing Protocols in Mobile Ad-hoc Networks [3]

2.5.1 Flat Routing Protocols

Flat routing [3] protocols are divided mainly into two classes; the first one is proactive routing (table driven) protocols and other is reactive (on-demand) routing protocols. One thing is general for both protocol classes is that every node participating in routing play an equal role. They have further been classified after their design principles; proactive routing is mostly based on LS (link-state) while on-demand routing is based on DV (distance-vector).

2.5.1.1 Pro-Active / Table Driven routing Protocols

Proactive MANET protocols are also called as table-driven protocols and will actively determine the layout of the network. Through a regular exchange of network topology packets between the nodes of the network, at every single node an absolute picture of the network is maintained. There is hence minimal delay in determining the route to be taken. This is especially important for time-critical traffic [3].

When the routing information becomes worthless quickly, there are many short-lived routes that are being determined and not used before they turn invalid. Therefore, another drawback resulting from the increased mobility is the amount of traffic overhead generated when evaluating these unnecessary routes. This is especially altered when the network size increases. The portion of the total control traffic that consists of actual practical data is further decreased.

Lastly, if the nodes transmit infrequently, most of the routing information is considered redundant. The nodes, however, continue to expend energy by continually updating these unused entries in their routing tables as mentioned, energy conservation is very important in a MANET system design. Therefore, this excessive expenditure of energy is not desired. Thus, proactive MANET protocols work best in networks that have low node mobility or where the nodes transmit data frequently. Examples of Proactive MANET Protocols include:

- Optimized Link State Routing (OLSR)
- Fish-eye State Routing (FSR)
- Destination-Sequenced Distance Vector (DSDV)
- Cluster-head Gateway Switch Routing Protocol (CGSR)

2.5.1.2 Reactive (On Demand) protocols

Portable nodes- Notebooks, palmtops or even mobile phones usually compose wireless ad-hoc networks. This portability also brings a significant issue of mobility. This is a key issue in ad-hoc networks. The mobility of the nodes causes the topology of the network to change constantly. Keeping track of this topology is not an easy task, and too many resources may be consumed in signaling. Reactive routing protocols were intended for these types of environments. These are based on the design that there is no point on trying to have an image of the entire network topology, since it will be constantly changing. Instead, whenever a node needs a route to a given target, it initiates a route discovery process on the fly, for discovering out a pathway [8].

Reactive protocols start to set up routes on-demand. The routing protocol will try to establish such a route, whenever any node wants to initiate communication with another node to which it has no route. This kind of protocols is usually based on flooding the network with Route Request (RREQ) and Route reply (RERP) messages .By the help of Route request message the route is discovered from source to target node; and as the target node gets a RREQ message it send RERP message for the confirmation that the route has been established. This kind of protocol is usually very effective on single-rate networks. It usually minimizes the number of hops of the selected path. However, on multi-rate networks, the number of hops is not as important as the throughput that can be obtained on a given path [15].

The different types of On Demand driven protocols are:

- Ad hoc On Demand Distance Vector (AODV)
- Dynamic Source routing protocol (DSR)
- Temporally ordered routing algorithm (TORA)
- Associativity Based routing (ABR)
- Signal Stability-Based Adaptive Routing (SSA)
- Location-Aided Routing Protocol (LAR)

2.5.2 Hybrid Routing Protocols

Since proactive and reactive protocols each work best in oppositely different scenarios, hybrid method uses both. It is used to find a balance between both protocols. Proactive operations are restricted to small domain, whereas, reactive protocols are used for locating nodes outside those domains [8]. Examples of hybrid protocols are:

- Zone Routing Protocol, (ZRP)
- Wireless Ad hoc Routing Protocol, (WARP)

2.5.3 Hierarchical Routing Protocols

As the size of the wireless network increases, the flat routing protocols may produce too much overhead for the MANET. In this case a hierarchical solution may be preferable[8].

- Hierarchical State Routing (HSR)
- Zone Routing Protocol (ZRP)
- Cluster-head Gateway Switch Routing Protocol (CGSR)
- Landmark Ad Hoc Routing Protocol (LANMAR)

2.5.4 Geographical Routing Protocols

There are two approaches to geographic mobile ad hoc networks:

1. Actual geographic coordinates (as obtained through GPS – the Global Positioning System).

2. Reference points in some fixed coordinate system.

An advantage of geographic routing protocols [8] is that they prevent network-wide searches for destinations. If the recent geographical coordinates are known then control and data packets can be sent in the general direction of the destination. This trim downs control overhead in the network. A disadvantage is that all nodes must have access to their geographical coordinates all the time to make the geographical routing protocols useful. The routing updates must be done faster in compare of the network mobility rate to consider the location-based routing effective. This is because locations of nodes may change quickly in a MANET. Examples of geographical routing protocols are:

- GeoCast (Geographic Addressing and Routing)
- DREAM (Distance Routing Effect Algorithm for Mobility)
- GPSR (Greedy Perimeter Stateless Routing)

2.6 Comparison of Proactive and Reactive routing protocols

The following Table 2.1 briefly compares the Proactive (Table –Driven) routing protocol with Reactive (On-Demand) routing protocols.

Table 2.1 Comparison of Proactive and Reactive routing protocols

Proactive Protocols	**Reactive protocols**
Attempt to maintain consistent, up-to-date routing information from each node to every other node in the network.	A route is built only when required.
Constant propagation of routing information periodically even when topology change does not occur.	No periodic updates. Control information is not propagated unless there is a change in the topology
Incurs substantial traffic and power consumption, which is generally scarce in mobile computers	Does not incur substantial traffic and power consumption compared to Table Driven routing protocols.
First packet latency is less when compared with on-demand protocols	First-packet latency is more when compared with table-driven protocols because a route need to be built
A route to every other node in ad-hoc network is always available	Not available

Chapter 3

Description of Reactive Protocols

Reactive protocol is identified as On-demand protocols because it creates routes only when these routes are needed. The need is initiated by the source, as the name suggests. When a source node requires a route to a destination, it initiates a route discovery process within the network. This process is completed once a route is found or all possible route permutations have been examined. After that there is a route maintenance procedure to keep up the valid routes and to remove the invalid routes**.** The various Reactive Routing Protocols are discussed below:

3.1 Ad hoc On Demand Distance Vector Routing (AODV)

Ad hoc On-Demand Distance Vector (AODV) routing is a routing protocol for mobile ad hoc networks and other wireless ad-hoc networks. It is jointly developed in Nokia Research Centre of University of California, Santa Barbara and University of Cincinnati by C. Perkins and S. Das. It is an on-demand and distance-vector routing protocol, meaning that a route is established by AODV from a destination only on demand [24].

AODV is capable of both unicast and multicast routing [17]. It keeps these routes as long as they are desirable by the sources. Additionally, AODV creates trees which connect multicast group members. The trees are composed of the group members and the nodes needed to connect the members. The sequence numbers are used by AODV to ensure the freshness of routes. It is loop-free, self-starting, and scales to large numbers of mobile nodes [17] [25]. AODV defines three types of control messages for route maintenance:

RREQ- A route request message is transmitted by a node requiring a route to a node. As an optimization AODV uses an expanding ring technique when flooding these messages. Every RREQ carries a time to live (TTL) value that states for how many hops this message should be forwarded. This value is set to a predefined value at the first transmission and increased at retransmissions. Retransmissions occur if no replies are received. Data packets waiting to be transmitted (i.e. the packets that initiated the

RREQ). Every node maintains two separate counters: a node sequence number and a broadcast_ id. The RREQ contains the following fields [17]:-

source address	broadcast ID	source sequence no.	destination address	destination sequence no.	Hop count

The pair <source address, broadcast ID> uniquely identifies a RREQ. Broadcast_id is incremented whenever the source issues a new RREQ [7].

RREP- A route reply message is unicasted back to the originator of a RREQ if the receiver is either the node using the requested address, or it has a valid route to the requested address. The reason one can unicast the message back, is that every route forwarding a RREQ caches a route back to the originator.

RERR- Nodes monitor the link status of next hops in active routes. When a link breakage in an active route is detected, a RERR message is used to notify other nodes of the loss of the link. In order to enable this reporting mechanism, each node keeps a “precursor list", containing the IP address for each its neighbours that are likely to use it as a next hop towards each destination.

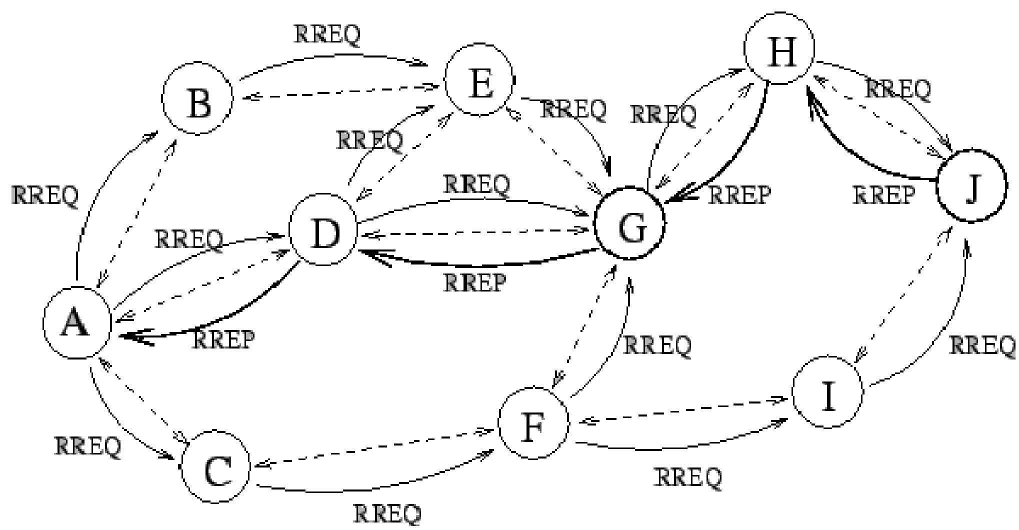


Figure 3.1: A possible path for a route replies if A wishes to find a route to J [9]

The above Figure3.1 illustrates an AODV route lookup session. Node A wants to initiate traffic to node J for which it has no route. A transmit of a RREQ has been done, which is flooded to all nodes in the network. When this request is forwarded to J from H, J generates a RREP. This RREP is then unicasted back to A using the cached entries in nodes H, G and D.

