Study and Simulation for various Wireless Mesh Networks Routing Protocols

Project report submitted in partial fulfillment of the requirement for the degree of Bachelor of Technology

in

Computer Science and Engineering/Information Technology

By

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Certificate

Candidate’s Declaration

I hereby declare that the work presented in this report entitled**” Study and Simulation for various wireless Mesh Networks Routing Protocols”** in partial fulfillment of the requirements for the award of the degree of **Bachelor of Technology** in **Computer Science and Engineering/Information Technology** submitted in the department of Computer Science & Engineering and Information Technology**,** Jaypee University of Information Technology Waknaghat is an authentic record of my own work carried out over a period from August 2015 to December 2015 under the supervision of **Dr. Hemraj Saini .**

The matter embodied in the report has not been submitted for the award of any other degree or diploma.

(Student Signature)

Shashank Sharmaa, 123212

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

(Supervisor Signature)

Dr. Hemraj Saini

Assistant Professor

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Dated:

Acknowledgement

I would like to express our gratitude and appreciation to all those who have gave us the perfect environment for completion of this report. A special thanks to our final year project supervisor Dr. Hemraj Saini, whose simulating suggestions and encouragement helped us to get the trust of our topic and understanding the importance of this project. We would also acknowledge with much appreciation the crucial role of the staff of Computer Laboratory, who provided us with the lab facilities, as and when required.

Additionally, we appreciate the guidance given by the panels especially during the previous project presentation which made us realize the various dimensions we were probably missing out and hence, they gave away a room for improvement in the project. Again a special thanks to our friends who gave us valuable suggestions during the project

Date: **Shashank Sharma**

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List of Abbreviations

1. ETX : Expected Transmission Count
2. WMN : Wireless Mesh Network
3. ML : Minimum Loss
4. ETT : Expected transmission time
5. ELP : Expected Link Performance
6. RTT: Per-Hop Round Trip Time
7. PPD: Per-Hop Packet Pair Delay
8. ETOP: Expected Transmission on a Path
9. ENT: Effective Number of Transmissions
10. AODV-Ad-Hoc On-Demand Distance Vector Routing Algorithm
11. LQSR-Link Quallity Source Routing
12. DSR- Direct Source Routing

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Abstract

Wireless Mesh Networks (WMNs) are bringing revolutionary change in the field of wireless networking. It is a trustworthy technology in applications like broadband home networking, network management and latest transportation systems. WMNs consist of mesh routers, mesh clients and gateways. It is a special kind of wireless Ad-hoc networks. One of the issues in WMNs is resource management which includes routing and for routing there are particular routing protocols that gives better performance when checked with certain parameters. Parameters in WMNs include delay, throughput, network load etc. There are two types of routing protocols i.e. reactive protocols and proactive protocols. Three routing protocols AODV, DSR and OLSR have been tested in WMNs under certain parameters which are delay, throughput and network load. The testing of these protocols will be performed in the Network Simulator (ns2). The obtained results from NS2 will be displayed in this thesis in the form of graphs and figures. This thesis will help in validating which routing protocol will give the best performance under the assumed conditions. Moreover this thesis report will help in doing more research in future in this area and help in generating new ideas in this research area that will enhance and bring new features in WMNs.

CHAPTER 1- INTRODUCTION

1.1 Introduction

WIRELESS mesh networks (WMNs) are dynamically self-organized and self-confirmed, with the nodes in the network automatically establishing an ad hoc network and maintaining the mesh connectivity. WMNs are comprised of two types of nodes: mesh routers and mesh clients. Other than the routing capability for gateway/bridge functions as in a conventional wireless router, a mesh router contains additional routing functions to support mesh networking. Through multi-hop communications, the same coverage can be achieved by a mesh router with much lower transmission power. Mesh routers have minimal mobility and form the mesh backbone for mesh clients. Consequently, instead of being another type of ad-hoc networking, WMNs diversify the capabilities of ad-hoc networks. This feature brings many advantages to WMNs, such as low up-front cost, easy network maintenance, robustness, reliable service coverage, etc. Therefore, in addition to being widely accepted in the traditional application sectors of ad hoc networks, WMNs are undergoing rapid commercialization in many other application scenarios such as broadband home networking, community networking, building automation, high speed metropolitan area networks, and enterprise networking. Nevertheless, because of heterogeneous and disturbing wireless links conditions, preserving the efficient performance of such WMNs are still a tricky problem.

WMN Architecture:

Infrastructure/Backbone WMNs. In this architecture, mesh routers form an infrastructure for clients, as shown in Fig. 1.1, where dashed and solid lines indicate wireless and wired links, respectively. The WMN infrastructure/backbone can be built using various types of radio technologies. The mesh routers form a mesh of self-configuring, self-healing links among themselves. With gateway functionality, mesh routers can be connected to the Internet. This approach, also referred to as *infrastructure meshing*, provides a backbone for conventional clients and enables integration of WMNs with existing wireless networks, through gateway/bridge functionalities in mesh routers. Conventional clients with an Ethernet interface can be connected to mesh routers via Ethernet links. For conventional clients with the same radio technologies as mesh routers, they can directly communicate with mesh routers. If different radio technologies are used, clients must communicate with their base stations that have Ethernet connections to mesh routers.

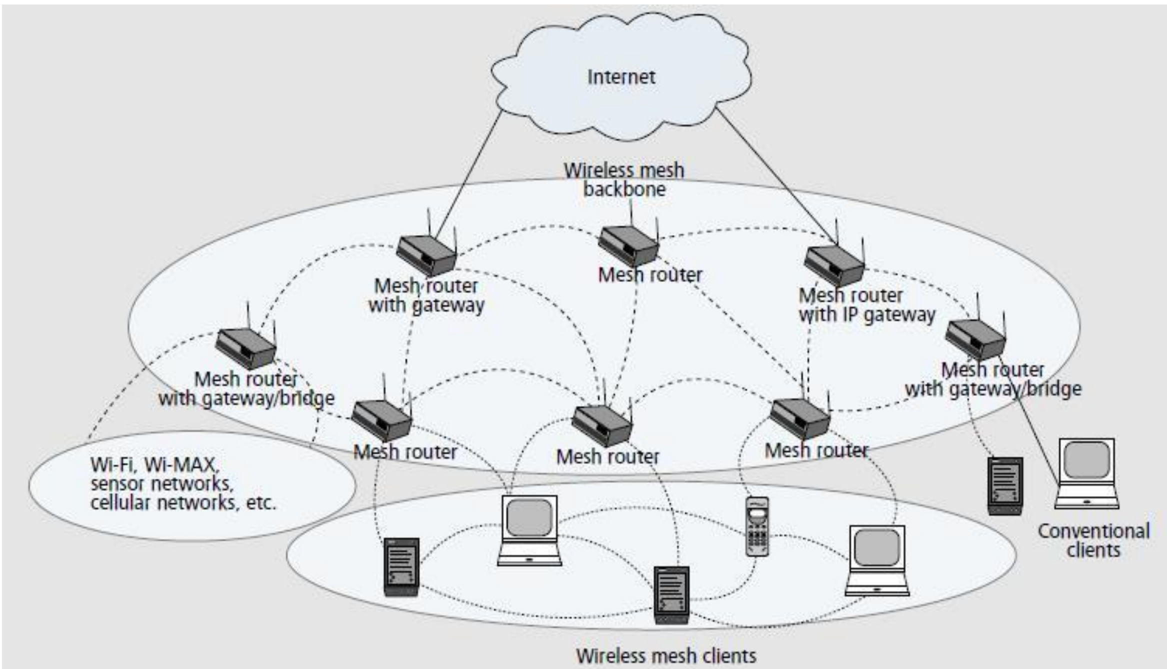


Fig.1.1 Infrastructure/Backbone WMNs

Client WMNs. *Client meshing* provides peer-to-peer networks among client devices. In this type of architecture, client nodes constitute the actual network to perform routing and configuration functionalities as well as providing end-user applications to customers. Hence, a mesh router is not required for these types of networks. Client *WMNs* are usually formed using one type of radios on devices. Thus, a Client *WMN* is actually the same as a conventional ad hoc network.

However, the requirements on end-user devices is increased when compared to infrastructure meshing, since in Client WMNs the end-users must perform additional functions such as routing and self-configuration.

Hybrid WMNs. This architecture is the combination of infrastructure and client meshing, as shown in Fig.1.2. Mesh clients can access the network through mesh routers as well as directly meshing with other mesh clients. While the infrastructure provides connectivity to other networks such as the Internet, Wi-Fi, WiMAX, cellular, and sensor networks, the routing capabilities of clients provide improved connectivity and coverage inside WMNs.

The characteristics of WMNs are outlined below, where the hybrid architecture is considered for WMNs, since it comprises all the advantages of WMNs:

• WMNs support ad hoc networking, and have the capability of self-forming, self-healing, and self-organization.

• WMNs are multi-hop wireless networks, but with a wireless infrastructure/backbone provided by mesh routers.

• Mesh routers have minimal mobility and perform dedicated routing and configuration, which significantly decreases the load of mesh clients and other end nodes.

• Mobility of end nodes is supported easily through the wireless infrastructure.

• Power-consumption constraints are different for mesh routers and mesh clients.

• WMNs are not stand-alone and need to be compatible and interoperable with other wireless networks.

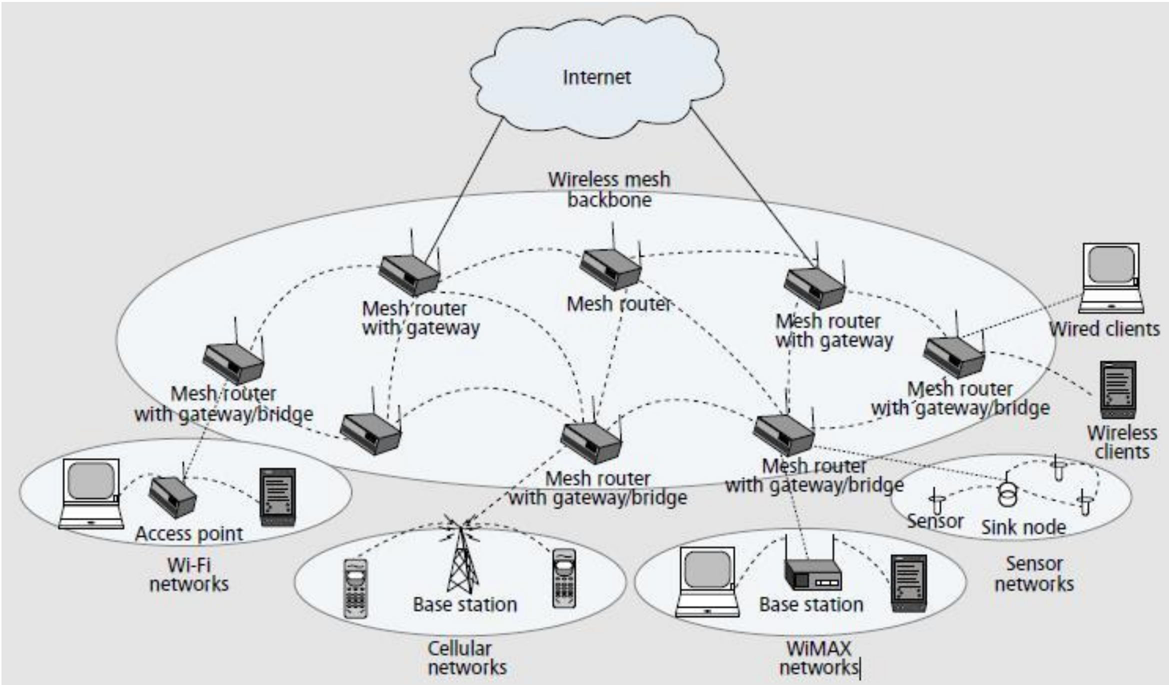


Fig.1.2 Hybrid WMNs

Routing in WMNs:

Routing protocols in wireless mesh networks can be divided into two categories: proactive and reactive . Proactive protocols involve a situation where network nodes continuously maintain one, or a number, of routing tables that store routes to each of the nodes of a network and, at the same time, recurrently send them along the network to exchange and update information in neighboring nodes. Reactive protocols, in turn, receive information on the route to the destination (node) of a packet only at the moment when data transmission is to be effected (on demand). These protocols do not generate additional traffic in the network, but the time needed for data to be forwarded is prolonged by the time necessary to effect the exchange of information concerning the available route.

Another classification of the protocols that takes into account their particular features is proposed in :

•**Hop Count Based Routing** – protocols based the on metrics of the hop-count type. Though these protocols do not in fact indicate the most effective connection paths, they are still in common use due to their low computational complexity.

• **Link-Level QoS Routing** – this group includes protocols that use the cumulative or the bottleneck value that defines the quality of the connection path (or section thereof).

• **End-to-End QoS Routing** – these protocols are based on the quality parameters, but in a global approach, i.e. for the end-to-end connection path.

• **Reliability-Aware Routing** – protocols based on the assumption of the availability of a number of simultaneous routes. In this group of protocols, depending of available implementation, packets are sent concurrently along a number of routes, or alternative routes are used only as an auxiliary solution.

• **Stability-Aware Routing** – protocols grouped in his category use a special architecture of the system to improve the stability of the operation of a network. These protocols prefer cable connection links in MESH networks or links in which no sections (segments) that are executed via mobile users are included.

• **Scalable Routing** – protocols for large networks where scalability is pivotal. The most typical representatives of this category are the hierarchical and the geographical routing.

1.2 Problem Statement:

To compare the performance of all the four routing protocols (aodv, dsr dsdv and olsr) and then to make the observations about how the performance of these routing protocols can be improved. Performance of these routing protocols are compared on the basis of various parameters such as throughput, delay and packet delivery ratio.

1.3 Objectives:

An optimal routing protocol for WMNs must capture the following features:

• **Multiple Performance Metrics.** Many existing routing protocols use minimum hop-count as a performance metric to select the routing path. This has been demonstrated to be ineffective in many situations.

• **Scalability.** Setting up or maintaining a routing path in a very large wireless network may take a long time. Thus, it is critical to have a scalable routing protocol in WMNs.

• **Robustness.** To avoid service disruption, WMNs must be robust to link failures or congestion. Routing protocols also need to perform load balancing.