AODV builds routes using a route request/route reply query cycle. When a source node desires a route to a destination for which it does not already have a route, it broadcasts a route request (RREQ) packet across the network [18]. Nodes receiving this packet update their information for the source node and set up backwards pointers to the source node in the route tables. In addition to the source node's IP address, current sequence number, and broadcast ID, the RREQ also contains the most recent sequence number for the destination of which the source node is aware [7] [25]. A node getting the RREQ may send a route reply (RREP) if it is either the destination or if it has a route to the destination with corresponding sequence number greater than or equal to that contained in the RREQ. If this is the case, it unicasts a RREP back to the source. Otherwise, it rebroadcasts the RREQ. Nodes keep track of the RREQ's source IP address and broadcast ID. If they receive a RREQ which they have already processed, they discard the RREQ and do not forward it.

As the RREP propagates back to the source, nodes set up forward pointers to the destination [19]. Once the source node receives the RREP, it may begin to forward data packets to the destination. If the source later receives a RREP containing a greater sequence number or contains the same sequence number with a smaller hop count, it may update its routing information for that destination and begin using the better route.

As long as the route remains active, it will continue to be maintained. A route is considered active as long as there are data packets periodically travelling from the source to the destination along that path. Once the source stops sending data packets, the links will time out and eventually be deleted from the intermediate node routing tables. If a link break occurs while the route is active, the node upstream of the break propagates a route error (RERR) message to the source node to inform it of the now unreachable destinations. After receiving the RERR, if the source node still desires the route, it can reinitiate route discovery.

Multicast routes are set up in a similar manner. A node wishing to join a multicast group broadcasts a RREQ with the destination IP address set to that of the multicast group and with the 'J'(join) flag set to indicate that it would like to join the group. Any node receiving this RREQ that is a member of the multicast tree that has a fresh enough sequence number for the multicast group may send a RREP. As the RREPs propagate back to the source, the nodes forwarding the message set up pointers in their multicast route tables. As the source node receives the RREPs, it keeps track of the route with the freshest sequence number, and beyond that the smallest hop count to the next multicast group member. After the specified discovery period, the source nodes will unicast a Multicast Activation (MACT) [15] message to its selected next hop. This message serves the purpose of activating the route. A node that does not receive this message that had set up a multicast route pointer will timeout and delete the pointer. If the node receiving the MACT was not already a part of the multicast tree, it will also have been keeping track of the best route from the RREPs it received. Hence it must also unicast a MACT to its next hop, and so on until a node that was previously a member of the multicast tree is reached.

AODV maintains routes for as long as the route is active. This includes maintaining a multicast tree for the life of the multicast group. Because the network nodes are mobile, it is likely that many link breakages along a route will occur during the lifetime of that route [20].

The "counting to infinity" problem is avoided by AODV [9] from the classical distance vector algorithm by using sequence numbers for every route. The counting to infinity problem is the situation where nodes update each other in a loop.

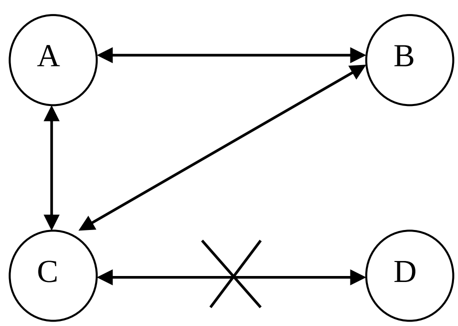


Figure 3.2 "counting to infinity" problem [9]

Consider nodes A, B, C and D making up a MANET as illustrated in Figure3.2. A is not updated on the fact that its route to D via C is broken. This means that A has a registered route, with a metric of 2, to D. C has registered that the link to D is down, so once node B is updated on the link breakage between C and D, it will calculate the shortest path to D to be via A using a metric of 3.C receives information that B can reach D in 3 hops and updates its metric to 4 hops. A then registers an update in hop-count for its route to D via C and updates the metric to 5. So they continue to increment the metric in a loop.

The way this is avoided in AODV, for the example described, is by B noticing that as route to D is old based on a sequence number. B will then discard the route and C will be the node with the most recent routing information by which B will update its routing table.

3.1.1 Characteristics of AODV

- Unicast, Broadcast, and Multicast communication.
- On-demand route establishment with small delay.
- Multicast trees connecting group members maintained for lifetime of multicast group.
- Link breakages in active routes efficiently repaired.
- All routes are loop-free through use of sequence numbers.
- Use of Sequence numbers to track accuracy of information.
- Only keeps track of next hop for a route instead of the entire route.
- Use of periodic HELLO messages to track neighbours [21].

3.1.2 Advantages and Disadvantages

The main advantage of AODV protocol is that routes are established on demand and destination sequence numbers are used to find the latest route to the destination. The connection setup delay is less. The HELLO messages supporting the routes maintenance are range-limited, so they do not cause unnecessary overhead in the network.

One of the disadvantages of this protocol is that intermediate nodes can lead to inconsistent routes if the source sequence number is very old and the intermediate nodes have a higher but not the latest destination sequence number, thereby having stale entries.

Also multiple RouteReply packets in response to a single RouteRequest packet can lead to heavy control overhead [21]. Another disadvantage of AODV is that the periodic beaconing leads to unnecessary bandwidth consumption.

3.2 Dynamic Source Routing (DSR)

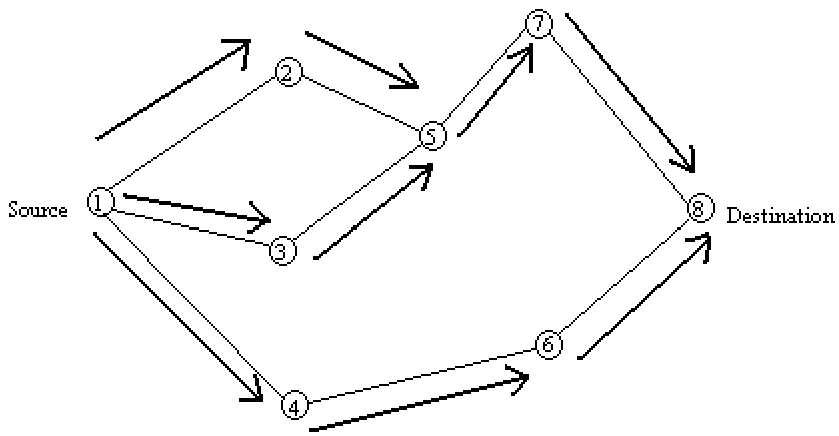
Dynamic Source Routing (DSR) is a routing protocol for wireless mesh networks. It is similar to AODV in that it establishes a route on-demand when a transmitting mobile node requests one. However, it uses source routing instead of relying on the routing table at each intermediate device [13].

Dynamic source routing protocol (DSR) is an on-demand, source routing protocol [27], whereby all the routing information is maintained (continually updated) at mobile nodes. DSR allows the network to be completely self-organizing and self-configuring, without the need for any existing network infrastructure or administration. The protocol is composed of the two main mechanisms of "Route Discovery" and "Route Maintenance", which work together to allow nodes to discover and maintain routes to arbitrary destinations in the ad hoc network [35].

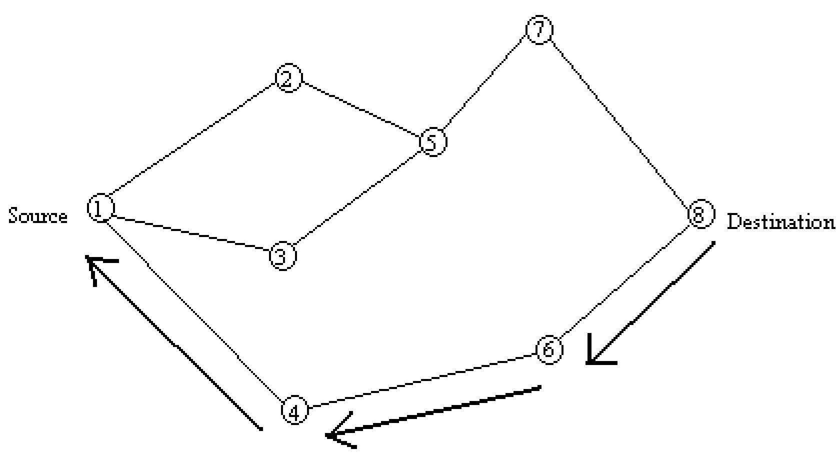
An optimum path for a communication between a source node and target node is determined by Route Discovery process. Route Maintenance ensures that the communication path remains optimum and loop-free according the change in network conditions, even if this requires altering the route during a transmission. Route Reply would only be generated if the message has reached the projected destination node (route record which is firstly contained in Route Request would be inserted into the Route Reply).

To return the Route Reply, the destination node must have a route to the source node. If the route is in the route cache of target node, the route would be used. Otherwise, the node will reverse the route based on the route record in the Route Reply message header (symmetric links). In the event of fatal transmission, the Route Maintenance Phase is initiated whereby the Route Error packets are generated at a node. The incorrect hop will be detached from the node's route cache; all routes containing the hop are reduced at that point. Again, the Route Discovery Phase is initiated to determine the most viable route.

The major dissimilarity between this and the other on-demand routing protocols is that it is beacon-less and hence it does not have need of periodic hello packet (beacon) transmissions, which are used by a node to inform its neighbours of its presence. The fundamental approach of this protocol during the route creation phase is to launch a route by flooding RouteRequest packets in the network. The destination node, on getting a RouteRequest packet, responds by transferring a RouteReply packet back to the source, which carries the route traversed by the RouteRequest packet received.



(a). Propagation of request (PREQ) packet



(b). Path taken by the Route Reply (RREP) packet

Figure 3.3 Creation of route in DSR [14]

A destination node, after receiving the first RouteRequest packet, replies to the source node through the reverse path the RouteRequest packet had traversed. Nodes can also be trained about the neighboring routes traversed by data packets if operated in the promiscuous mode. This route cache is also used during the route construction phase. If an intermediary node receiving a RouteRequest has a route to the destination node in its route cache, then it replies to the source node by sending a RouteReply with the entire route information from the source node to the destination node.

3.2.1 Advantages and Disadvantages

DSR uses a reactive approach which eliminates the need to periodically flood the network with table update messages which are required in a table-driven approach. The intermediate nodes also utilize the route cache information efficiently to reduce the control overhead.

The disadvantage of DSR is that the route maintenance mechanism does not locally repair a broken down link. The connection setup delay is higher than in table-driven protocols. Even though the protocol performs well in static and low-mobility environments, the performance degrades rapidly with increasing mobility. Also, considerable routing overhead is involved due to the source-routing mechanism employed in DSR. This routing overhead is directly proportional to the path length.

3.3 Temporally Ordered Routing Algorithm (TORA)

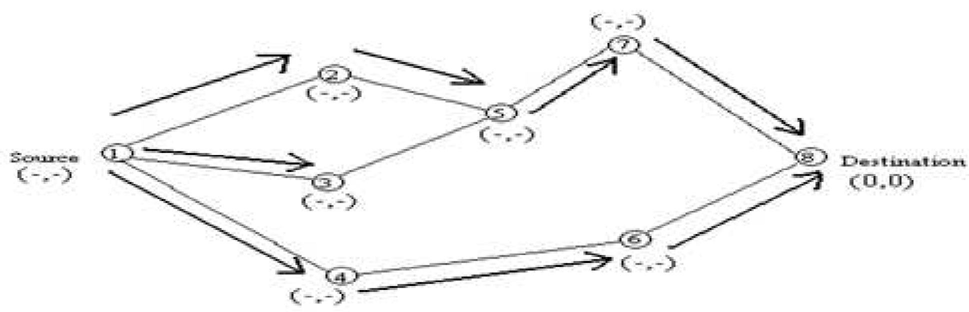
The Temporally Ordered Routing Algorithm (TORA) is a source-initiated on-demand routing protocol and Invented by Vincent Park and M.Scott Corson from University of Maryland.. It is a highly adaptive, proficient and scalable distributed routing algorithm based on the concept of link reversal [12]**.** TORA is proposed for highly dynamic mobile, multihop wireless networks [11]. It searches multiple routes from a source node to a destination node. The principal feature of TORA is that the control messages are localized to a very small set of nodes near the occurrence of a topological change. To achieve this, the nodes retain routing information about adjacent nodes. The protocol has three essential functions: **-** Route creation, Route maintenance, and Route erasure. Some quintuple are associated with every node [29]-

- Logical time of a link failure
- The unique ID of the node that defined the new reference level

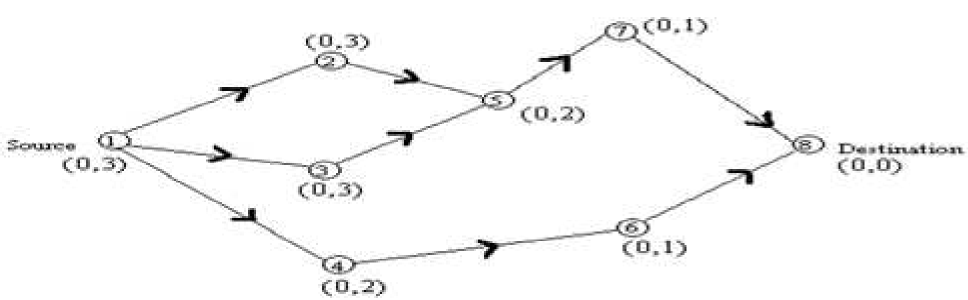
- A reflection indicator bit
- A propagation ordering parameter
- The unique ID of the node

The first three elements jointly stand for the reference level. A new reference level is defined each time a node loses its last downstream link due to a link breakdown. The last two values define a delta with respect to the reference level.

Route Creation in TORA is made using QRY and UPD packets. The route creation algorithm starts with the height (propagation ordering parameter in the quintuple) of destination set to 0 and all other height of node set to NULL. The source broadcasts a QRY packet with the destination node's id in it. A node with a non-NULL height responds with a UPD packet that has its height in it. A node receiving a UPD packet sets its height to one more than that of the node that generated the UPD [29]. A node with higher height is considered upstream and a node with lower height downstream. In this way a directed acyclic graph is constructed from source to the destination.



(a). Propagation of QRY message through the network



(b). Height of each node updated as a result of UPD messages

Figure 3.4 Route creations in TORA [29]

The subsequent Figure 3.4 shows the formation of route in TORA by transferring request from source and receiving reply from destination; in this figure Numbers in braces are reference level, height of node. When a node moves the DAG route is broken, and route maintenance is required to re-establish a DAG for the identical destination.

3.4 Associativity Based Routing (ABR)

The Associativity Based Routing (ABR) protocol is a new approach for routing proposed by C.K. Toh at the Cambridge University in 1996 [23]. ABR defines a new metric for routing known as the degree of association stability. It is free from loops, deadlock, and packet duplicates.

In ABR, a route is chosen based on associativity states of nodes and temporal stability of the links between the nodes [29]. ABR is beacon-based, so that each node generates periodic beacons (hello messages) to indicate its existence to the neighbors. These beacons are used to revise the associativity table of each node. With the temporal stability and the associativity table the nodes are able to classify each neighbor link as stable or unstable. The fundamental objective of ABR is to find longer-lived routes for ad hoc mobile networks. The three phases of ABR are Route discovery, Route reconstruction (RRC) and Route deletion [23].

Stable routes have a higher preference compared to shorter routes. Fewer paths will break which reduces flooding (bandwidth). In ABR a broken link is repaired locally, so the source node would not begin a new path-finding-process when a broken link appears.

Stability information is only used during the route selection process. Sometimes the elected path may be longer than the shortest path, because of the preference given to stable paths, which are not necessary, a disadvantage. In ABR local query broadcasts may result in high delays during the route repair.

3.5 Signal Stability-Based Adaptive Routing (SSA)

Signal Stability-Based Adaptive Routing protocol (SSA) has on-demand behaviour of routing protocol that selects longer-lived routes based on the signal strength and location stability of a node. This route selection criterion has the effect of choosing routes that have stronger connectivity. SSR comprises of two cooperative protocols: the Dynamic Routing Protocol (DRP) and the Static Routing Protocol (SRP) [15] [16].

The Dynamic routing protocol maintains the Signal Stability table (SST) and Routing table (RT). The SST keeps the signal strength of neighboring nodes acquired by periodic beacons from the link layer of every neighboring node. Signal strength is either recorded as a strong or weak channel. All transmissions are established by DRP and processed. After updating the appropriate table entries, the DRP passes the packet to the SRP [16].

The SRP passes the packet up the stack if it is the proposed receiver. If not, it looks up the destination in the RT and forwards the packet. If there is no entry for the destination in the RT, it initiates a route-search process to discover a route. Route-request packets are forwarded to the next hop only if they are received over strong channels and have not been earlier processed; it is done to keep away from looping [29]. The destination chooses the first incoming route-search packet to send back as it is highly likely that the packet arrived routing over the shortest and/or least congested path. The DRP reverses the selected route and sends a route-reply message back to the initiator of route-request. The DRP of the nodes along the path update their RTs accordingly. Route-search packets arriving at the destination have necessarily arrived on the path of strongest signal stability because the packets arriving over a weak channel are dropped at intermediate nodes. If the source times out before receiving a reply then it changes the PREF field in the header to indicate that weak channels are acceptable, since these may be the only links over which the packet can be propagated. When a link failure is detected within the network, the intermediate nodes send an error message to the source indicating which channel has failed. The source then sends an erase message to notify all nodes of the broken link and initiates a new route-search process to find a new path to the destination.

The main benefit of SSA is that this protocol finds more stable routes to a destination then DSR. With the beacons between the nodes, SSA classifies the link as secure or unstable to find the strongest path. The drawback to use SSA are that broken links are locally detected but not repaired and the multiple flooding of RouteRequest messages restricts the bandwidth; and the Route Request packets received over weak links are not measured but dropped.

3.6 Location-Aided Routing Protocol (LAR)

LAR is a reactive protocol which is based on the DSR (Dynamic Source Routing) [22]. This Routing Protocol uses location information to diminish routing overhead of the mobile ad-hoc network. Normally the LAR protocol uses the GPS (Global Positioning System) to get this location information. The mobile hosts recognize their physical location by the availability of GPS. To play down the complexity of the protocol, we assume that every host knows his position exactly; the differentiation between the exact position and the calculated position of GPS will not be considered. The route creation is done on the basis of the coordinates and the distance between source and destination node. An assumption is taken into consideration that the mobile nodes are only moving in a two-dimensional plane. It has two types of zones- Expected zone and Requested zone.

Chapter 4

Problem Statement

The objective of this work is to evaluate two routing protocols based on On-demand behaviour, namely, Ad hoc Demand Distance vector (AODV) and Dynamic Source Routing (DSR), for wireless ad hoc networks based on performance. This evaluation is to be carried out through exhaustive literature review and simulation.

The general objectives can be outlined as follows:

- Get a general understanding of ad -hoc networks.
- Literature review of AODV and DSR.
- Generate a simulation environment that could be used for further studies.
- Implement AODV and DSR routing protocols for wireless ad-hoc networks.
- Analyze the protocols and through simulation and verify it on the basis of literature review.
- Discuss the result of the proposed work.

Chapter 5

Simulation Model

5.1 Network Simulators

According to dictionary, Simulation can be defined as "reproduction of essential features of something as an aid to study or training." In simulation, we can construct a mathematical model to reproduce the characteristics of a phenomenon, system, or process often using a computer in order to information or solve problems. Nowadays, there are many network simulators that can simulate the MANET. In this section we will introduce the most commonly used simulators. We will compare their advantages and disadvantages and choose one to as platform to implement reactive/proactive protocol and conduct simulations in this thesis.

5.1.1 Network Simulator – NS-2

Ns-2 is a discrete event simulator targeted at networking research. It provides substantial support for simulation of TCP, routing and multicast protocols over wired and wireless networks. It consists of two simulation tools. The network simulator (ns) contains all commonly used IP protocols. The network animator (nam) is use to visualize the simulations. Ns-2 [28] fully simulates a layered network from the physical radio transmission channel to high-level applications.

Version 2 is the most recent version of ns (ns-2) [28]. The simulator was originally developed by the University of California at Berkeley and VINT project the simulator was recently extended to provide simulation support for ad hoc network by Carnegie Mellon University (CMU Monarch Project homepage, 1999). The ns-2 simulator has several features that make it suitable for our simulations.

- A network environment for ad-hoc networks,
- Wireless channel modules (e.g.802.11),
- Routing along multiple paths,
- Mobile hosts for wireless cellular networks.

Ns-2 is an object-oriented simulator written in C++ and OTcl. The simulator supports a class hierarchy in C++ and a similar class hierarchy within the OTcl interpreter. There is a one-to-one correspondence between a class in the interpreted hierarchy and one in the compile hierarchy. The reason to use two different programming languages is that OTcl is suitable for the programs and configurations that demand frequent and fast change while C++ is suitable for the programs that have high demand in speed. Ns-2 is highly extensible. It not only supports most commonly used IP protocols but also allows the users to extend or implement their own protocols. It also provides powerful trace functionalities, which are very important in our project since various information need to be logged for analysis. The full source code of ns-2 can be downloaded and compiled for multiple platforms such as UNIX, Windows and Cygwin.