• **Efficient Routing with Mesh Infrastructure.** Considering the minimal mobility and no constraints on power consumption in mesh routers, the routing protocol in mesh routers is expected to be much simpler than ad hoc network routing protocols. With the mesh infrastructure provided by mesh routers, the routing protocol for mesh clients can also be made simple.

The main objective is to compare the performance of all the three routing protocols (aodv, dsr and dsdv) and then to make the observations about how the performance of these routing protocols can be improved.Performance

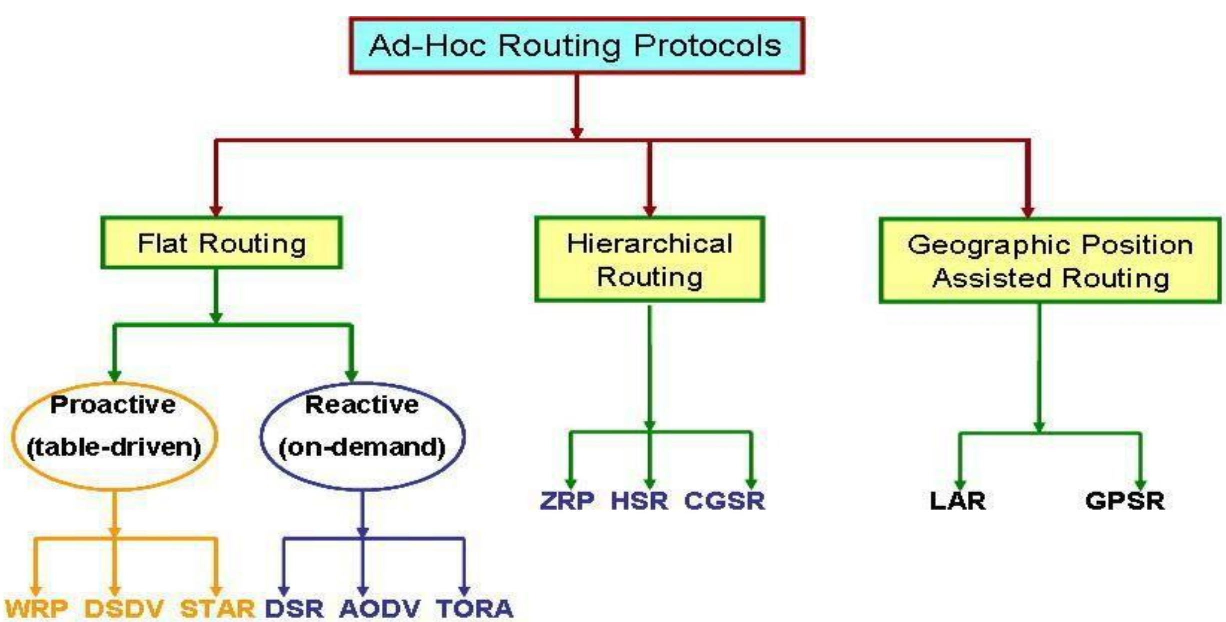
1.4 METHODOLOGY

The methods that we will be using throughout the project:

Phase1:

1.1: We will do a thorough literature review to examine the existing techniques. For this purpose we will conduct searching various Data Bases such as IEEE, Compendex, Google Scholar and Inspec. The detailed literature review will help us to understand the current techniques and to develop the theoretical base for our own research. We will examine Wireless Mesh Networks and their mechanisms, we will count the development of WMNs and their important applications and their added value to wireless networks [9], [10]. We would also study the connection means and mobility in WMN and the self healing mechanism it uses when the route to some nodes is terminated.

1.2: In the second part of literature review by studying characteristics of routing in wireless networks we give grounds to routing protocols. We assess different Ad-Hoc routing protocols, stating their attributes and behavior in different network conditions. We will also discuss the mechanisms of reactive and proactive protocols and how hybrid protocols utilize both of them. From this we will try to find the specific characteristics of our routing protocols. We would candidate protocols for our simulation.



Phase 2:

In second phase, we will be going to implement and simulate our research ideas. OPNET Modeler is a reliable simulation and design tool [22]. This is a technical phase, which includes the transformation of theoretical platform into simulating environment. We will design scenarios for simulation to provide an environment that represents a wireless mesh network with fixed server and routers and fixed and mobile nodes. We make these scenarios by varying the number of nodes and network elements and then varying mobility characteristics of the workstations and/or altering the background traffic represented in the whole network by servers.

Phase 3:

Performance evaluation will be conducted in this phase. Simulation results will be studied by a comparative analysis approach. Comparative analysis will show us how much correlation is obtained. This phase deals with simulation verification and mostly validation of the results. In this phase certain network performance parameters such as delay, packet loss and routing load will be analyzed and based on these parameters the efficiency of the routing mechanisms are observed. We will run our simulation and collect the results from several scenarios that have been designed in the last phase. Measured values in form of raw data are the result of simulation Run, which are based on scenarios with altering number of nodes and mobility. The results will be presented in tables and graphs to allow easy comparison. We will use Microsoft Excel to sketch our graphs for better understanding.

Phase4:

In the last phase we present the optimal conditions for each routing protocol. We define the conditions that each protocol can reach its maximum performance potential. We would also introduce one protocol that has the best performance in different general conditions.

1.5 Organization:

The rest of the report is organized as follows:

- Chapter 2 describes about the background and related work of the project. In this chapter we will focus on the work already done on WMN routing protocols. We will study different papers published and then try to implement any one of the algorithm in our project.
- Chapter 3 describes the the analysis done for System Development.. Basics of ns2, Its commands and NAM are also explained next. It tells the basic steps to create a simple network on the simulator and also discusses the performance metrics for the packet transfer over the network.
- Chapter 4 describes the performance analysis.
- Chapter 5 contains the conclusion and scope for further improvement in this project.

CHAPTER 2- LITERATURE SURVEY

2.1 A Survey on Wireless Mesh Networks.

IAN F. AKYILDIZ, GEORGIA INSTITUTE OF TECHNOLOGY XUDONG WANG, KIYON, INC.

Wireless mesh networks (WMNs) have emerged as a key technology for next-generation wireless networking. Because of their advantages over other wireless networks, WMNs are undergoing rapid progress and inspiring numerous applications. However, many technical issues still exist in this field. In order to provide a better understanding of the research challenges of WMNs, this article presents a detailed investigation of current state-of-the-art protocols and algorithms for WMNs. Open research issues in all protocol layers are also discussed, with an objective to spark new research interests in this field.

2.2 Routing protocols in wireless mesh networks – a comparison and classification

Piotr Owczarek, Piotr Zwierzykowski

Wireless Mesh Networks can give an answer for many open issues in the field of wireless net-works. For WMN to be effective enough, it is required for a chosen routing protocol based on routing metrics that fits application needs to be used properly. Until now, many different routing protocols have been proposed. All of them have their own characteristics and there is no easy way to make any reliable comparison. The proposed paper presents a review of the current state-of-the-art WMN routing protocols and metrics. The paper also includes an evaluation of properties and proposed classification of WMN routing protocols. Furthermore authors attempted to make a comparison of different features of selected routing metrics and characteristics of selected routing protocols.

2.3 **Wireless Mesh Networking Technology for Commercial and Industrial Customers Abdulrahman Yarali, IEEE Member, Murray State University**

Wireless Mesh Networks (WMNs) havebeen receiving a great deal of attention as a broadbandaccess alternative for a wide range of markets, includingthose in the metro, public-safety, energy, education,enterprise, carrier-access and residential sectors. Understanding the strengths and weaknesses of single, dual, and multi-radio mesh options is the first step. In this paper simulation results for three distinct generations of wireless mesh configuration is presented. The paper also address some of the technical influences of WMNs and in particular focus on the opportunities that wireless mesh technologies provide for implementing more efficient processes and smarter working for commercial and industrial customers.

2.4 Comparative analysis of link quality metrics and routing protocols for optimal route construction in wireless mesh networks Seongkwan Kim , Okhwan Lee , Sunghyun Choi , Sung-Ju Lee.

A comparative analysis of various routing strategies that affect the end-to-end performance in wireless mesh networks. We first improve well-known link quality metrics and routing algorithms to enhance performance in wireless mesh environments. We then investigate the route optimality, i.e., whether the best end-to-end route with respect to a given link quality metric is established, and its impact on the network performance. Network topologies, number of concurrent flows, and interference types are varied in our evaluation and we find that a non-optimal route is often established because of the routing protocol’s misbehaviour, inaccurate link metric design, interflow interference, and their interplay. Through extensive simulation analysis, we present insights on how to design wireless link metrics and routing algorithms to enhance the network capacity and provide reliable connectivity.

2.5 Improving Simulation for Network Research.

New protocols and algorithms are being developed to meet changing operational requirements in the Internet. Simulation is a vital tool to quickly and inexpensively explore the behavior of these new protocol across the range of topologies, cross-traÆc, and interactions that might occur in the Internet. This paper describes ns, a widely used, multi-protocol network simulator designed to address the needs of networking researchers. Ns provides multiple levels of abstraction to permit simulations to span a wide-range of scales, emulation, where real-world packets can enter the simulator.

2.6 Novel joint routing and scheduling algorithms for minimizing end-to-end delays in multiTx- Rx wireless mesh networks.

Multiple transmit(Tx) or receive(Rx) capability is a significant advance in wireless communications. This so called MTR capability allows the creation of wireless mesh networks(WMNs) that are ideal for use as a high speed wireless backbone that span vast geographical areas. A fundamental problem, however, is deriving a minimal transmission schedule or superframe that yields low end-to-end delays,with the primary constraint that routers are not allowed to Tx*and*Rx simultaneously. In this pape r, joint routing and link scheduling approach that addresses two fundamental issues that influence end-to-enddelays: super frame length and transmission slot order. Shortening the super frame length, in terms of slots, is expected to minimize the inter-link activation time while reordering transmissions lots increases the likelihood that links on a path are activated consecutively.

CHAPTER 3 – SYSTEM DEVELOPMENT

3.1 ANALYSIS:

3.1.1 METRICS USED IN WIRELESS MESH NETWORKS

The metrics that have been proposed for mesh networks can be divided as follows :

- metrics related to the number of hops (Hop Count),
- metrics that determine the quality of a connection (Link Quality Metrics)
- metrics that are based on network load rate (Load-Dependant Metrics),
- Multi Channel Metrics.

The Hop Count Metrics is the oldest type of metric that has been used in the RIP protocol since the inception of the Internet. More attention should be given then to the remaining metrics. One can distinguish seven metrics based on the link quality : Expected Transmission Count (ETX), Minimum Loss (ML) , Expected Transmission Time (ETT) , Expected Link Performance (ELP) , Per-Hop Round Trip Time (RTT), Per-Hop Packet Pair Delay (PPD) and Expected Transmission on a Path (ETOP). Load-Dependent Metrics include: Distribution Based Expected Transmission Count (DBEXT) and Bottleneck Aware Routing Metric (BATD). The following multi-channel metrics stand out among other multi-channel metrics: Weighted Cumulative ETT (WCETT), Metric of Interference and Channel-switching (MIC) , Modified ETX (mETX) , Effective Number of Transmissions (ENT), iAWARE – and Exclusive Expected Transmission Time (EETT) . Table below shows a comparison of selected characteristics of the metrics used in most routing protocols for mesh networks. Results shown in the table are the effects of comparison made by the authors of the article based on the available literature sources.

Table 1. A comparison of main routing metrics

Name of Metric	Quality-aware	Data Rate	Packet Size	Intra-flow Interferences	Inter-flow Interferences	Medium Instability
Hop Count Metrics						
Hop	×	×	×	×	×	×
Link-Quality Metrics						
ETX	✓	×	×	×	×	×
ML	✓	×	×	×	×	×
ETT	✓	✓	✓	×	×	×
ELP	✓	×	×	✓	✓	×
RTT	✓	✓	×	×	×	×
PPD	✓	✓	✓	×	×	✓
ETOP	✓	×	×	×	×	×
Load-Dependent Metrics						
DBEXT	✓	×	×	✓	×	✓
BATD	✓	✓	×	✓	×	×
Multi-Channel Metrics						
WCETT	✓	✓	✓	✓	×	×
MIC	✓	✓	✓	✓	✓	×
mETX	✓	✓	✓	×	×	✓
ENT	✓	✓	✓	×	×	✓
iAWARE	✓	✓	✓	✓	✓	✓
EETT	✓	✓	✓	✓	×	×

Table 3.1

3.1.2 ROUTING PROTOCOLS IN AD HOC NETWORKS

HOP COUNT BASED ROUTING PROTOCOLS:

I. Light Client Management Routing Protocols (LCMR)

In this protocol, the destination routing path from the sender to the receiver between routers in the net-work is selected in the proactive way, whereas the path between clients and the routers of the network in the reactive way. In order to determine the best route, the hop-count metric is used. In this protocol, the functionality of routing is based exclusively on routers. To achieve that, routers service two routing tables: one for local clients of the network, the other for clients and remote routers. On the basis of the information they store, destination routing paths are selected.

II. Orthogonal Rendezvous Routing Protocols (ORR)

The operation of this pro-tocol is based on the assumption that in the two-dimensional Euclidean space two orthogonal lines have at least two common points with a group of other orthogonal Lines. In the process of finding a route, the source node sends a route discovery packet in the orthogonal directions, while the destination node sends a route dissemination packet. The packets meet in a node called the rendezvous point. In this way, the end-to-end routing path is established in which the segment from the source to the rendezvous point is a reactive route, whereas the other part is a pro-active route. This protocol requires a strict description of the directions towards the nodes of a network.

III. HEAT Protocol

The HEAT protocol uses distribution of temperature. The protocol adopts that each of the nodes of a network is a source of heat. The assumption is that gateways are the warmest, followed by nodes/clients that in the closest vicinity, and that the further from gateways, the temperature becomes lower and lower. Using the temperature distribution, the protocol always sends packets to a neighbouring node that has the warmest temperature, thus reaching the destination.