5.1.2 GloMoSim

GloMoSim is a scalable simulation environment for wired and wireless network systems. Currently it only supports protocols for a purely wireless network. It is also built in a layered approach; such as OSI layer network architecture. GloMoSim [28] is designed as a set of library modules, each of which simulates a specific wireless communication protocol in the protocol stack. The library has been developed using PARSEC, a C-based parallel simulation language. New protocols and modules can be programmed and added to the library using this language. The latest version of GloMoSim has implemented DSR. GloMoSim's source and binary code can be downloaded only by academic institutions for research purposes. Commercial users must use QualNet, the commercial version of GloMoSim.

5.1.3 OPNET Modeler

OPNET Modeler [28] is commercial network simulation environment for network modeling and simulation. It allows the users to design and study communication networks, devices, protocols, and applications with flexibility and scalability. It simulates the network graphically and its graphical editors mirror the structure of actual networks and network components. The users can design the network model visually.

The modeler uses object-oriented modeling approach. The nodes and protocols are modeled as classes with inheritance and specialization. The development language is C.

5.2 Comparison

When choosing a network simulator, we normally consider the accuracy of the simulator. Unfortunately there is no conclusion on which of the above three simulator is the most accurate one. David Cavin et al. has conducted experiments to compare the accuracy of the simulators and it finds out that the results are barely comparable. Furthermore, it warns that no standalone simulations can fit all the needs of the wireless developers. It is more realistic to consider a hybrid approach in which only the lowest layers (MAC and physical layers [31]) and the mobility model are simulated and all the upper layers (from transport to application layers) are executed on a dedicated hosts (e.g. cluster of machines).

Although there is no definite conclusion about the accuracy of the three network simulators, we have to choose one of them as our simulation environment. We compare the simulators using some metrics and the results are summarized in Table 4.1.

Table 4.1: Comparison of the three simulators

	Free	Open Source	Programming Language
NS-2	Yes	Yes	C++,TCL
GloMoSim	Limited	Yes	Parsec
Opnet Modeler	No	No	C

After comparing the three simulators, we decide to choose NS-2 as network simulator for our thesis because:-

1. Ns-2 is open source free software. It can be easily downloaded and installed.
2. Programming language C++ is compatible.

5.3 Mobility Models

To evaluate the performance of a protocol for an ad-hoc network, it is necessary to test the protocol under realistic conditions, especially including the movement of the mobile nodes. Surveys of different mobility models [33] [34] have been done. This includes the

Random Waypoint Mobility Model that is used in our work.

5.3.1 Random Walk Mobility Model

Random Walk Mobility [34] model is based on random directions and speeds. By randomly choosing a direction between 0 and 2 and a speed between 0 and Vmax, the mobile node moves from its current position. A recalculation of speed and direction occurs after a given time or a given distance walked. The random walk mobility model is memory less. Future directions and speeds are independent of the past speeds and directions. This can cause unrealistic movement such as sharp turns or sudden stops. If the specified time or distance is short, the nodes are only walking on a very restricted area on the simulation area.

5.3.2 Random Waypoint Mobility Model

A mobile node begins the simulation by waiting a specified pause-time. After this time it selects a random destination in the area and a random speed distributed uniformly between 0 m/s and Vmax. After reaching its destination point, the mobile node waits again pause-time seconds before choosing a new way point and speed.

The mobile nodes are initially distributed over the simulation area. This distribution is not representative to the final distribution caused by node movements. To ensure a random initial configuration for each simulation, it is necessary to discard a certain simulation time and to start registering simulation results after that time.

The Random Waypoint Mobility Model is very widely used in simulation studies of MANET [34]. As described in the performance measures in mobile ad-hoc networks are affected by the mobility model used. One of the most important parameters in mobile ad-hoc simulations is the nodal speed. The users want to adjust the average speed to be stabilized around a certain value and not to change over time. They also want to be able to compare the performance of the mobile ad-hoc routing protocols under different nodal speeds. For the Random Waypoint Mobility Model common expectation is that the average is about half of the maximum, because the speeds in a Random Waypoint Model are chosen uniformly between 0 m/s and Vmax. But is this the average speed really reached in simulations? Not at all, the studies in show that the average speed is decreasing over time and will approach 0. This could lead to wrong simulation results.

This phenomenon can be intuitively explained as follows. In the Random Waypoint Mobility Model a node selects its destination and its speed. The node keeps moving until it reaches its destination at that speed. If it selects a far destination and a low speed around 0 m/s, it travels for a long time with low speed. If it selects a speed near Vmax the time traveling with this high speed will be short. After a certain time the node has traveled much more time at low speed than at high speed. The average speed will approach 0 m/s. The suggestion in to prevent this problem is choosing, e.g. 1 m/s instead of 0 m/s as Vmin. With this approach the average speed stabilizes after a certain time at a value below 1/2 * Vmax. There are some limitations of random waypoint mobility model:

- Temporal dependency
- Spatial dependency
- Geographic restrictions

5.3.3 Random Direction Mobility Model

To reduce density waves in the average number of neighbors by the Random Waypoint Model the Random Direction Mobility Model was created [34]. Density waves are the clustering of nodes in one part of the simulation area. For the Random Waypoint Mobility Model the probability of choosing a location near the center or a waypoint which requires traveling through the center of the area is high. The Random Direction Mobility Model was invented to prevent this behavior and to promote a semi-constant number of neighbors. The mobile node selects a direction and travels to the border of the simulation area. If the boundary is reached, the node pauses for a specific time and then chooses a new direction and the process goes on. Because of pausing on the border of the area, the hop count for this mobility model is much higher than for most other mobility models.

A detailed simulation model based on ns-2 [28] is used in the evaluation. In a recent paper the Monarch research group at Carnegie-Mellon University developed support for simulating multihop wireless networks complete with physical, data link, and medium access control (MAC) layer models on ns-2. The Distributed Coordination Function

(DCF) of IEEE 802.11 for wireless LANs is used as the MAC layer protocol. An unslotted carrier sense multiple access (CSMA) technique with collision avoidance (CSMA/CA) is used to transmit the data packets. The radio model uses characteristics similar to a commercial radio interface, Lucent's WaveLAN. WaveLAN is modeled as a shared-media radio with a nominal bit rate of 2 Mb/s and a nominal radio range of 250 m.

The protocols maintain a send buffer of 64 packets. It contains all data packets waiting for a route, such as packets for which route discovery has started, but no reply has arrived yet. To prevent buffering of packets indefinitely, packets are dropped if they wait in the send buffer for more than 30 s. All packets (both data and routing) sent by the routing layer are queued at the interface queue until the MAC layer can transmit them. The interface queue has a maximum size of 50 packets and is maintained as a priority queue with two priori-ties each served in FIFO order. Routing packets get higher priority than data packets.

5.4 The Traffic and Mobility Models

Continuous bit rate (CBR) [30] traffic sources are used. The source-destination pairs are spread randomly over the network. Only 512-byte data packets are used. The number of source-destination pairs and the packet-sending rate in each pair is varied to change the offered load in the network.

The mobility model uses the random waypoint model in a rectangular field. The field configurations used is: 800 m x 800 m field with 10 nodes. Here, each packet starts its journey from a random location to a random destination with a randomly chosen speed (uniformly distributed between 0–20 m/s). Once the destination is reached, another random destination is targeted after a pause. The pause time, which affects the relative speeds of the mobiles, is varied. Simulations are run for 10, 15, 20 simulated seconds. Identical mobility and traffic scenarios are used across protocols to gather fair results.

5.5 Performance Metrics

Some important performance metrics can be evaluated:-

5.5.1 Packet delivery fraction — The ratio of the data packets delivered to the destinations to those generated by the CBR sources. Packets delivered and packets lost are taking in to consideration.

5.5.2 Throughput — There is two representations of throughput; one is the amount of data transferred over the period of time expressed in kilobits per second (Kbps). The other is the packet delivery percentage obtained from a ratio of the number of data packets sent and the number of data packets received.

Chapter 6
Results and Discussions

6.1 Simulation

As already outlined we have taken two On-demand (Reactive) routing protocols, namely Ad hoc On-Demand Distance Vector Routing (AODV) and Dynamic Source Routing (DSR). The mobility model used is Random waypoint mobility model because it models the random movement of the mobile nodes. For all the simulations, the same movement models were used, the number of traffic sources was fixed at 10, the maximum speed of the nodes was set to 20m/s and the simulation time was varied as 10s, 15s, and 20s.

6.1.1 Scenario 1:

In this scenario some parameters with a specific value are considered. Those are as shown in table 6.1.

Table 6.1: Scenario 1 for implementation of AODV and DSR

Parameter	Value
Number of nodes	10
Simulation Time	10 sec
Pause Time	5ms
Environment Size	800x800
Transmission Range	250 m
Traffic Size	CBR (Constant Bit Rate)
Packet Size	512 bytes
Packet Rate	5 packets/s
Maximum Speed	20 m/s
Queue Length	50
Simulator	ns-2.29
Mobility Model	Random Waypoint
Antenna Type	Omnidirectional