IV. Dynamic Source Routing Algorithm (DSR)

DSR is one of the most commonly used routing protocol in WMN networks and belongs to the group of unicast reactive protocols. The protocol uses source routing, which results in the knowledge of the whole of the destination routing path by any packet. The operation of the protocol occurs in the two consecutive stages: the route discovery phase and the route maintenance phase. The first, initiated by the source node, involves sending broadcast packets that include the destination address, the source address and a unique id to neighbouring nodes. If the packet is received by a node that is not a destination node, this node adds its address to the header and then forwards the packet according to the same scheme. Thus, a packet that has reached its destination has in its header information on the end-to-end connection path. On the basis of information carried in the header, intermediate nodes collect information on routing paths. In the second phase, nodes supervise updated information on stored routes by generating error packets (RERR) forwarded towards the source node. When such a packet is received, a given router is removed from the database and further process proceeds in line with the phase one described earlier.

V. Ad-Hoc On-Demand Distance Vector Routing Algorithm (AODV)

The AODV protocol belongs to the most popular protocols because they employ simple mechanisms of the type “question - reply” to define routing paths. For this pur-pose, three types of packets are used: Route Request (RREQ), Route Reply (RREP) and Route Error (RERR). The source node sends RREQ packets when a necessity to send packets arises and then intermediate nodes, provided they know the route, send a RREQ packet further on towards the destination node, whereas when intermediate nodes do not know the route, they reply with a RERR packet. This process is then repeated until the packet reaches the destination node (the node sends then a RREP packet). In the case when the node receives RREQ packets from different routes, then the route along which the packet has reached the node as first is selected.

LINK LEVEL BASED ROUTING PROTOCOLS

I. Link Quality Source Routing Protocol (LQSR)

A reactive routing protocol proposed by Microsoft Research Group that is based on the Dynamic Source Routing (DSR) algorithm. To improve the quality of the link, the LQSR protocol employs single link parameters instead of end-to-end path parameters. In the process of setting a connection path, the protocol describes individual links by the quality metric, and then sends back the information to the node that initiates the setting up of the path. Quality parameters may vary depending on the mobility of nodes and metrics used in the process, e.g. for stationary nodes they may include strictly quality parameters such as ETX, while for mobile nodes this can be a hop-count based parameter such as RTT and ETX. Though the protocol has many ad-vantages, it is still necessary to develop more appropriate routing metrics that would take into account the specificity of the WMN network and the features of the LQSR protocol

II. Multi-Radio LQSR Routing Protocol (MR-LQSR)

A protocol based on LQSR that takes into consideration the use of the multi-radio architecture in WMN networks. This is effected by the application of WCETT metrics that take into ac-count both quality parameters of the link and the minimum number of hops. This protocol makes it possible to achieve the expected equilibrium (balance) between the delay and the throughput by selecting channels of best quality with a diversity of radio channels taken into account. The protocol also allows researchers to effectively compensate load among individual radio channels.

III. AODV – Spanning Tree Protocol (AODV-ST)

This protocol has been specially designed for WMN networks that use a multi-radio architecture and is based on the AODV protocol. The special feature of the AODV-ST is hybrid routing, which means that it employs AODV mechanisms for internetwork routing in WMNs and Spanning Tree (ST) between the network and edge routers. In short, AODV-ST makes advantage of proactive routing between nodes of the network and routers, and reactive routing with nodes of the internal WMN network. The AODV-ST protocol uses the ETT metric taking into account the expected time for a given packet traversing the link necessary to reach its destination

IV. BABEL Routing Protocol

BABEL is a proactive protocol based on the dis-tance-vector routing protocol. During the process of selection of tracks, it takes advantage of some historical information available, including the error statistics for individual links. Within this process, links that have been used earlier and their quality satisfies the assumed criteria are favored in selection. The BABEL protocol performs simultaneously updating of the state of neighboring nodes (in the reactive way) and can make an exchange of routing information (e.g. following a failure of a link) effective.

V. Better Approach To Mobile Ad Hoc (B.A.T.M.A.N.)

A proactive protocol that shows a different approach to the selection of a connection path. Here, nodes find only the appropriate (adequate) link towards the source without taking into consideration the end-to-end route. Data are forwarded to the next node along the route, while the procedure is repeated according to the same assumption. The pro-cess is regarded to be completed when the destination node is reached. Each of nodes recurrently sends broadcasts to let the neighbouring nodes about its existence. The neighbouring nodes forward this information on until all the nodes in the net-work receive appropriate information on the other nodes in the network.

END-TO-END QOS ROUTING

I. Quality Aware Routing Protocol

This protocol makes it possible to maintain a given loss ratio along the end-to-end connection path through appropriate use of the ETX and ENT metrics. During the selection process of feasible connection routes, the number of retransmissions is checked and then this number is compared with the maximum admissible value in the protocols of the link layer. So long as the ENT value is higher than the admissible value, the link cost is deemed as infinitely high. At the same time, the ETX metric is also used to estimate the cost of individual links and, following that, links that do not satisfy the assumed parameters are eliminated from the connection route. The most important in this protocol

II. Ring-Mesh Routing Protocol

The protocol is based on the Token Ring protocol for wireless LAN networks. The protocol assumes that many concurrent rings are emerging to maintain a secure service of the WMN network with a large number of hops. Individual rings are implemented in the direction from the gateway to the rest of nodes, similarly as in the case of the Spaning Tree. Another assumption is that neighboring rings use different radio frequencies. The ring that spans the gateway is treated as the root ring, whereas other rings are the so-called child rings. Individual rings always include a common node called the pseudo gateway. Subsequent nodes of the network implement further rings created according to the procedure described above and to the transmission delay criterion opposite the source node.

Table 2. Characteristic features of particular groups of routing protocols [9]

Lp	Category of routing protocols	Features
1	Hop-count routing	Simple in routing metric; easy to be integrated with complicated schemes of routing path selection
2	Link-quality based routing	A certain metric for link quality is used to select routing path
3	Interference based routing	Interference or contention is directly considered in routing
4	Load-balanced routing	Congestion or network capacity is explicitly considered
5	Stability based routing	Stability has higher priority
6	End-toEnd QoS Routing	End-to-end QoS is ensured

3.1.3 Proactive and Reactive Protocols

Routing protocols in wireless mesh networks can be divided into two categories: proactive and reactive. Proactive protocols involve a situation where network nodes continuously maintain one, or a number, of routing tables that store routes to each of the nodes of a network and, at the same time, recurrently send them along the network to exchange and update information in neighboring nodes. Reactive protocols, in turn, receive information on the route to the destination (node) of a packet only at the moment when data transmission is to be effected (on demand). These protocols do not generate additional traffic in the network, but the time needed for data to be forwarded is prolonged by the time necessary to effect the exchange of information concerning the available route.

3.2 FOCUS

3.2.1Table-Driven (or Proactive)

The nodes maintain a table of routes to every destination in the network, for this reason they periodically exchange messages. At all times the routes to all destinations are ready to use and as a consequence initial delays before sending data are small. Keeping routes to all destinations up-to-date, even if they are not used, is a disadvantage with regard to the usage of bandwidth and of network resources.

a) DSDV (Destination-Sequence Distance Vector)

DSDV has one routing table, each entry in the table contains: destination address, number of hops toward destination, next hop address. Routing table contains all the destinations that one node can communicate. When a source A communicates with a destination B, it looks up routing table for the entry which contains *destination* address as B. Next hop address C was taken from that entry. A then sends its packets to C and asks C to forward to B. C and other intermediate nodes will work in a similar way until the packets reach B. DSDV marks each entry by sequence number to distinguish between old and new route for preventing loop.

DSDV use two types of packet to transfer routing information: full dump and incremental packet. The first time two DSDV nodes meet, they exchange all of their available routing information in full dump packet. From that time, they only use incremental packets to notice about change in the routing table to reduce the packet size. Every node in DSDV has to send update routing information periodically. When two routes are discovered, route with larger sequence number will be chosen. If two routes have the same sequence number, route with smaller hop count to destination will be chosen.

DSDV has advantages of simple routing table format, simple routing operation and guarantee loop-freedom. The disadvantages are

(i) a large overhead caused by periodical update

(ii) waste resource for finding all possible routes between each pair, but only one route is used.

3.2.2 On-Demand (or Reactive)

These protocols were designed to overcome the wasted effort in maintaining unused routes. Routing information is acquired only when there is a need for it. The needed routes are calculated on demand. This saves the overhead of maintaining unused routes at each node, but on the other hand the latency for sending data packets will considerably increase.

In on-demand trend, routing information is only created to requested destination. Link is also monitored by periodical Hello messages. If a link in the path is broken, the source needs to rediscovery the path. On-demand strategy causes less overhead and easier to scalability. However, there is more delay because the path is not always ready. The following part will present AODV, DSR, TORA and ABR as characteristic protocols of on-demand trend.

b) AODV Routing

Ad hoc on demand distance vector routing (AODV) is the combination of DSDV and DSR. In AODV, each node maintains one routing table. Each routing table entry contains:

- Active neighbor list: a list of neighbor nodes that are actively using this route entry. Once the link in the entry is broken, neighbor nodes in this list will be informed.
- Destination address
- Next-hop address toward that destination
- Number of hops to destination
- Sequence number: for choosing route and prevent loop
- Lifetime: time when that entry expires

Routing in AODV consists of two phases: Route Discovery and Route Maintenance. When a node wants to communicate with a destination, it looks up in the routing table. If the destination is found, node transmits data in the same way as in DSDV. If not, it start Route Discovery mechanism: Source node broadcast the Route Request packet to its neighbor nodes, which in turns rebroadcast this request to their neighbor nodes until finding possible way to the destination. When intermediate node receives a RREQ, it updates the route to previous node and checks whether it satisfies the two conditions: (i) there is an available entry which has the same destination with RREQ (ii) its sequence number is greater or equal to sequence number of RREQ. If no, it rebroadcast RREQ. If yes, it generates a RREP message to the source node. When RREP is routed back, node in the reverse path updates their routing table with the added next hop information. If a node receives a RREQ that it has seen before (checked by the sequence number), it discards the RREQ for preventing loop. If source node receives more than one RREP, the one with greater sequence number will be chosen. For two RREPs with the same sequence number, the one will less number of hops to destination will be chosen. When a route is found, it is maintained by Route Maintenance mechanism: Each node periodically send Hello packet to its neighbors for proving its availability. When Hello packet is not received from a node in a time, link to that node is considered to be broken.

The node which does not receive Hello message will invalidate all of its related routes to the failed node and inform other neighbor using this node by Route Error packet. The source if still want to transmit data to the destination should restart Route Discovery to get a new path. AODV has advantages of decreasing the overhead control messages, low processing, quick adapt to net work topology change, more scalable up to 10000 mobile nodes . However, the disadvantages are that AODV only accepts bi-directional link and has much delay when it initiates a route and repairs the broken link.

c) DYNAMIC SOURCE ROUTING PROTOCOL

DSR is a reactive routing protocol which is able to manage a MANET without using periodic table-update messages like table-driven routing protocols do. DSR was specifically designed for use in multi-hop wireless ad hoc networks. Ad-hoc protocol allows the network to be completely self-organizing and self-configuring which means that there is no need for an existing network infrastructure or administration.

For restricting the bandwidth, the process to find a path is only executed when a path is required by a node (On-Demand-Routing). In DSR the sender (source, initiator) determines the whole path from the source to the destination node (Source-Routing) and deposits the addresses of the intermediate nodes of the route in the packets.

Compared to other reactive routing protocols like ABR or SSA, DSR is beacon-less which means that there are no hello-messages used between the nodes to notify their neighbours about her presence.

DSR was developed for MANETs with a small diameter between 5 and 10 hops and the nodes should only move around at a moderate speed. DSR is based on the Link-State-Algorithms which mean that each node is capable to save the best way to a destination. Also if a change appears in the network topology, then the whole network will get this information by flooding.

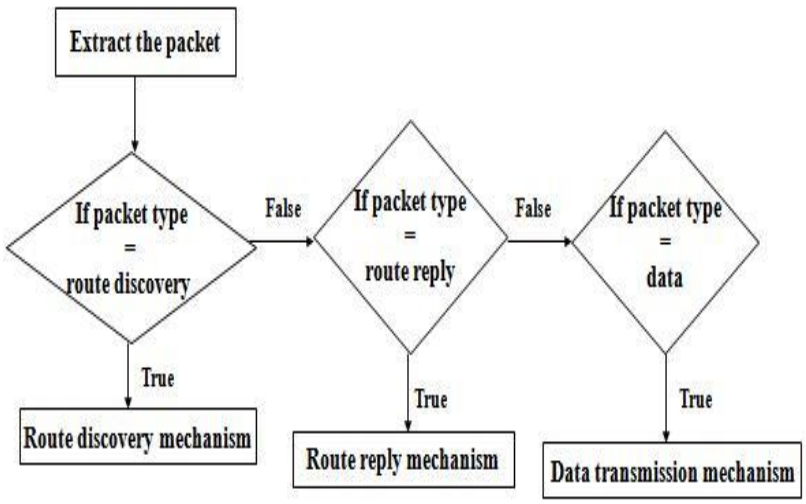


Fig 3: Basic operation- Flow chart of Dynamic Source routing protocol

DSR contains 2 phases

1.Route Discovery(find a path)

2.Route Maintenance (maintain a path)

Route Discovery

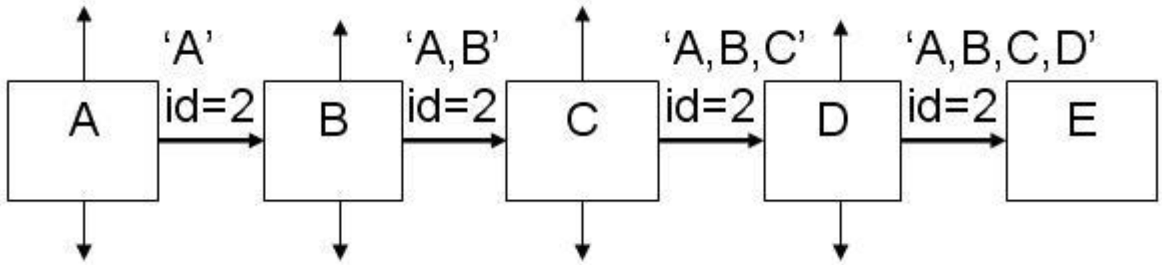


Fig 3.2 Route Discovery

If node A has in his Route Cache a route to the destination E, this route is immediately used. If not, the Route Discovery protocol is started:

1. Node A (initiator) sends a RouteRequest packet by flooding the network

2. If node B has recently seen another RouteRequest from the same target or if the address of node B is already listed in the Route Record, Then node B discards the request!

3. If node B is the target of the Route Discovery, it returns a RouteReply to the initiator.

   The RouteReply contains a list of the “best” path from the initiator to the target. When the initiator receives this RouteReply, it caches this route in its Route Cache for use in sending subsequent packets to this destination.

4. Otherwise node B isn’t the target and it forwards the Route Request to his neighbors

   (except to the initiator).

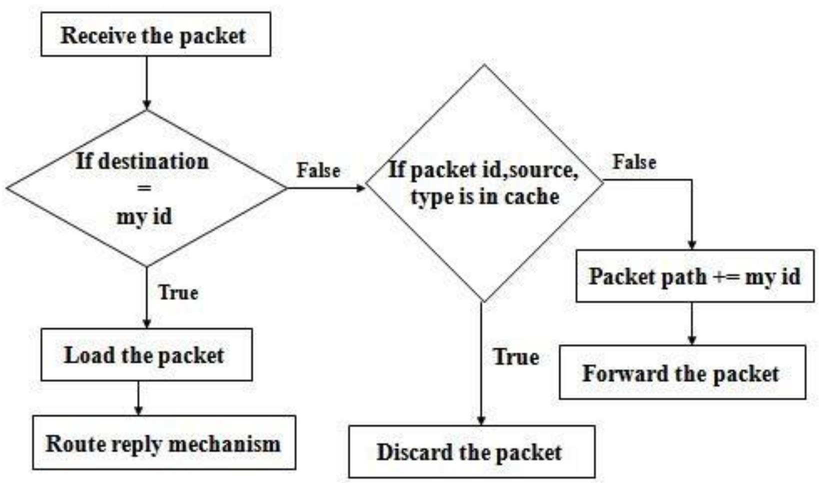


Fig 4:Path Request: Route Request Mechanism

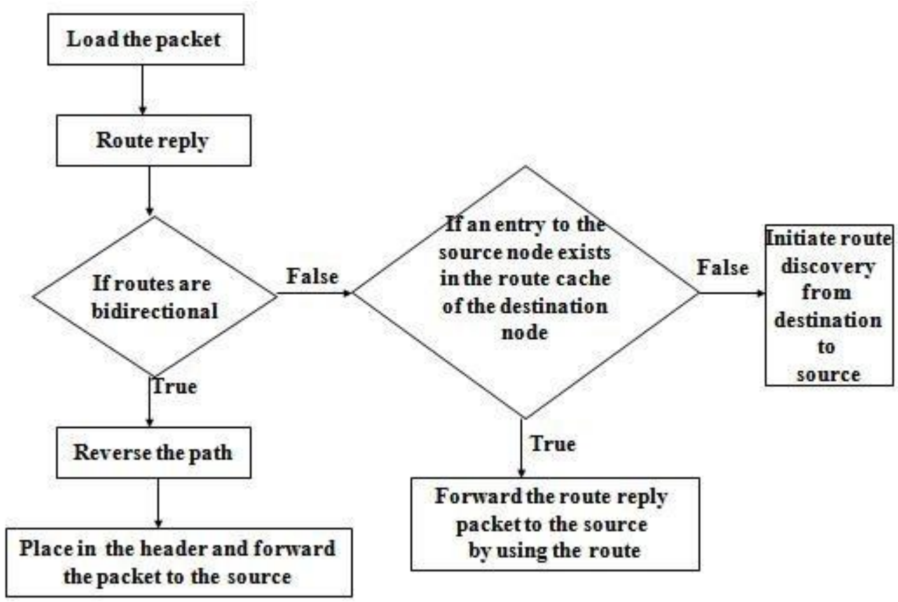


Fig 5:Path Reply: Route reply mechanism

Route Maintenance

In DSR every node is responsible for confirming that the next hop in the Source Route receives the packet. Also each packet is only forwarded once by a node (hop-by-hop routing). If a packet can’t be received by a node, it is retransmitted up to some maximum number of times until a confirmation is received from the next hop.

Only if retransmission results then in a failure, a Route Error message is sent to the initiator that can remove that Source Route from its Route Cache. So the initiator can check his Route Cache for another route to the target. If there is no route in the cache, a RouteRequest packet is broadcasted.

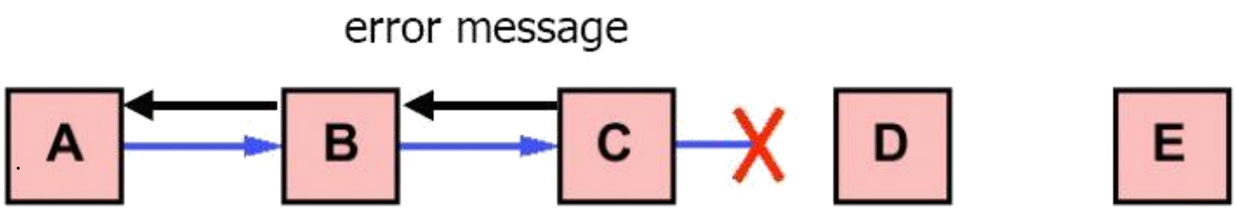


Fig 3.5 Error occurred between node C and D

1. If node C does not receive an acknowledgement from node D after some number of requests, it returns a RouteError to the initiator A.
2. As soon as node receives the RouteError message, it deletes the broken-link-route from its cache. If A has another route to E, it sends the packet immediately using this new route.
3. Otherwise the initiator A is starting the Route Discovery process again.

Advantages

Reactive routing protocols have no need to periodically flood the network for updating the routing tables like table-driven routing protocols do. Intermediate nodes are able to utilize the Route Cache information efficiently to reduce the control overhead. The initiator only tries to find a route (path) if actually no route is known (in cache). Current and bandwidth saving because there are no hello messages needed (beacon-less).

Disadvantages

The Route Maintenance protocol does not locally repair a broken link. The broken link is only communicated to the initiator. The DSR protocol is only efficient in MANETs with less then 200 nodes. Problems appear by fast moving of more hosts, so that the nodes can only move around in this case with a moderate speed. Flooding the network can cause collusions between the packets. Also there is always a small time delay at the begin of a new connection because the initiator must first find the route to the target.

3.3 Pseudo code :For a simple mesh topology

```
************************************************************************#
#Aim : To monitor traffic for Mesh topology using NS2
#************************************************************************#

#Create a simulator object
set ns [new Simulator]

#Open the nam trace file
set nf [open out.nam w]
$ns namtrace-all $nf

#Define a 'finish' procedure
proc finish {} {
   global ns nf
   $ns flush-trace
   #Close the trace file
   close $nf
   #Executenam on the trace file
   exec nam out.nam &
   exit 0
}

#Create four nodes
set n0 [$ns node]
set n1 [$ns node]
set n2 [$ns node]
set n3 [$ns node]

#Create links between the nodes
$ns duplex-link $n0 $n1 1Mb 10ms DropTail
$ns duplex-link $n0 $n2 1Mb 10ms DropTail
$ns duplex-link $n0 $n3 1Mb 10ms DropTail
$ns duplex-link $n1 $n2 1Mb 10ms DropTail
$ns duplex-link $n1 $n3 1Mb 10ms DropTail
$ns duplex-link $n2 $n3 1Mb 10ms DropTail

#Create a TCP agent and attach it to node n0
set tcp0 [new Agent/TCP]
$tcp0 set class_ 1
$ns attach-agent $n1 $tcp0
#Create a TCP Sink agent (a traffic sink) for TCP and attach it to node n3
set sink0 [new Agent/TCPSink]
$ns attach-agent $n3 $sink0
#Connect the traffic sources with the traffic sink
$ns connect $tcp0 $sink0

# Create a CBR traffic source and attach it to tcp0
set cbr0 [new Application/Traffic/CBR]
$cbr0 set packetSize_ 500
$cbr0 set interval_ 0.01
$cbr0 attach-agent $tcp0
```

#Schedule events for the CBR agents
$ns at 0.5 "$cbr0 start"
$ns at 4.5 "$cbr0 stop"

#Call the finish procedure after 5 seconds of simulation time
$ns at 5.0 "finish"

#Run the simulation
$ns run

3.5 Pseudo code(algorithm) for transmission using LQSR Protocol.

(1) Monitoring period(tm)

for every link j **do**

measure link-quality (lq) using passive monitoring;

end for

send monitoring results to a gateway g;

(2) Failure detection and group formation period (tx)

if link l violates link requirements r **then**

request a group formation on channel c of link l ;

end if

participate in a leader election if a request is received;

(3) Planning period (M ,tp)

if node i is elected as a leader **then**

send a planning request message (c ,M) to a
gateway; **else if** node is a gateway **then**

synchronize requests from reconfiguration groups
Mn generate a reconfiguration plan (p) for Mi ;

send a reconfiguration plan to a leader of Mi;

end if

**(4) Reconfiguration period (p
,tx) if p** includes changes of
node i **then** apply the changes to

links at t;

end if

relay to neighboring members, if any

3.6 Performance Metrics

The performance metrics helps to characterize the network that is substantially affected by the routing algorithm to achieve the required Quality of Service (QoS). In this work, the following metrics are considered.

End-to-End Delay(EED): It is the time taken for an entire message to completely arrive at the destination from the source. Evaluation of end-to-end delay mostly depends on the following components i.e. propagation time (PT), transmission time (TT), queuing time (QT) and processing delay (PD). Therefore, EED is evaluated as:

EED = PT + TT + QT + PD. (1)

Throughput: It is the measure of how fast a node can actually sent the data through a network. So throughput is the average rate of successful message delivery over a communication channel.

Control Overhead: It is ratio of the control information sent to the actual data received at each node.

Packet Delivery Ratio (PDR): It is the ratio of the total data bits received to total data bits sent from source to destination

Table: Simulation parameters

Parameter	**Value**
Simulator	NS-2 (Version 2.34)
Channel type	Channel/Wireless channel
Radio-propagation model	Propagation/Two ray round wave
Network interface type	Phy/WirelessPhy
MAC Type	Mac /802.11
Interface queue Type	Queue/Drop Tail
Link Layer Type	LL
Antenna	Antenna/Omni Antenna
Maximum packet in ifq	60
Area (M*M)	500 5 900
Number of mobile node	16
Source Type	UDP, TCP
Simulation Time	350 sec
Routing Protocols	AODV, DSDR& DSR

3.7 Hardware and Software Specification

3.5.1 Hardware Specification

Main processor	Intel(R) Core(TM) i5-2410M CPU @ 2.30GHz
Hard disk capacity	500 GB
Cache memory	512 MB

3.5.2 Software specification:

- The Software Used for Simulation of Protocols would be NS2(Network Simulator 2)
- NS is a discrete event simulator targeted at network research.

  - Physical activities are translated to events.
  - Events are queued and processed in the order of their scheduled occurrences.
  - Time progresses as the events are processed.

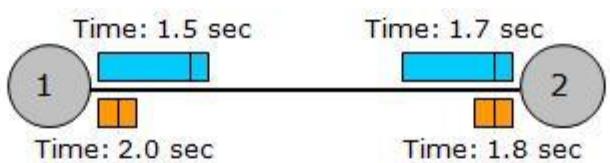


Fig.3.7 NS2 Discrete event simulation

Provides substantial support for simulation of TCP, routing and multicast protocols over wired and wireless networks.

- NS2 Languages:
  Uses Two Languages:

1.Otcl: Used to build network structure and topology which is the surface of simulation.

- quickly exploring a number of scenarios.

- iteration time (change the model and re-run) is more important.

1. C++: Used to Implement new protocols in NS2.

- byte manipulation, packet processing, algorithm implementation.
- Run time speed is important.
- Turn around time (run simulation, find bug, fix bug, recompile, re-run) is slower.

 NS-2 : Components:

1. NS – Simulator
2. NAM – Network AniMator

   - visual demonstration of NS output

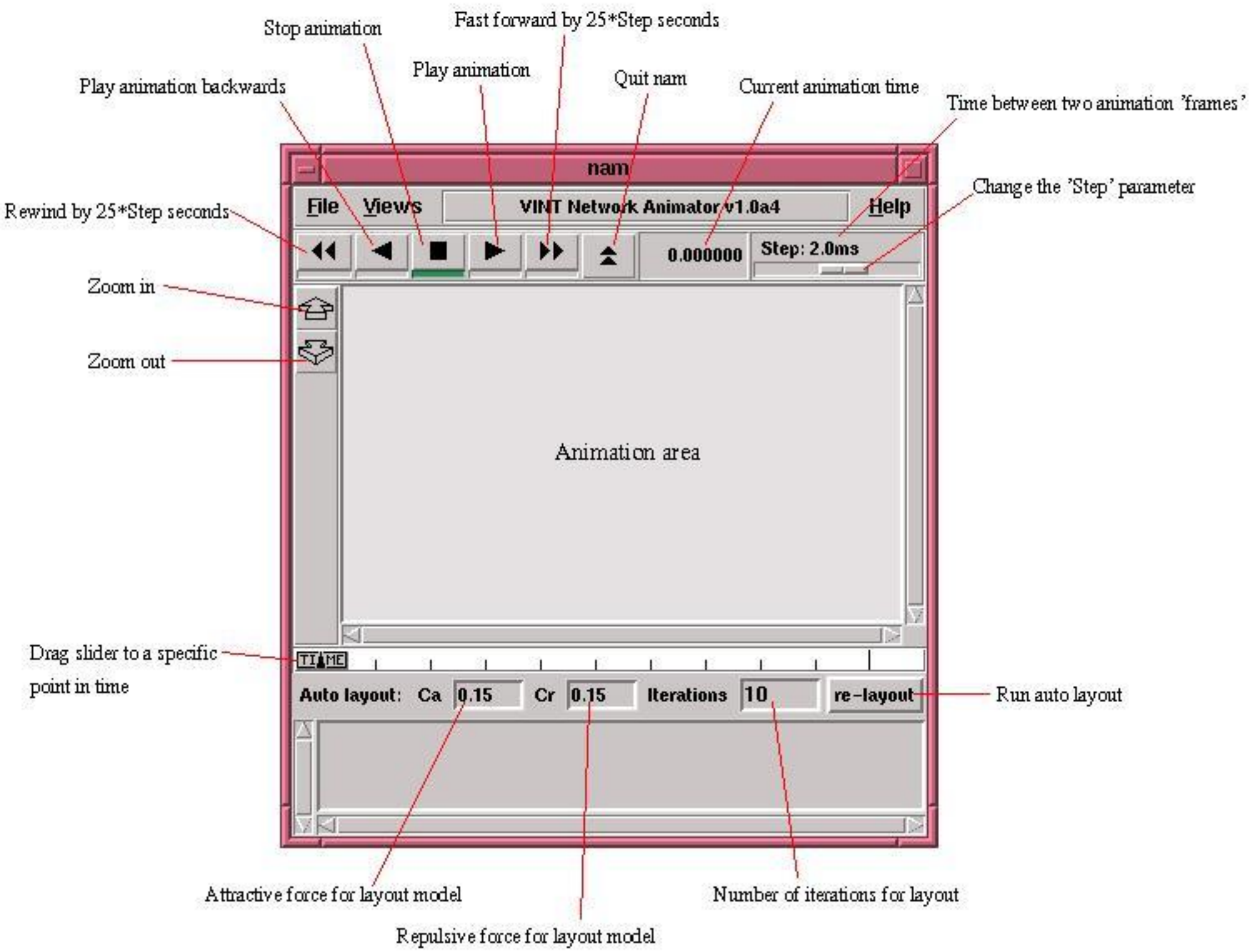


Fig 3.8 Network Animator

3. Preprocessing
    - Handwritten TCL or
    - Topology generator
4. Post analysis
    - Trace analysis using Perl/TCL/AWK/MATLAB