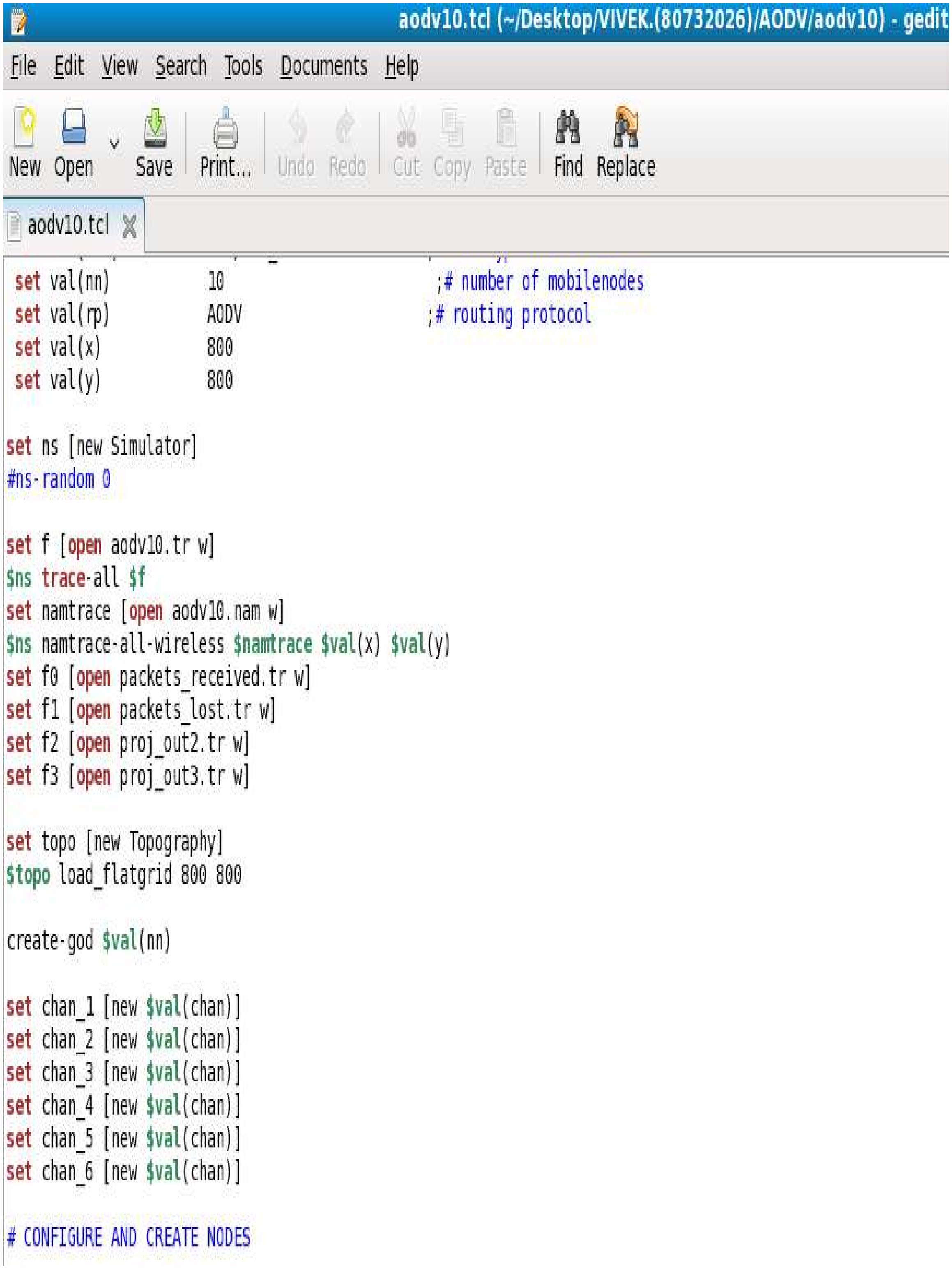


Figure 6.1: A Screenshot of AODV tcl script

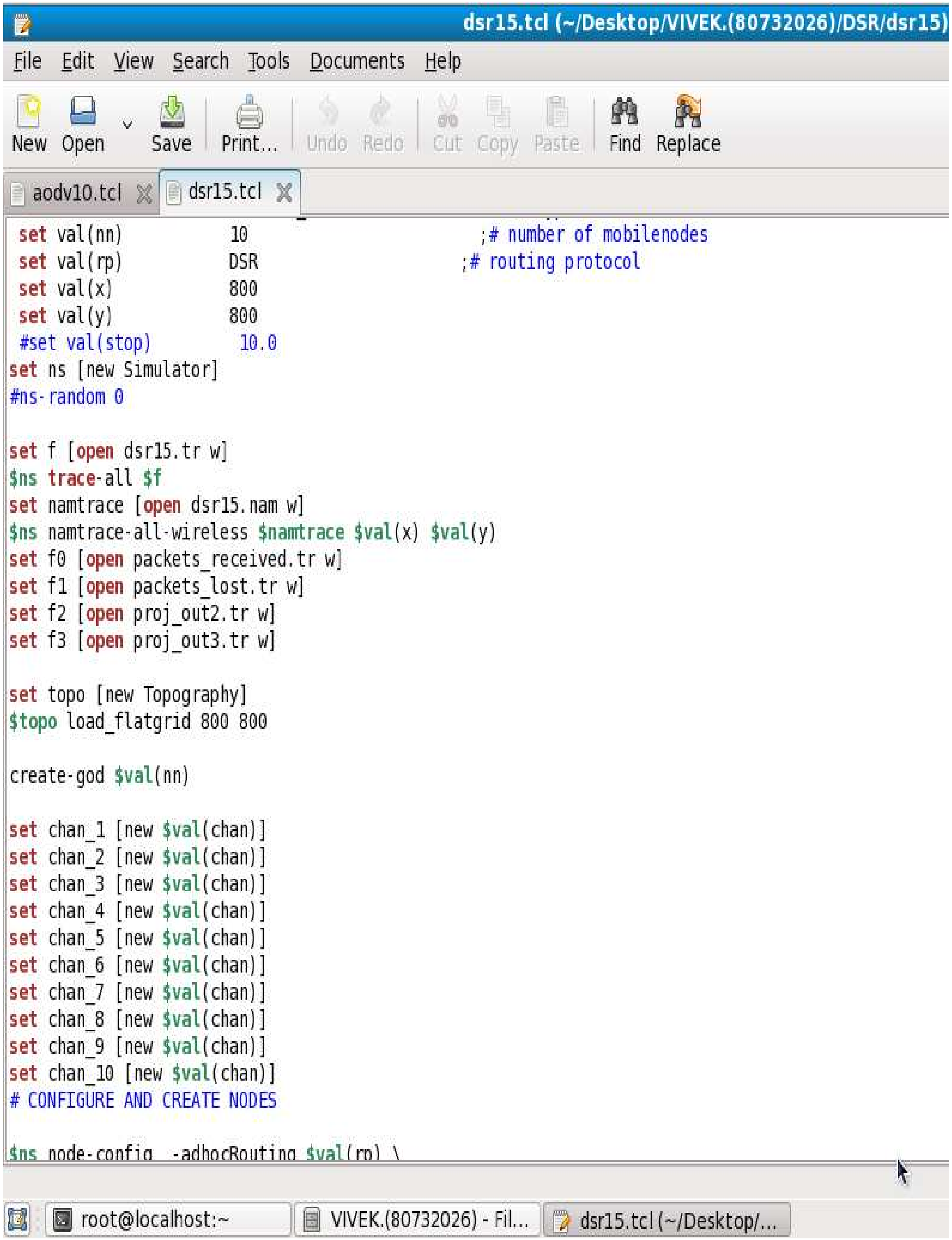


Figure 6.2: A Screenshot of DSR tcl script

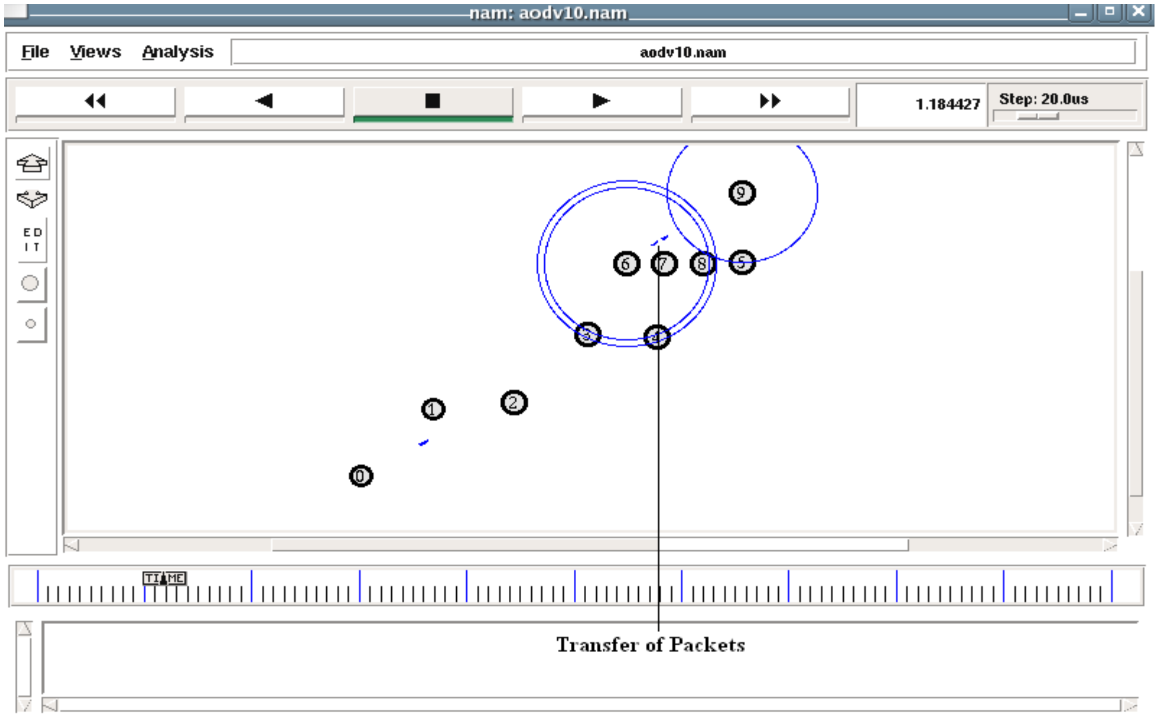


Figure 6.3: A Screenshot of 10 nodes of AODV NAM – Network animator

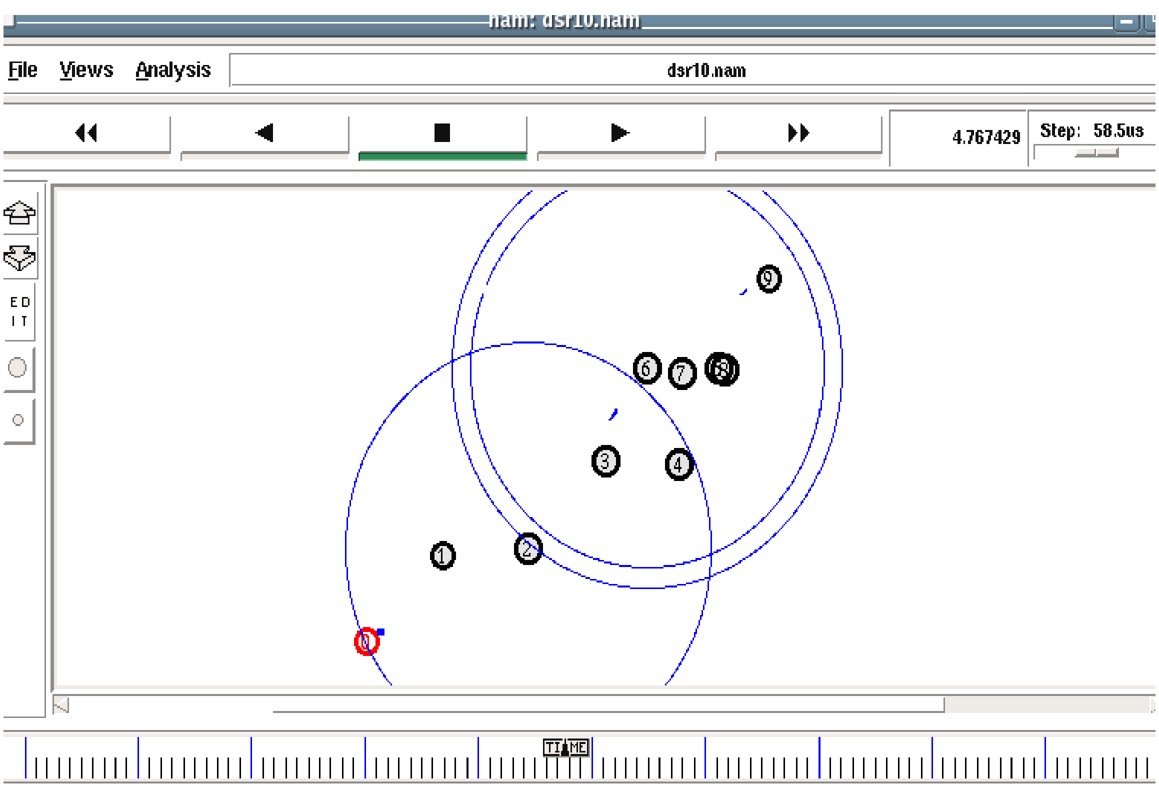


Figure 6.4: A Screenshot of 10 nodes of DSR NAM – Network animator

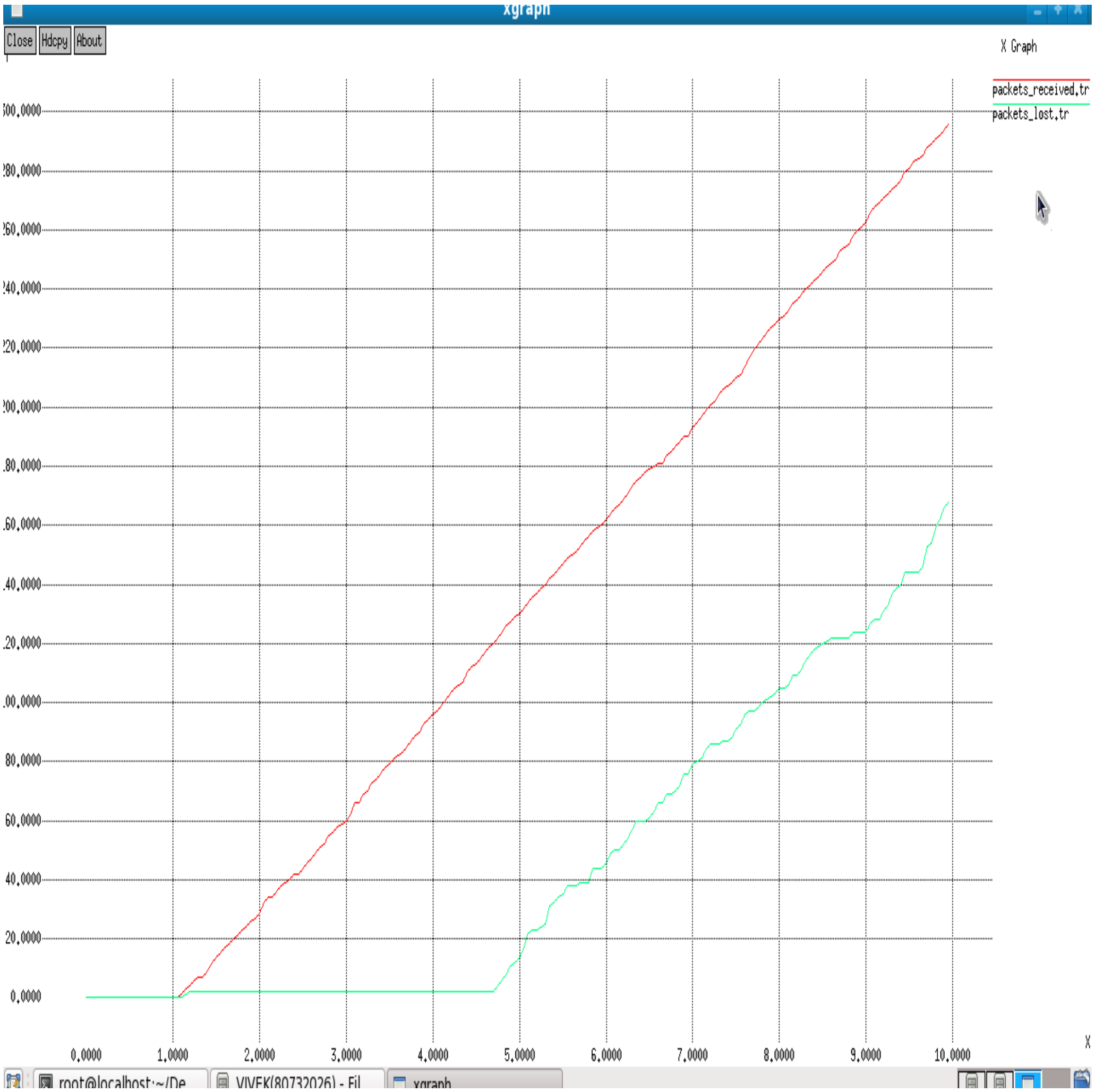


Figure 6.5: X Graph of 10 seconds simulation time of AODV

The Figure 6.5 shows the X graph of AODV. By the Figure we see that as the simulation start the packet received and packet loss is initially zero, because initially there is no CBR connection and nodes taking their right place. As the CBR connections establish between the nodes the number of packet received increases but no packet loss is there, it means all generated packets are being received by the nodes. But the packet loss increases substantially on the simulation time increases. Finally the packet received is more than the packet loss.

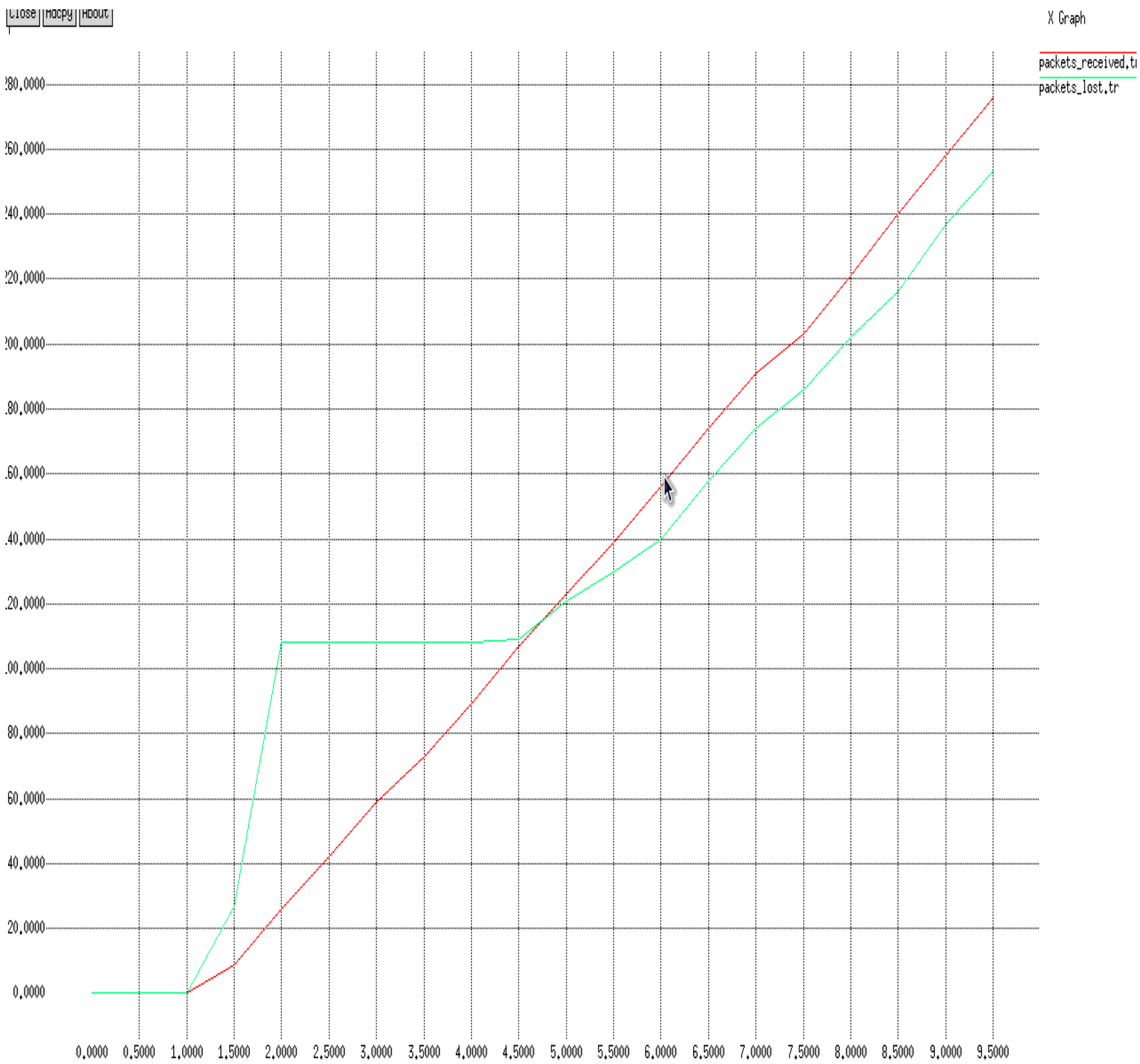


Figure 6.6: X Graph of and 10 seconds simulation time of DSR

The Figure 6.6 shows the X graph of DSR. By the Figure we see that as the simulation start the packet received and packet loss is initially zero, because initially there is no CBR connection and nodes taking their right place. As the CBR connections establish the number of packet lost increases very much as compare to packet received. It shows that mostly generated packets are being dropped by the nodes. But the packet loss decreases substantially on the simulation time increases, and number of packet received increases substantially on the simulation time increases.

6.1.2 Scenario 2:

Table 6.2: Scenario 2 for implementation of AODV and DSR

Parameter	Value
Number of nodes	10
Simulation Time	15 sec
Pause Time	5ms
Environment Size	800x800
Transmission Range	250 m
Traffic Size	CBR (Constant Bit Rate)
Packet Size	512 bytes
Packet Rate	5 packets/s
Maximum Speed	20 m/s
Queue Length	50
Simulator	ns-2.29
Mobility Model	Random Waypoint
Antenna Type	Omnidirectional

Figure 6.7: X Graph of and 15 seconds simulation time of AODV

The Figure 6.7 shows that the number of packet received increases according to simulation time; it means generated packets are being received at a good ratio by the node. But the simulation time increases the packet loss increases substantially.