 NS-2 : Environment:

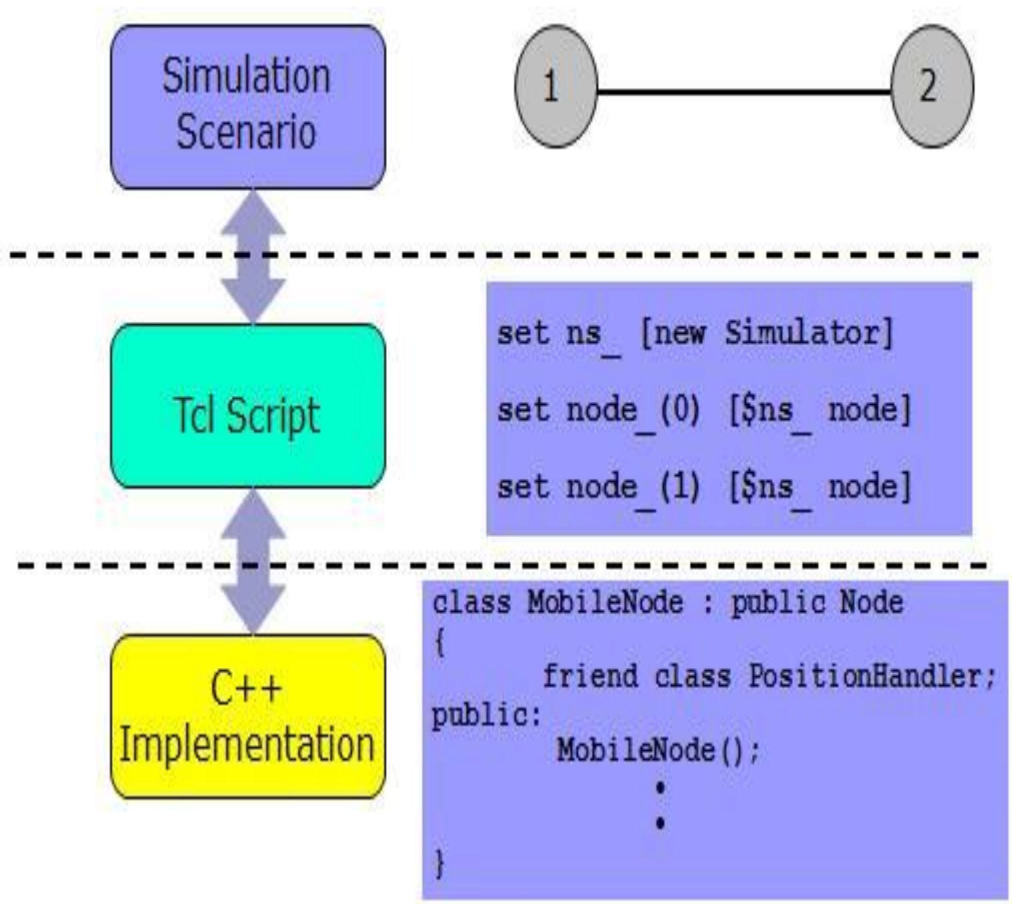


Fig. 3.8 NS-2 Environment

CHAPTER 4 -PERFORMANCE ANALYSIS

4.1 SIMULATION

4.1 Simulation model

The performance evaluation of three routing protocol for mobile ad hoc networks by using an open-source network simulation tool called NS-2. Three routing protocols: AODV, DSDV and DSR have been considered for performance evaluation in this work. The simulation environment has been conducted with the LINUX operating system, because NS-2 works with Linux platform only.

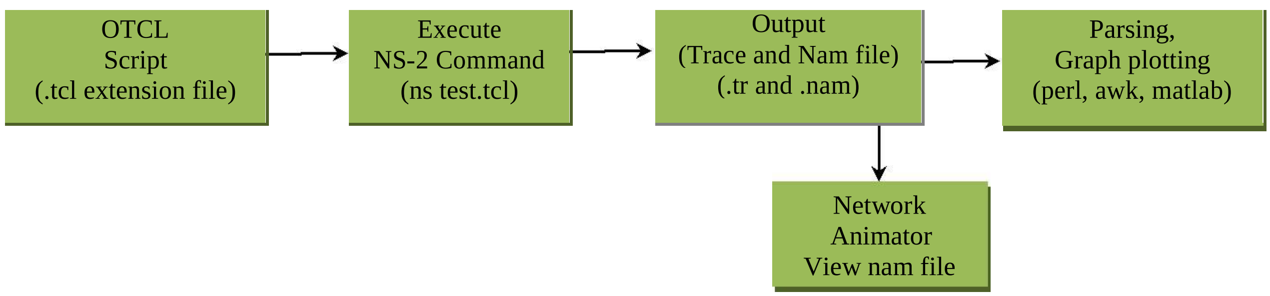


Figure 5: Simulation Overview

Whole simulation study is divided into two part one is create the node (that may be cell phone, internet or any other devices) i.e. NS-2 output. It‟s called NAM (Network Animator) file, which shows the nodes movement and communication occurs between various nodes in various conditions or to allow the users to visually appreciate the movement as well as the interactions of the mobile nodes. And another one is graphical analysis of trace file (.tr). Trace files contain the traces of event that can be further processed to understand the performance of the network.

Figure 5 depicts the overall process of how a network simulation is conducted under NS-2. Output files such as trace files have to be parsed to extract useful information. The parsing can be done using the *awk* command (in UNIX and LINUX, it is necessary to use gwak for the windows environment) or *perl* script. The results have been analyzed using Excel or Matlab. A software program which can shorten the process of parsing trace files (Xgraph and TraceGraph) has also been used in this paper. However, it doesn‟t work well when the trace file is too large. By varying the simulation parameter shown in table 1, we can see the graphical variation between various performance metrics like throughput, drop, delay, jitter etc.

Major assumption

Random waypoint mobility scenario creates random mobility scene every time it is executed by using setdest command in ns-2 tool. So that compares a protocol with themself, we use the same mobility scenario for each modification. At same time using the random way point model we have the two cases for performance analyzes of wireless routing protocols. Finally, by varying the number of nodes (30,40 and 50) and also by varying the speed(5ms,10ms,20ms) of the nodes then calculate the parameter values such as throughput, control overhead, average end to end delay and packet delivery ratio.

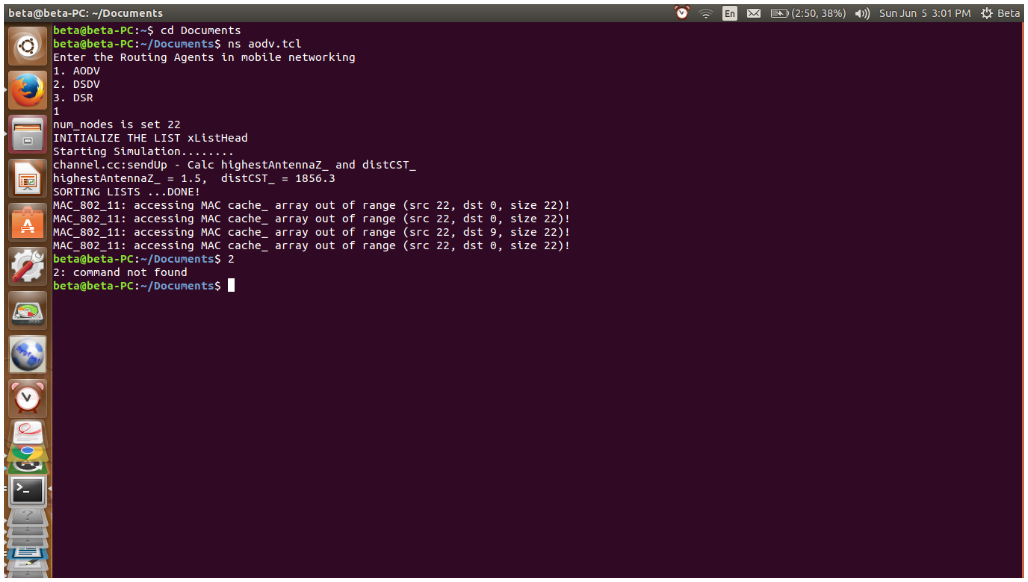


Figure 7: Running TCL script in Terminal

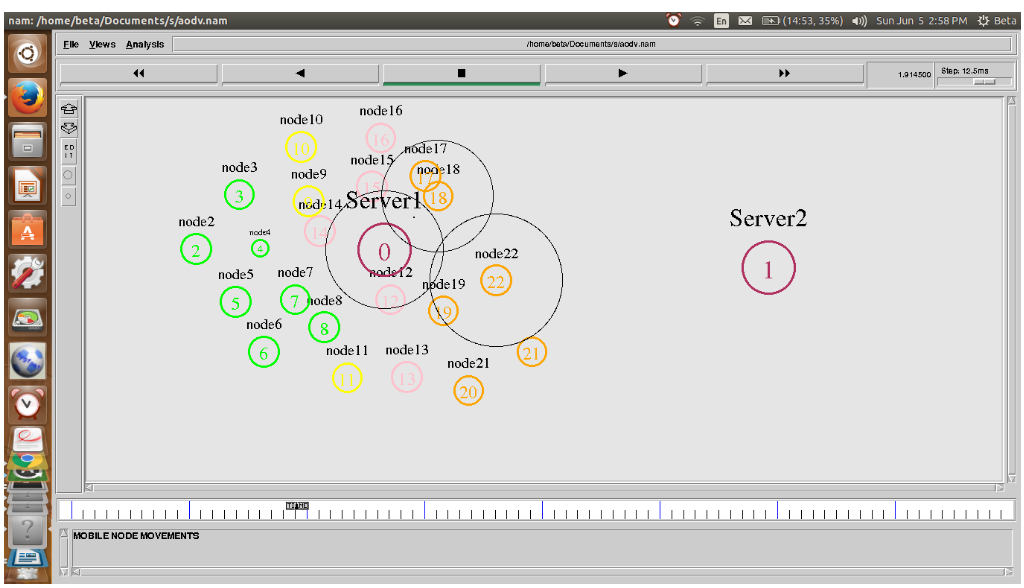


Figure : A snapshot of the simulation topology in NAM

4.1 RESULT ANALYSIS

Case 1: By varying speed of nodes

Topology area	500 x 500 m	Max. Speed	20ms
Pause time	10s	UDP traffic	3 conn

Table.1.Simulation parameter

By changing number of nodes then measure the parameter values such as control overhead, normalized routing overhead, delay, packet delivery ratio, throughput and jitter by keeping the speed of the node is constant.

Parameter measured	**25 Nodes**			**40 Nodes**			**50 Nodes**		
	AODV	**DSR**	**DSDV**	**AODV**	**DSR**	**DSDV**	**AODV**	**DSR**	**DSDV**
No. of packets send	557	560	578	573	572	555	568	558	562
No. of Packets Received	549	557	351	567	571	390	565	558	497
Packet delivery ratio	98.56	99.46	60.72	98.95	99.82	70.27	99.47	100	88.43
Control Overhead	399	88	444	285	107	585	253	46	780
Delay	0.03299	0.01291	0.01044	0.01011	0.01204	0.00762	0.00929	0.0090	0.0074
Throughput	23984	23425	15377	24766	24034	17057	24691	23479	21741
Jitter	0.1742	0.1748	0.2465	0.1718	0.1705	0.2256	0.1726	0.1747	0.1961
No. of packets dropped	8	3	227	6	1	165	3	0	65

Table.3. Simulation parameter values by varying number of nodes

Case (2) By varying speed of the nodes:

Topology area	500 x 500 m	No.of nodes	40
Pause time	10s	UDP traffic	3 conn

Table.2.Simulation parameter

In this circumstance by varying the speed(5ms,10ms,20ms) of the node then measure the parameter values such as packet delivery ratio, control overhead, normalized routing overhead, delay, throughput and jitter by keeping the number (40nodes) of the node is constant.

Parameter measured	**5ms**			**10ms**			**20ms**		
	AODV	**DSR**	**DSDV**	**AODV**	**DSR**	**DSDV**	**AODV**	**DSR**	**DSDV**
No. of packets send	579	567	558	570	554	561	557	561	559
No. of packets received	576	568	494	566	553	347	550	556	367
Packet delivery ratio	99.4819	100.176	88.5305	99.298	99.81	61.85	98.74	99.10	65.65
Control Overhead	242	50	590	324	61	607	525	92	624
Delay	0.01163	0.01003	0.00885	0.01432	0.0142	0.00988	0.01969	0.0103	0.00658
Throughput	25170.1	23903.7	21607	24728	23247	15172	24067	23376	16038
Jitter	0.169339	0.17164	0.19737	0.17232	0.1764	0.2813	0.17710	0.1755	0.2657
No. of packets dropped	3	-1	64	4	1	214	7	5	192

Table.4. Simulation parameter values by varying speed of the mobile nodes

Comparison based on Packet Delivery Ratio

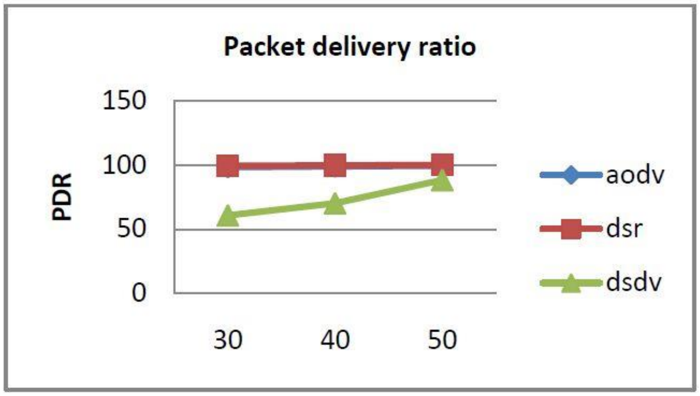


Fig.2.By varying number of nodes

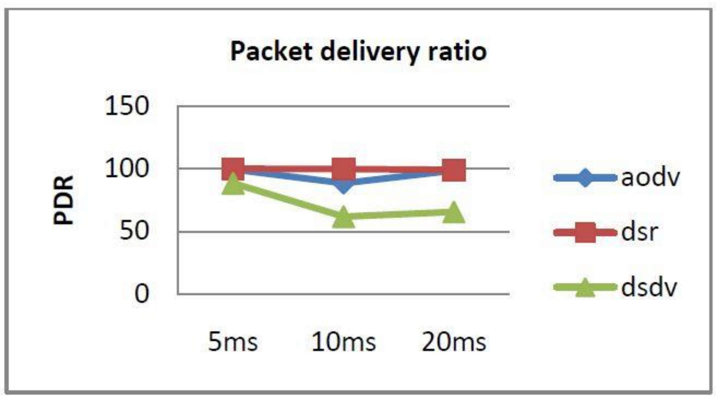


Fig.3.By varying speed of the nodes

As it can be seen from the above results ,the pdr remains the same in all the scenario despite the increase the number of nodes and increase in the speed of nodes which could be due to the multihop characteristics of the Ad hoc Routing protocol.DSR has slight higher pdr than AODV and Table driven routing protocol(DSDV) lower pdr than reactive protocols(AODV,DSR).Among these three protocols DSR is better pdr than AODV and DSDV.

Comparison based on Throughput

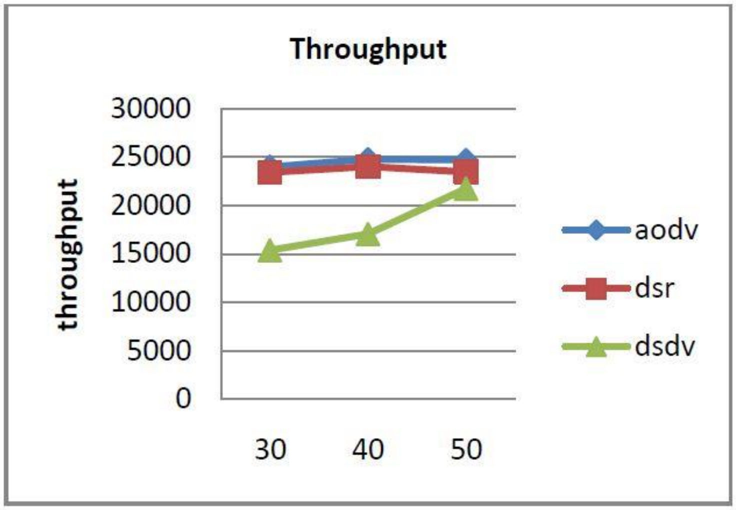


Fig.6.By varying number of nodes

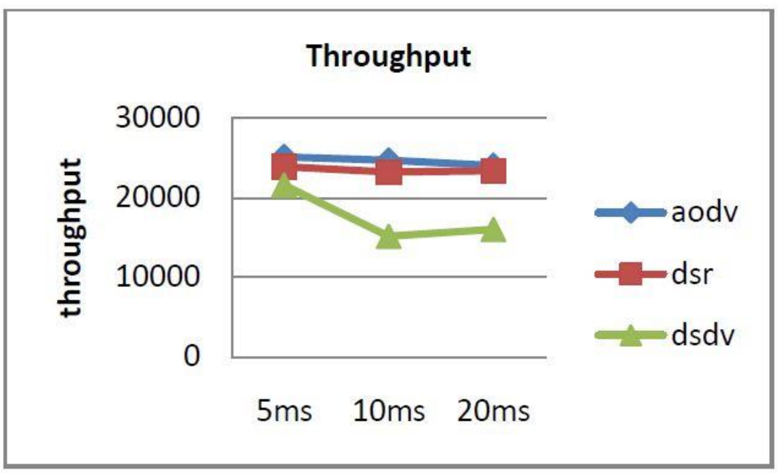


Fig.7.By varying speed of the nodes

The number of nodes was varied (30, 40, 50) each time in Fig. 6. and the throughput was calculated at destination node during entire AODV shows higher throughput than the DSR and DSDV. The AODV has much more routing packets than DSR because the AODV avoids loop and freshness of routes while DSR uses stale routes. Its throughput is higher than other two routing protocols at high mobility simulation period. As it can be clearly show that simulation and expected throughput can be obtained in AODV routing protocol. Among these three routing protocols AODV is better than other two routing protocols and DSR have slightly lower throughput than AODV. The DSDV have lower throughput than other routing protocols shown in Fig.6 and Fig.7.

Comparison based on End to End delay

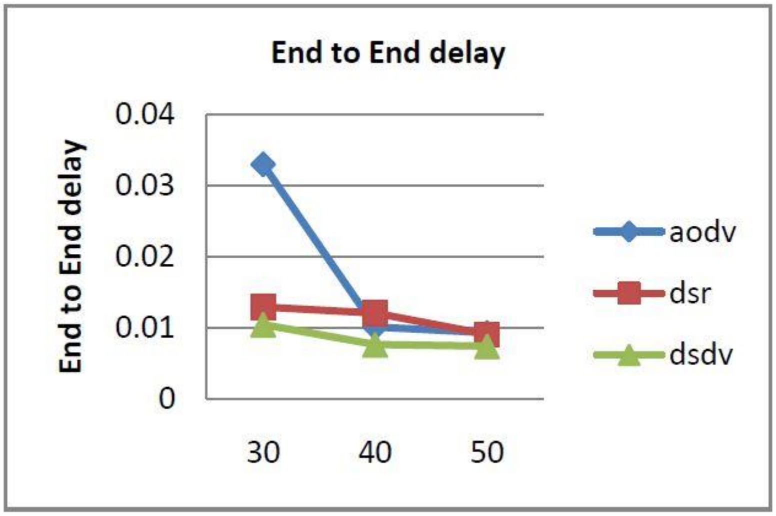


Fig.8. By varying number of nodes

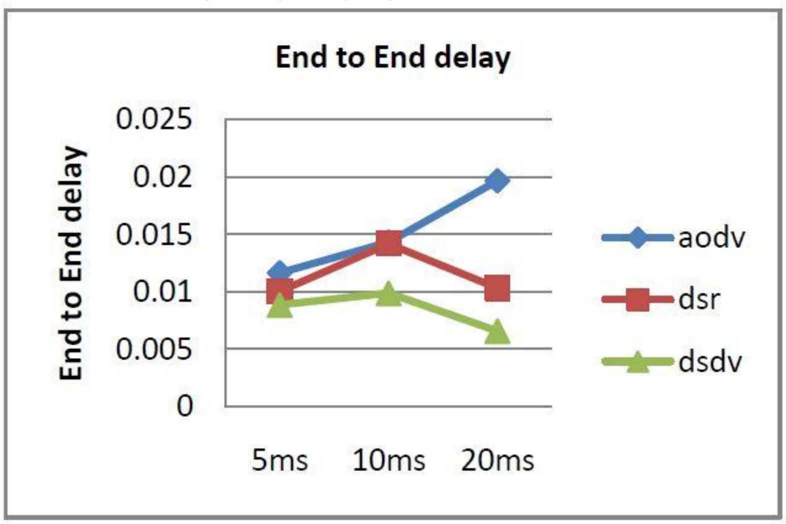


Fig.9. By varying speed of the nodes

As it can be seen from the above simulation, end to end delay is higher in AODV followed by DSR and DSDV having the lowest and most stable End to End Delay in mobility. By increasing number of nodes in small area then reduce the end to end delay in AODV and increasing speed of the node then increase the delay in AODV. In DSR and DSDV slightly lower delay compared to AODV.

CHAPTER 5- CONCLUSION

5.1 Conclusions

Our simulation work illustrates the performance of three routing protocols AODV, DSR and DSDV. The paper presents a study of the performance of routing protocols, used in WMNs, in high mobility case under low, medium and high density scenario. We vary the number of nodes from 30 (low density) to 50 (high density) in a fixed topography of 500*500 meters. Moreover, since Random Waypoint Mobility Model has been used in this study to generate node mobility. We find that the performance varies widely across different number of nodes and different types of speed in node mobility.

AODV performance is the best considering its ability to maintain connection by periodic exchange of data’s. As far as Throughput is concerned, AODV and DSR perform better than the DSDV even when the network has a large number of nodes. Overall, our simulation work shows that AODV performs better in a network with a larger number of nodes whereas DSR performs better when the number of nodes is slight. Average End-to-End Delay is the least for DSDV and does not change if the no of nodes are increased. Thus, we find that AODV is a viable choice for MANETs

5.2 Future Work

future plan is to evaluate security issues in AODV and DSDV..

REFERENCES

[1]. F. Kaabi,S. Ghannay, and F. Filali “Channel Allocation and Routing in Wireless Mesh Networks: A survey and qualitative comparison between schemes” International Journal of Wireless and Mobile Networks(IJWMN),Vol.2,No.1,February 2010.

[2]. Kyu-Han Kim, *Member, IEEE*, and Kang G. Shin*, Fellow, IEEE, ACM “*Self-Reconfigurable Wireless Mesh Networks*”* IEEE/ACM TRANSACTIONS ON NETWORKING, VOL. 19, NO. 2, APRIL 2011.

[3]. Xiaoqin Chen, Haley M. Jones, and Dhammika Jayalath, Senior Member, IEEE, “Channel-Aware Routing in MANETs with Route Handoff” IEEE TRANSACTIONS ON MOBILE COMPUTING, VOL. 10, NO. 1, JANUARY 2011.

[4]. Majid Ghaderi, Member, IEEE, Ashwin Sridharan, Member, IEEE, Hui Zang, Senior Member, IEEE,Don Towsley, Fellow, IEEE, and Rene Cruz, Fellow, IEEE “TCP-Aware Channel Allocation in CDMA Networks” IEEE TRANSACTIONS ON MOBILE COMPUTING, VOL. 8, NO. 1, JANUARY 2009.

[5]. I. Akyildiz, X. Wang, and W. Wang, “Wireless mesh networks: A survey,” *Comput. Netw.*, vol. 47, no. 4, pp. 445–487, Mar. 2005.

[6]. P. Kyasanur and N. Vaidya, “Capacity of multi-channel wireless networks: Impact of number of channels and interfaces,” in *Proc. ACM MobiCom*, Cologne, Germany, Aug. 2005

[7]. A. Brzezinski, G. Zussman, and E. Modiano, “Enabling distributed throughput maximization in wireless mesh networks: A partitioning approach,” in *Proc. ACM MobiCom*, Los Angeles, CA, Sep. 2006, pp.26–37.

[8]. A. Raniwala and T. Chiueh, “Architecture and algorithms for an IEEE 802.11-based multi-channel wireless mesh network,” in *Proc. IEEE INFOCOM*, Miami, FL, Mar. 2005, vol. 3.

[9]. A. P. Subramanian, H. Gupta, S. R. Das, and J. Cao, “Minimum interference channel assignment in multiradio wireless mesh networks,” *IEEE Trans. Mobile Comput.*, vol. 7, no. 12, pp. 1459–1473, Dec. 2008.

[10]. LuyaoWanga, Kwan-WuChina, SietengSohb,RaadRaada, “Novel joint routing and scheduling algorithms forminimizing end-to-end delays in multi Tx-Rx wireless mesh networks” *Department ofComputing,Curtin University of Technology, W A, Australia,* 27 May 2015.

[11]. Comparative analysis of link quality metrics and routing protocols for optimal route construction in wireless mesh networks Seongkwan Kim, Okhwan Lee , Sunghyun Choi , Sung-Ju Lee.

[12]. Probing-based anypath forwarding routing algorithms in wireless mesh networks Fajun Chen , Yijie Wang , Jiangchuan Liu , Zongpeng Li. Key Laboratory of Science and Technology for National Defence of Parallel and Distributed Processing, School of Computer, National University of Defense Technology, China. April, 2011.

Certificate

Candidate's Declaration

I hereby declare that the work presented in this report entitled**" Study and Simulation for various wireless Mesh Networks Routing Protocols"** in partial fulfillment of the requirements for the award of the degree of **Bachelor of Technology** in **Computer Science and Engineering/Information Technology** submitted in the department of Computer Science & Engineering and Information Technology**,** Jaypee University of Information Technology Waknaghat is an authentic record of my own work carried out over a period from August 2015 to December 2015 under the supervision of **Dr. HemrajSaini .**

The matter embodied in the report has not been submitted for the award of any other degree or diploma.

(Student Signature)

Shashank Sharmaa, 123212

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

(Supervisor Signature)

Dr. Hemraj Saini

Assistant Professor

Dept. of Computer science & Engineering and Information Technology

Dated:

Acknowledgement

I would like to express our gratitude and appreciation to all those who have gave us the perfect environment for completion of this report. A special thanks to our final year project supervisor Dr. Hemraj Saini, whose simulating suggestions and encouragement helped us to get the trust of our topic and understanding the importance of this project. We would also acknowledge with much appreciation the crucial role of the staff of Computer Laboratory, who provided us with the lab facilities, as and when required.