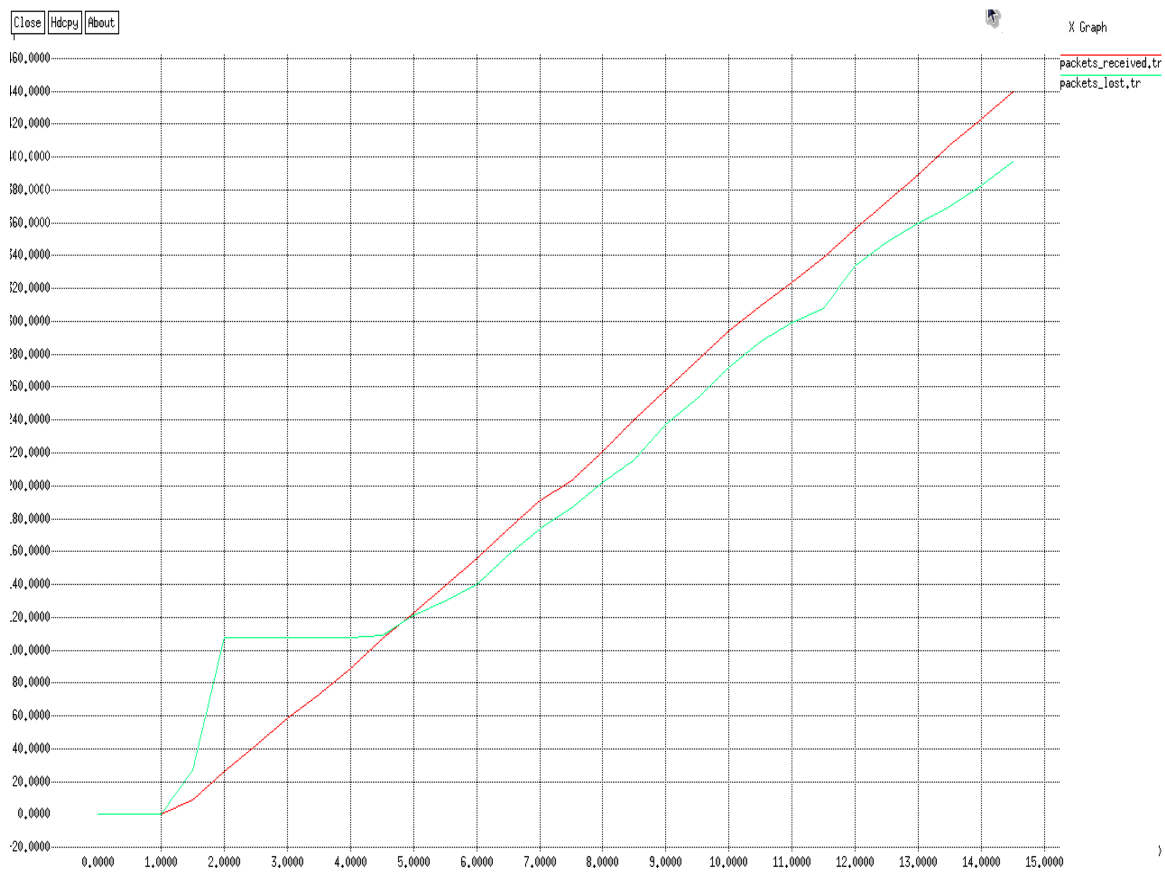


Figure 6.8 X Graph of 15 seconds simulation time of DSR

The Figure 6.7 shows that initially there is very high packet loss but the number of packet received increases according to simulation time; it means generated packets are being received at a good ratio by the nodes. Because the simulation time increases the packet loss decreases substantially.

6.1.3 Scenario 3:

Table 6.3: Scenario 3 for implementation of AODV and DSR

Parameter	Value
Number of nodes	10
Simulation Time	20 sec
Pause Time	5ms
Environment Size	800x800

Transmission Range	250 m
Traffic Size	CBR (Constant Bit Rate)
Packet Size	512 bytes
Packet Rate	5 packets/s
Maximum Speed	20 m/s
Queue Length	50
Simulator	ns-2.29
Mobility Model	Random Waypoint
Antenna Type	Omnidirectional