Additionally, we appreciate the guidance given by the panels especially during the previous project presentation which made us realize the various dimensions we were probably missing out and hence, they gave away a room for improvement in the project. Again a special thanks to our friends who gave us valuable suggestions during the project

Date: **Shashank Sharma**

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List of Abbreviations

13. ETX : Expected Transmission Count
14. WMN : Wireless Mesh Network
15. ML : Minimum Loss
16. ETT : Expected transmission time
17. ELP : Expected Link Performance
18. RTT: Per-Hop Round Trip Time
19. PPD: Per-Hop Packet Pair Delay
20. ETOP: Expected Transmission on a Path
21. ENT: Effective Number of Transmissions
22. AODV-Ad-Hoc On-Demand Distance Vector Routing Algorithm
23. LQSR-Link Quallity Source Routing
24. DSR- Direct Source Routing

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Abstract

Wireless Mesh Networks (WMNs) are bringing revolutionary change in the field of wireless networking. It is a trustworthy technology in applications like broadband home networking, network management and latest transportation systems. WMNs consist of mesh routers, mesh clients and gateways. It is a special kind of wireless Ad-hoc networks. One of the issues in WMNs is resource management which includes routing and for routing there are particular routing protocols that gives better performance when checked with certain parameters. Parameters in WMNs include delay, throughput, network load etc. There are two types of routing protocols i.e. reactive protocols and proactive protocols. Three routing protocols AODV, DSR and OLSR have been tested in WMNs under certain parameters which are delay, throughput and network load. The testing of these protocols will be performed in the Network Simulator (ns2). The obtained results from NS2 will be displayed in this thesis in the form of graphs and figures. This thesis will help in validating which routing protocol will give the best performance under the assumed conditions. Moreover this thesis report will help in doing more research in future in this area and help in generating new ideas in this research area that will enhance and bring new features in WMNs.

CHAPTER 1- INTRODUCTION

1.1 Introduction

WIRELESS mesh networks (WMNs) are dynamically self-organized and self-confirmed, with the nodes in the network automatically establishing an ad hoc network and maintaining the mesh connectivity. WMNs are comprised of two types of nodes: mesh routers and mesh clients. Other than the routing capability for gateway/bridge functions as in a conventional wireless router, a mesh router contains additional routing functions to support mesh networking. Through multi-hop communications, the same coverage can be achieved by a mesh router with much lower transmission power. Mesh routers have minimal mobility and form the mesh backbone for mesh clients. Consequently, instead of being another type of ad-hoc networking, WMNs diversify the capabilities of ad-hoc networks. This feature brings many advantages to WMNs, such as low up-front cost, easy network maintenance, robustness, reliable service coverage, etc. Therefore, in addition to being widely accepted in the traditional application sectors of ad hoc networks, WMNs are undergoing rapid commercialization in many other application scenarios such as broadband home networking, community networking, building automation, high speed metropolitan area networks, and enterprise networking. Nevertheless, because of heterogeneousand disturbing wireless links conditions, preserving the efficient performance of such WMNs arestill a tricky problem.

WMN Architecture:

Infrastructure/Backbone WMNs. In this architecture, mesh routers form an infrastructure forclients, as shown in Fig. 1.1, where dashed and solid lines indicate wireless and wired links, respectively. The WMN infrastructure/backbone can be built using various types of radio technologies. The mesh routers form a mesh of self-configuring, self-healing links among themselves. With gateway functionality, mesh routers can be connected to the Internet. This approach, also referred to as *infrastructure meshing*, provides a backbone for conventional clients and enables integration of WMNs with existing wireless networks, through gateway/bridge functionalities in mesh routers. Conventional clients with an Ethernet interface can be connected to mesh routers via Ethernet links. For conventional clients with the same radio technologies as mesh routers, they can directly communicate with mesh routers. If different radio technologies are used, clients must communicate with their base stations that have Ethernet connections to mesh routers.

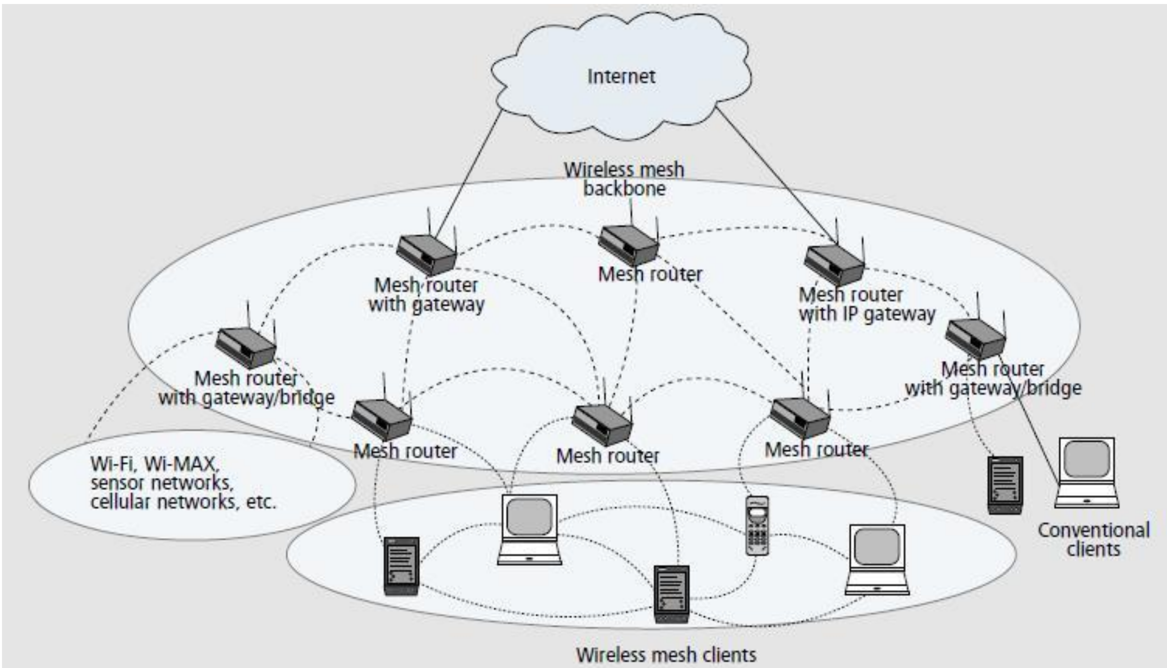


Fig.1.1 Infrastructure/Backbone WMNs

Client WMNs. *Client meshing*provides peer-to-peer networks among client devices. In this typeof architecture, client nodes constitute the actual network to perform routing and configuration functionalities as well as providing end-user applications to customers. Hence, a mesh router is not required for these types of networks. Client *WMNs* are usually formed using one type of radios on devices. Thus, a Client *WMN* is actually the same as a conventional ad hoc network.

However, the requirements on end-user devices is increased when compared to infrastructure meshing, since in Client WMNs the end-users must perform additional functions such as routing and self-configuration.

Hybrid WMNs. This architecture is the combination of infrastructure and client meshing, asshown in Fig.1.2. Mesh clients can access the network through mesh routers as well as directly meshing with other mesh clients. While the infrastructure provides connectivity to other networks such as the Internet, Wi-Fi, WiMAX, cellular, and sensor networks, the routing capabilities of clients provide improved connectivity and coverage inside WMNs.

The characteristics of WMNs are outlined below, where the hybrid architecture is considered for WMNs, since it comprises all the advantages of WMNs:

• WMNs support ad hoc networking, and have the capability of self-forming, self-healing, and self-organization.

• WMNs are multi-hop wireless networks, but with a wireless infrastructure/backbone provided by mesh routers.

• Mesh routers have minimal mobility and perform dedicated routing and configuration, which significantly decreases the load of mesh clients and other end nodes.

• Mobility of end nodes is supported easily through the wireless infrastructure.

• Power-consumption constraints are different for mesh routers and mesh clients.

• WMNs are not stand-alone and need to be compatible and interoperable with other wireless networks.

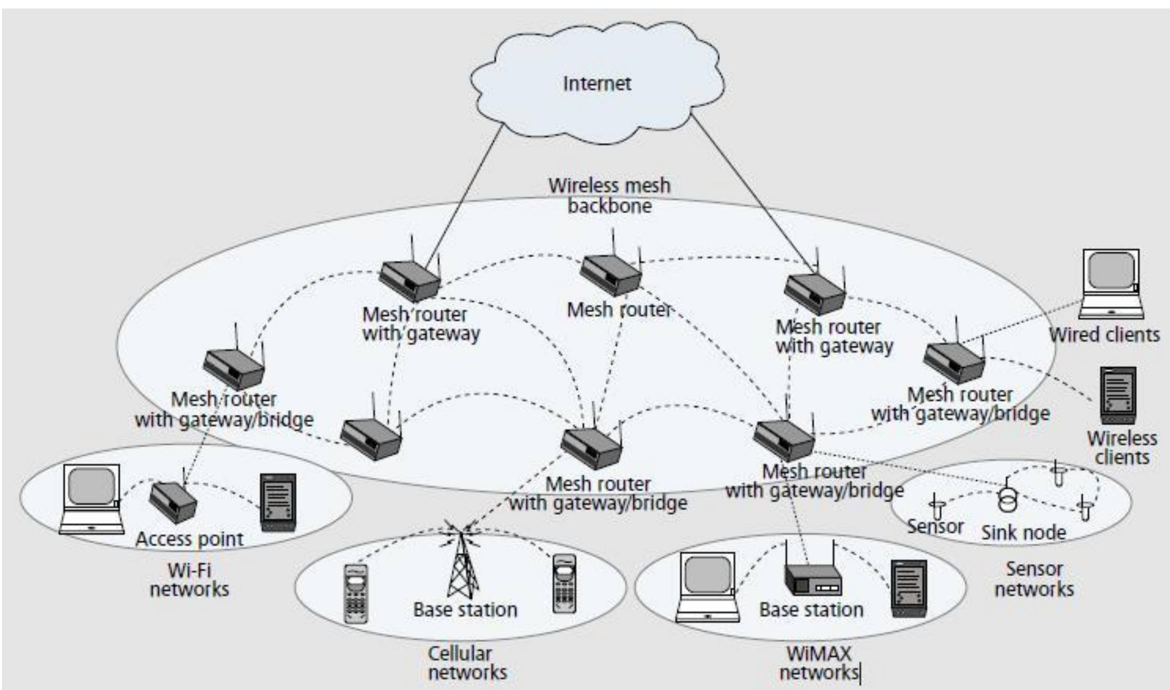


Fig.1.2 Hybrid WMNs

Routing in WMNs:

Routing protocols in wireless mesh networks can be divided into two categories: proactive and reactive . Proactive protocols involve a situation where network nodes continuously maintain one, or a number, of routing tables that store routes to each of the nodes of a network and, at the same time, recurrently send them along the network to exchange and update information in neighboring nodes. Reactive protocols, in turn, receive information on the route to the destination (node) of a packet only at the moment when data transmission is to be effected (on demand). These protocols do not generate additional traffic in the network, but the time needed for data to be forwarded is prolonged by the time necessary to effect the exchange of information concerning the available route.

Another classification of the protocols that takes into account their particular features is proposed in :

•**Hop Count Based Routing** – protocols based the on metrics of the hop-count type. Though these protocols do not in fact indicate the most effective connection paths, they are still in common use due to their low computational complexity.

• **Link-Level QoS Routing** –this group includes protocols that use the cumulative or thebottleneck value that defines the quality of the connection path (or section thereof).

• **End-to-End QoS Routing** –these protocols are based on the quality parameters, but in aglobal approach, i.e. for the end-to-end connection path.

• **Reliability-Aware Routing** –protocols based on the assumption of the availability of anumber of simultaneous routes. In this group of protocols, depending of available implementation, packets are sent concurrently along a number of routes, or alternative routes are used only as an auxiliary solution.

• **Stability-Aware Routing** –protocols grouped in his category use a special architecture of thesystem to improve the stability of the operation of a network. These protocols prefer cable connection links in MESH networks or links in which no sections (segments) that are executed via mobile users are included.

• **Scalable Routing** –protocols for large networks where scalability is pivotal. The most typicalrepresentatives of this category are the hierarchical and the geographical routing.

1.2 Problem Statement:

To compare the performance of all the four routing protocols (aodv, dsr dsdv and olsr) and then to make the observations about how the performance of these routing protocols can be improved. Performance of these routing protocols are compared on the basis of various parameters such as throughput, delay and packet delivery ratio.

1.3 Objectives:

An optimal routing protocol for WMNs must capture the following features:

• **Multiple Performance Metrics.** Many existing routing protocols use minimum hop-count as aperformance metric to select the routing path. This has been demonstrated to be ineffective in many situations.

• **Scalability.** Setting up or maintaining a routing path in a very large wireless network may takea long time. Thus, it is critical to have a scalable routing protocol in WMNs.

• **Robustness.** To avoid service disruption, WMNs must be robust to link failures or congestion.Routing protocols also need to perform load balancing.

• **Efficient Routing with Mesh Infrastructure.** Considering the minimal mobility and noconstraints on power consumption in mesh routers, the routing protocol in mesh routers is expected to be much simpler than ad hoc network routing protocols. With the mesh infrastructure provided by mesh routers, the routing protocol for mesh clients can also be made simple.

The main objective is to compare the performance of all the three routing protocols (aodv, dsr and dsdv) and then to make the observations about how the performance of these routing protocols can be improved.Performance

1.4 METHODOLOGY

The methods that we will be using throughout the project:

Phase1:

1.1: We will do a thorough literature review to examine the existing techniques. For this purpose we will conduct searching various Data Bases such as IEEE, Compendex, Google Scholar and Inspec. The detailed literature review will help us to understand the current techniques and to develop the theoretical base for our own research. We will examine Wireless Mesh Networks and their mechanisms, we will count the development of WMNs and their important applications and their added value to wireless networks [9], [10]. We would also study the connection means and mobility in WMN and the self healing mechanism it uses when the route to some nodes is terminated.

1.2: In the second part of literature review by studying characteristics of routing in wireless networks we give grounds to routing protocols. We assess different Ad-Hoc routing protocols, stating their attributes and behavior in different network conditions. We will also discuss the mechanisms of reactive and proactive protocols and how hybrid protocols utilize both of them. From this we will try to find the specific characteristics of our routing protocols. We would candidate protocols for our simulation.