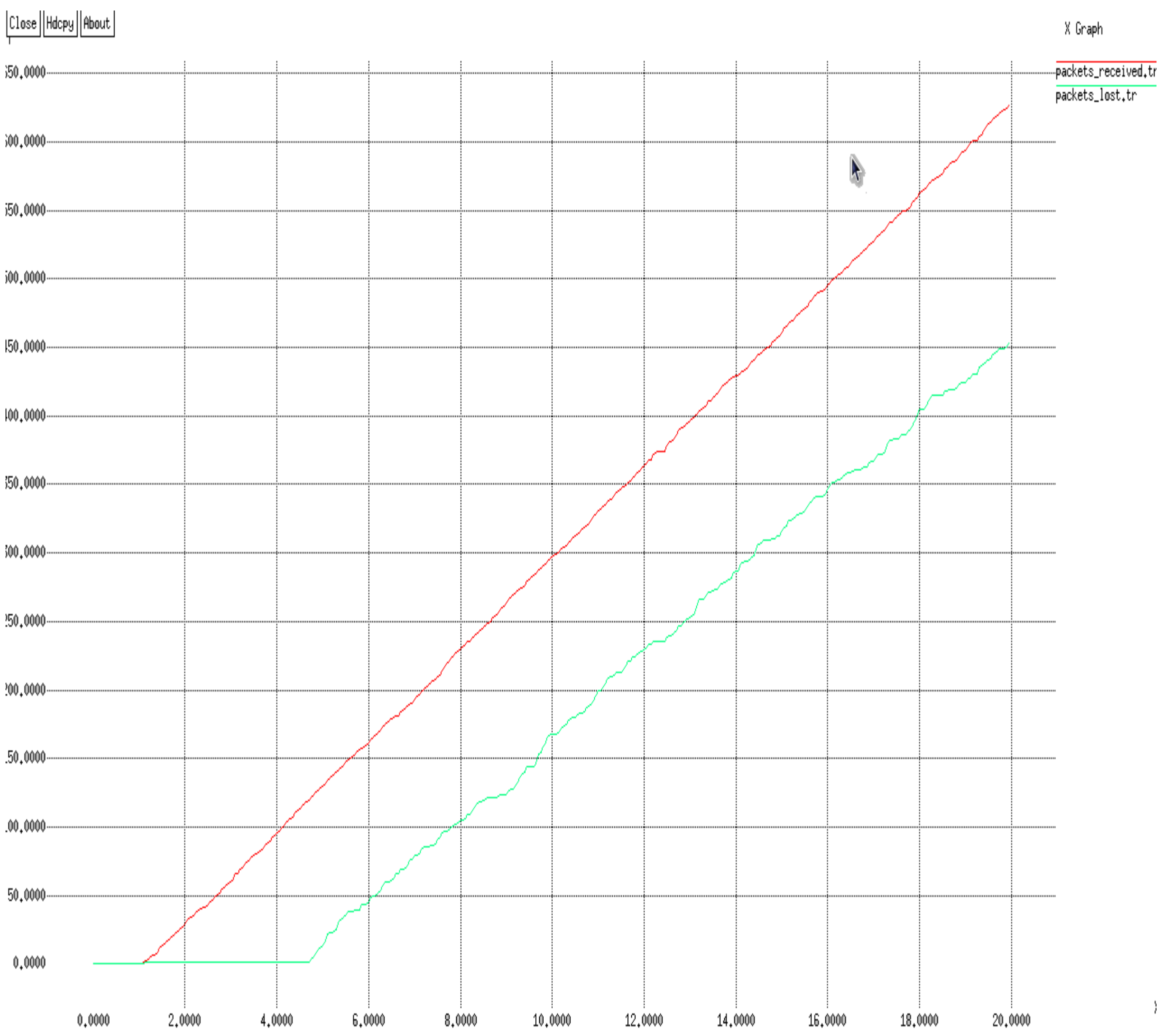


Figure 6.9 X Graph of 20 seconds simulation time of AODV

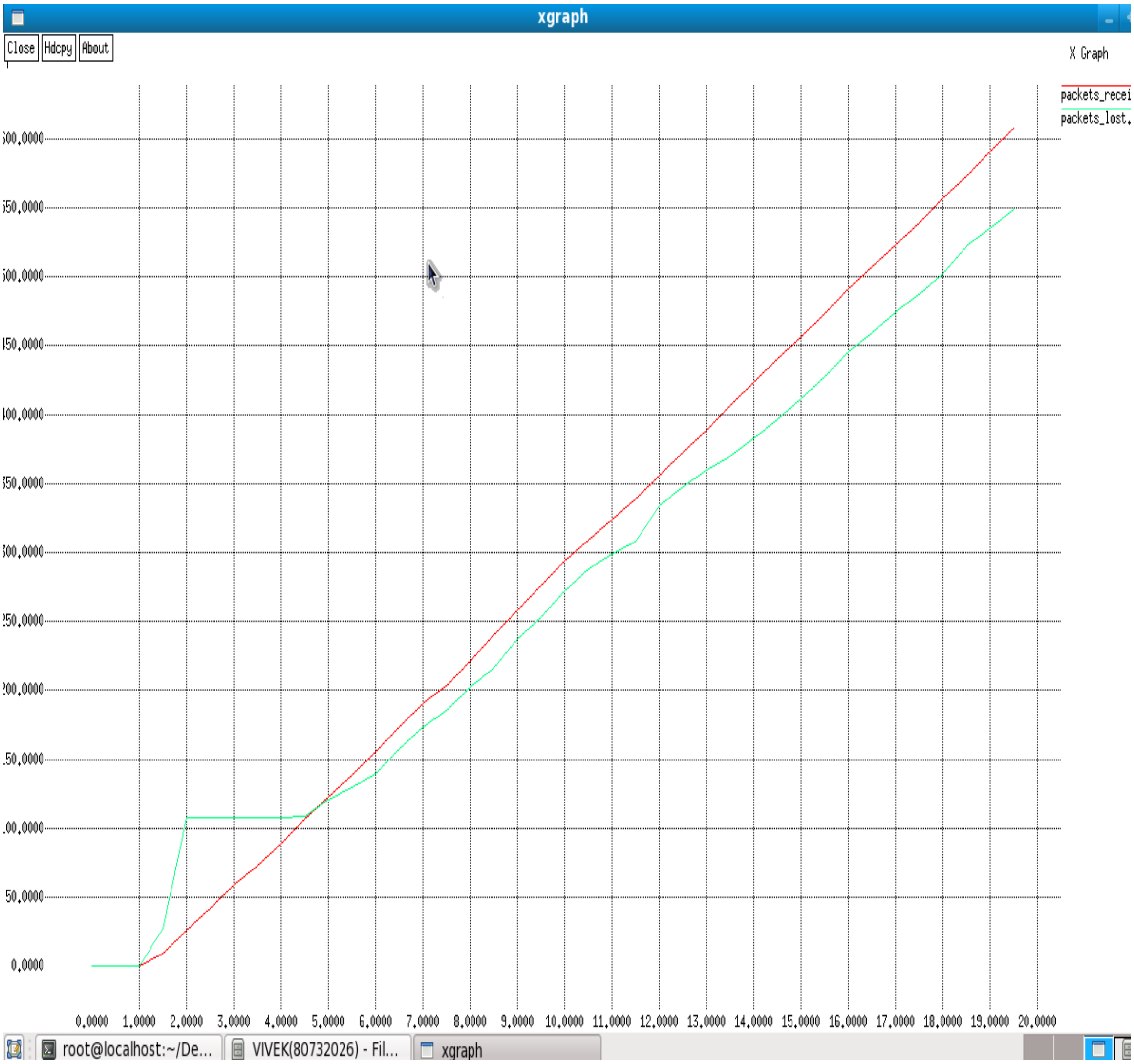


Figure 6.10: X Graph of 20 seconds simulation time of DSR

The above figures shows the same behavior of AODV & DSR in fact of packet receiving and packet loss, initially in AODV no packet loss and in DSR very high packet loss. But as simulation time increases the packet loss goes down and packet receiving increases

Chapter 7

Conclusion and Future Scope

We have compared two On-demand routing protocols, namely, Ad hoc On-Demand Distance Vector Routing (AODV) and Dynamic Source Routing (DSR). The simulation of these protocols has been carried out using Ns-2 simulator on a “Pentium-IV, 2.0Ghz /RAM-1 GB /HDD- 120GB” computer and “Fedora-10” operating system.

Three different simulation scenarios are generated and the simulation time has varied from 10sec, 15sec and 20 sec. Other network parameters are kept constant during the simulation.

It is observed that the packet loss is very less in case of AODV, initially but it increases substantially on the simulation time increases. In case of DSR simulation the packet loss is very high initially but it decreases substantially on the simulation time increases.

So, we can conclude that if the MANET has to be setup for a small amount of time then AODV should be prefer due to low initial packet loss and DSR should not be prefer to setup a MANET for a small amount of time because initially there is packet loss is very high. If we have to use the MANET for a longer duration then both the protocols can be used, because after some times both the protocols have same ratio of packet delivering. But AODV have very good packet receiving ratio in comparison to DSR

The two protocols Ad hoc On-Demand Distance Vector Routing (AODV) and Dynamic Source Routing (DSR) have been compared using simulation, it would be interesting to note the behaviour of these protocols on a real life test bed.

In this work other network parameters such as number of mobile nodes, traffic type-CBR, simulation area etc. are kept constant. Whereas the simulation time is varied in the three different simulation scenarios. It would be interesting to observe the behaviour of these two protocols by varying these network parameters.

ANNEXURE-I

References

[1] Mobile Ad-hoc Networks (MANET), http://www.ietf.org/html.charters/manet-charter.html. (1998-11-29).

[2] Hadi Sargolzaey, Ayyoub Akbari Moghanjoughi and Sabira Khatun, "A Review and Comparison of Reliable Unicast Routing Protocols For Mobile Ad Hoc Networks", IJCSNS International Journal of Computer Science and Network Security, VOL.9 No.1, pp. 186-196, January 2009.

[3] Krishna Gorantala, "Routing in Mobile Ad-hoc Networks", Umea University, Sweden, June-2006.

[4] Geetha Jayakumar and Gopinath Ganapathy, "Performance Comparison of Mobile Ad-hoc Network Routing Protocol", International Journal of Computer Science and Network Security (IJCSNS), VOL.7 No.11, pp. 77-84 November 2007.

[5] Azizol Abdullah, Norlida Ramly, Abdullah Muhammed, Mohd Noor Derahman, "Performance Comparison Study of Routing Protocols for Mobile Grid Environment", IJCSNS International Journal of Computer Science and Network Security, VOL.8 No.2, pp.82-88, February 2008.

[6] Laura Marie Feeney, "A taxonomy for routing protocols in mobile ad hoc networks", Technical report, Swedish Institute of Computer Science, Sweden, 1999.

[7] C.E. Perkins and E.M. Royer, "Ad hoc On Demand Distance Vector Routing" , University of California, Santa Barbara.

[8] Elizabeth M. Royer and Chai-Keong Toh, "A review of current routing protocols for ad hoc mobile wireless networks", Technical report, University of California and Georgia Institute of Technology, USA, 1999.

[9] Ad-hoc distance vector protocol for mobile ad hoc network http://www.olsr.org/docs/report_html/node16.html#adhoc_aodv#adhoc_aodv – accessed on may 2009.

[10] Natrajan Meghanathan, "A Location Prediction-Based Reactive Routing Protocol to Minimize the Number of Route Discoveries and Hop Count per Path in Mobile Ad Hoc Networks"- Department of Computer Science, Jackson State University, Jackson, MS 39217, USA.

[11] Vincent D. Park and M. Scott Corson, "Temporally-Ordered Routing Algorithm (TORA) Version 1: Functional specification", Internet draft, draft-ietf-manettora-spec-01 .txt, August 1998.

[12] V.D Park and M.S Corson, "A highly adaptive distributed routing algorithm for mobile wireless Networks", Proc.INFOCOM'97, Apr.1997.

[13] J. Broch, David A. Maltz, David B. Johnson, Y-Ch Hu and J Jetcheva, "A performance Comparison of Multi-hop Wireless Ad Hoc Network for mobile ad hoc networks", in Proc. 4th annual IEEE/ACM international conference on Mobile Computing and Networking, Dallas, Texas, U.S. pp. 85-97, Oct. 1998.

[14] Josh Broch, David B. Johnsson, David A. Maltz, 'The Dynamic Source Routing Protocol for Mobile Ad Hoc Network", RFC-4728

[15] E.M. Royer and Charles E. Perkins, "Multicast Operation of the Ad-hoc On-Demand Distance Vector Routing Algorithm", University of California, Santa Barbara.

[16] Rohit Dube, Cynthia D.Rais, Kuang-Yeh Wang, and Satish K.Tripathi, "Signal Stability-based adaptive routing (SSA) for ad hoc mobile networks, IEEE Personal Communications, pp. 36-45, Feb. 1997.

[17] C.E. Perkins and E.M. Royer, "Ad-hoc On-Demand Distance Vector Routing", Proceedings of the 2nd IEEE Workshop on Mobile Computing Systems and Applications, New Orleans, LA, pp. 90-100, February 1999.

[18] P. Johansson,T. Larsson, N. Hedman, B. Mielczarek, M. Degermark, “Scenario-based Performance Analysis of Routing Protocols for Mobile Ad-hoc Networks”, Mobicom ‘99 Scattlc Washington USA, pp. 195-206

[19] Charles E. Perkins, “Ad Hoc On Demand Distance Vector (AODV) Routing”. Internet draft, draft-ietf-manetaodv- 0l.txt, August 1998. Work in progress.

[20] Charles E. Perkins, “Ad Hoc On Demand Distance Vector (AODV) Routing”. Internet draft, draft-ietf-manetaodv-02.txt, November 1998.

[21] Luke Klein-Bernd, “A Quick Guide to AODV Routing”, National Institute of Standards and Technology, US.

[22] Y.-B. Ko and N.H. Vaidya, Location-aided routing (LAR) in mobile ad hoc networks, in: Proc. of Mobicom’98 (1998).

[23] C-K. Toh, “A Novel Distributed Routing Protocol To Support Ad-Hoc Mobile Computing”, Proc. 1996 IEEE 15th Annual Int’l. Phoenix Conf.Comp. and Communication., pp. 480–86, Mar. 1996.

[24] C.E Perkins, E.M. Royer, and S. Das, “Ad hoc On-demand Distance Vector (AODV),” RFC 3561, July 2005.

[25] Abdul Hadi Abd Rahman and Zuriati Ahmad Zukarnain, “Performance Comparison of AODV, DSDV and I-DSDV Routing Protocols in Mobile Ad Hoc Networks”, European Journal of Scientific Research, ISSN 1450-216X Vol.31 No.4, pp.566-576, 2009.

[26] Josh Broch, David B. Johnsson, David A. Maltz, “The Dynamic Source Routing Protocol for Mobile Ad Hoc Networks”. Draft, draft-ietf-manet-dsr-00.txt, October 1999. Work in progress

[27] D. B. Johnson and D. A. Maltz, “Dynamic Source Routing in Ad Hoc Wireless Networks, Mobile Computing”, Chapter 5, pp. 153-181, Kluwer Academic Publishers, 1996,

[28] The VINT Project, The network simulator - ns-2. http://www.isi.edu/nsnam/ns/

[29] Padmini Misra, “Routing Protocols for Ad Hoc Mobile Wireless Networks” URL- http://www.cse.wustl.edu/~jain/cis788-99/ftp/adhoc_routing/

[30] Larry L. Peterson and Bruce S. Davie, “Computer Networks -A Systems

Approach". San Francisco, Morgan Kaufmann Publishers Inc. ISBN 1-55860-368-9.

[31] IEEE Computer Society LAN MAN Standards Committee, "Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) Specifications- IEEE Std 802", Nov-1997. The Institute of Electrical and Electronics, New York.

[32] The CMU Monarch Project, "The CMU Monarch Projects Wireless and Mobility Extensions to ns". http://www.monarch.cs.cmu.edu/ (1998-11-29).Work in progress.

[33] V. Davies, "Evaluating mobility models within an ad hoc network", Master's thesis, Colorado School of Mines, 2000.

[34] M. Zonoozi and P. Dassanayake, "User mobility modeling and characterization of mobility patterns. IEEE Journal on Selected Areas in Communications, 15(7): 1239-1252, September 1997.

[35] http://www.networksorcery.com/enp/protocol/dsr.htm-- Dynamic source routing protocol (DSR).

ANNEXURE-II

LIST OF PUBLICATIONS

[1] Vivek Kumar and Sumit Miglani, “Performance Comparison of Reactive Routing Protocols of MANET”, National conference on Emerging principles and Practices of Computer Science and Information Technology (EPPCSIT 2009), Guru Nanak Dev Engineering College, Ludhiana, September 4-5, 2009. [Communicated]