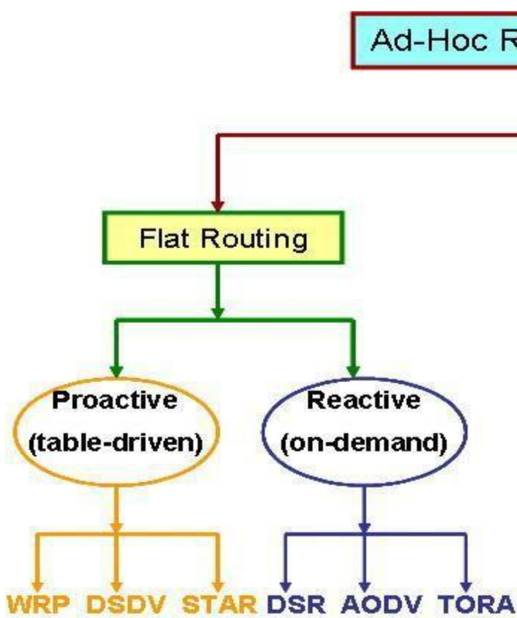


Fig. 1.3 Ad-Hoc Routing protocols

Phase 2:

In second phase, we will be going to implement and simulate our research ideas. OPNET Modeler is a reliable simulation and design tool [22]. This is a technical phase, which includes the transformation of theoretical platform into simulating environment. We will design scenarios for simulation to provide an environment that represents a wireless mesh network with fixed server and routers and fixed and mobile nodes. We make these scenarios by varying the number of nodes and network elements and then varying mobility characteristics of the workstations and/or altering the background traffic represented in the whole network by servers.

Phase 3:

Performance evaluation will be conducted in this phase. Simulation results will be studied by a comparative analysis approach. Comparative analysis will show us how much correlation is obtained. This phase deals with simulation verification and mostly validation of the results. In this phase certain network performance parameters such as delay, packet loss and routing load will be analyzed and based on these parameters the efficiency of the routing mechanisms are observed. We will run our simulation and collect the results from several scenarios that have been designed in the last phase. Measured values in form of raw data are the result of simulation Run, which are based on scenarios with altering number of nodes and mobility. The results will be presented in tables and graphs to allow easy comparison. We will use Microsoft Excel to sketch our graphs for better understanding.

Phase4:

In the last phase we present the optimal conditions for each routing protocol. We define the conditions that each protocol can reach its maximum performance potential. We would also introduce one protocol that has the best performance in different general conditions.

1.5 Organization:

The rest of the report is organized as follows:

- Chapter 2 describes about the background and related work of the project. In this chapter we will focus on the work already done on WMN routing protocols. We will study different papers published and then try to implement any one of the algorithm in our project.
- Chapter 3 describes the the analysis done for System Development.. Basics of ns2, Its commands and NAM are also explained next. It tells the basic steps to create a simple network on the simulator and also discusses the performance metrics for the packet transfer over the network.
- Chapter 4 describes the performance analysis.
- Chapter 5 contains the conclusion and scope for further improvement in this project.

CHAPTER 2- LITERATURE SURVEY

2.3 A Survey on Wireless Mesh Networks. IAN F. AKYILDIZ, GEORGIA INSTITUTE OF TECHNOLOGY XUDONG WANG, KIYON, INC.

Wireless mesh networks (WMNs) have emerged as a key technology for next-generation wireless networking. Because of their advantages over other wireless networks, WMNs are undergoing rapid progress and inspiring numerous applications. However, many technical issues still exist in this field. In order to provide a better understanding of the research challenges of WMNs, this article presents a detailed investigation of current state-of-the-art protocols and algorithms for WMNs. Open research issues in all protocol layers are also discussed, with an objective to spark new research interests in this field.

2.4 Routing protocols in wireless mesh networks – a comparison and classification
Piotr Owczarek, Piotr Zwierzykowski

Wireless Mesh Networks can give an answer for many open issues in the field of wireless net-works. For WMN to be effective enough, it is required for a chosen routing protocol based on routing metrics that fits application needs to be used properly. Until now, many different routing protocols have been proposed. All of them have their own characteristics and there is no easy way to make any reliable comparison. The proposed paper presents a review of the current state-of-the-art WMN routing protocols and metrics. The paper also includes an evaluation of properties and proposed classification of WMN routing protocols. Furthermore authors attempted to make a comparison of different features of selected routing metrics and characteristics of selected routing protocols.

2.4 **Wireless Mesh Networking Technology for Commercial and Industrial Customers**
Abdulrahman Yarali, IEEE Member, Murray State University

Wireless Mesh Networks (WMNs) havebeen receiving a great deal of attention as a broadbandaccess alternative for a wide range of markets, includingthose in the metro, public-safety, energy, education,enterprise, carrier-access and residential sectors. Understanding the strengths and weaknesses of single, dual, and multi-radio mesh options is the first step. In this paper simulation results for three distinct generations of wireless mesh configuration is presented. The paper also address some of the technical influences of WMNs and in particular focus on the opportunities that wireless mesh technologies provide for implementing more efficient processes and smarter working for commercial and industrial customers.

2.4 Comparative analysis of link quality metrics and routing protocols for optimal route construction in wireless mesh networks Seongkwan Kim , Okhwan Lee , Sunghyun Choi , Sung-Ju Lee.

A comparative analysis of various routing strategies that affect the end-to-end performance in wireless mesh networks. We first improve well-known link quality metrics and routing algorithms to enhance performance in wireless mesh environments. We then investigate the route optimality, i.e., whether the best end-to-end route with respect to a given link quality metric is established, and its impact on the network performance. Network topologies, number of concurrent flows, and interference types are varied in our evaluation and we find that a non-optimal route is often established because of the routing protocol's misbehaviour, inaccurate link metric design, interflow interference, and their interplay. Through extensive simulation analysis, we present insights on how to design wireless link metrics and routing algorithms to enhance the network capacity and provide reliable connectivity

2.6 Improving Simulation for Network Research.

New protocols and algorithms are being developed to meet changing operational requirements in the Internet. Simulation is a vital tool to quickly and inexpensively explore the behavior of these new protocol across the range of topologies, cross-traÆc, and interactions that might occur in the Internet. This paper describes ns, a widely used, multi-protocol network simulator designed to address the needs of networking researchers. Ns provides multiple levels of abstraction to permit simulations to span a wide-range of scales, emulation, where real-world packets can enter the simulator.

2.6 Novel joint routing and scheduling algorithms for minimizing end-to-end delays in multiTx- Rx wireless mesh networks.

Multiple transmit(Tx) or receive(Rx) capability is a significant advance in wireless communications. This so called MTR capability allows the creation of wireless mesh networks(WMNs) that are ideal for use as a high speed wireless backbone that span vast geographical areas. A fundamental problem, however, is deriving a minimal transmission schedule or superframe that yields low end-to-end delays,with the primary constraint that routers are not allowed to Tx*and*Rx simultaneously. In this pape r, joint routing and link scheduling approach that addresses two fundamental issues that influence end-to-enddelays: super frame length and transmission slot order. Shortening the super frame length, in terms of slots, is expected to minimize the inter-link activation time while reordering transmissions lots increases the likelihood that links on a path are activated consecutively.

CHAPTER 3 – SYSTEM DEVELOPMENT

3.1 ANALYSIS:

3.1.1 METRICS USED IN WIRELESS MESH NETWORKS

The metrics that have been proposed for mesh networks can be divided as follows :

- metrics related to the number of hops (Hop Count),
- metrics that determine the quality of a connection (Link Quality Metrics)
- metrics that are based on network load rate (Load-Dependant Metrics),
- Multi Channel Metrics.

The Hop Count Metrics is the oldest type of metric that has been used in the RIP protocol since the inception of the Internet. More attention should be given then to the remaining metrics. One can distinguish seven metrics based on the link quality : Expected Transmission Count (ETX), Minimum Loss (ML) , Expected Transmission Time (ETT) , Expected Link Performance (ELP) , Per-Hop Round Trip Time (RTT), Per-Hop Packet Pair Delay (PPD) and Expected Transmission on a Path (ETOP). Load-Dependent Metrics include: Distribution Based Expected Transmission Count (DBEXT) and Bottleneck Aware Routing Metric (BATD). The following multi-channel metrics stand out among other multi-channel metrics: Weighted Cumulative ETT (WCETT), Metric of Interference and Channel-switching (MIC) , Modified ETX (mETX) , Effective Number of Transmissions (ENT), iAWARE – and Exclusive Expected Transmission Time (EETT) . Table below shows a comparison of selected characteristics of the metrics used in most routing protocols for mesh networks. Results shown in the table are the effects of comparison made by the authors of the article based on the available literature sources.

Table 1. A comparison of main routing metrics

Name of Metric	Quality-aware	Data Rate	Packet Size	Intra-flow Interferences	Inter-flow Interferences	Medium Instability
Hop Count Metrics						
Hop	×	×	×	×	×	×
Link-Quality Metrics						
ETX	✓	×	×	×	×	×
ML	✓	×	×	×	×	×
ETT	✓	✓	✓	×	×	×
ELP	✓	×	×	✓	✓	×
RTT	✓	✓	×	×	×	×
PPD	✓	✓	✓	×	×	✓
ETOP	✓	×	×	×	×	×
Load-Dependent Metrics						
DBEXT	✓	×	×	✓	×	✓
BATD	✓	✓	×	✓	×	×
Multi-Channel Metrics						
WCETT	✓	✓	✓	✓	×	×
MIC	✓	✓	✓	✓	✓	×
mETX	✓	✓	✓	×	×	✓
ENT	✓	✓	✓	×	×	✓
iAWARE	✓	✓	✓	✓	✓	✓
EETT	✓	✓	✓	✓	×	×

Table 3.1

3.1.2 ROUTING PROTOCOLS IN AD HOC NETWORKS

HOP COUNT BASED ROUTING PROTOCOLS:

J. Light Client Management Routing Protocols (LCMR)

In this protocol, the destination routing path from the sender to the receiver between routers in the net-work is selected in the proactive way, whereas the path between clients and the routers of the network in the reactive way. In order to determine the best route, the hop-count metric is used. In this protocol, the functionality of routing is based exclusively on routers. To achieve that, routers service two routing tables: one for local clients of the network, the other for clients and remote routers. On the basis of the information they store, destination routing paths are selected.

JJ. Orthogonal Rendezvous Routing Protocols (ORR)

The operation of this pro-tocol is based on the assumption that in the two-dimensional Euclidean space two orthogonal lines have at least two common points with a group of other orthogonal Lines. In the process of finding a route, the source node sends a route discovery packet in the orthogonal directions, while the destination node sends a route dissemination packet. The packets meet in a node called the rendezvous point. In this way, the end-to-end routing path is established in which the segment from the source to the rendezvous point is a reactive route, whereas the other part is a pro-active route. This protocol requires a strict description of the directions towards the nodes of a network.

JJJ. HEAT Protocol

The HEAT protocol uses distribution of temperature. The protocol adopts that each of the nodes of a network is a source of heat. The assumption is that gateways are the warmest, followed by nodes/clients that in the closest vicinity, and that the further from gateways, the temperature becomes lower and lower. Using the temperature distribution, the protocol always sends packets to a neighbouring node that has the warmest temperature, thus reaching the destination.

IV. Dynamic Source Routing Algorithm (DSR)

DSR is one of the most commonly used routing protocol in WMN networks and belongs to the group of unicast reactive protocols. The protocol uses source routing, which results in the knowledge of the whole of the destination routing path by any packet. The operation of the protocol occurs in the two consecutive stages: the route discovery phase and the route maintenance phase. The first, initiated by the source node, involves sending broadcast packets that include the destination address, the source address and a unique id to neighbouring nodes. If the packet is received by a node that is not a destination node, this node adds its address to the header and then forwards the packet according to the same scheme. Thus, a packet that has reached its destination has in its header information on the end-to-end connection path. On the basis of information carried in the header, intermediate nodes collect information on routing paths. In the second phase, nodes supervise updated information on stored routes by generating error packets (RERR) forwarded towards the source node. When such a packet is received, a given router is removed from the database and further process proceeds in line with the phase one described earlier.

W. Ad-Hoc On-Demand Distance Vector Routing Algorithm (AODV)

The AODV protocol belongs to the most popular protocols because they employ simple mechanisms of the type "question - reply" to define routing paths. For this pur-pose, three types of packets are used: Route Request (RREQ), Route Reply (RREP) and Route Error (RERR). The source node sends RREQ packets when a necessity to send packets arises and then intermediate nodes, provided they know the route, send a RREQ packet further on towards the destination node, whereas when intermediate nodes do not know the route, they reply with a RERR packet. This process is then repeated until the packet reaches the destination node (the node sends then a RREP packet). In the case when the node receives RREQ packets from different routes, then the route along which the packet has reached the node as first is selected.

LINK LEVEL BASED ROUTING PROTOCOLS

I. Link Quality Source Routing Protocol (LQSR)

A reactive routing protocol proposed by Microsoft Research Group that is based on the Dynamic Source Routing (DSR) algorithm. To improve the quality of the link, the LQSR protocol employs single link parameters instead of end-to-end path parameters. In the process of setting a connection path, the protocol describes individual links by the quality metric, and then sends back the information to the node that initiates the setting up of the path. Quality parameters may vary depending on the mobility of nodes and metrics used in the process, e.g. for stationary nodes they may include strictly quality parameters such as ETX, while for mobile nodes this can be a hop-count based parameter such as RTT and ETX. Though the protocol has many ad-vantages, it is still necessary to develop more

appropriate routing metrics that would take into account the specificity of the WMN network and the features of the LQSR protocol

JJ. Multi-Radio LQSR Routing Protocol (MR-LQSR)

A protocol based on LQSR that takes into consideration the use of the multi-radio architecture in WMN networks. This is effected by the application of WCETT metrics that take into ac-count both quality parameters of the link and the minimum number of hops. This protocol makes it possible to achieve the expected equilibrium (balance) between the delay and the throughput by selecting channels of best quality with a diversity of radio channels taken into account. The protocol also allows researchers to effectively compensate load among individual radio channels.

JJJ. AODV – Spanning Tree Protocol (AODV-ST)

This protocol has been specially designed for WMN networks that use a multi-radio architecture and is based on the AODV protocol. The special feature of the AODV-ST is hybrid routing, which means that it employs AODV mechanisms for internetwork routing in WMNs and Spanning Tree (ST) between the network and edge routers. In short, AODV-ST makes advantage of proactive routing between nodes of the network and routers, and reactive routing with nodes of the internal WMN network. The AODV-ST protocol uses the ETT metric taking into account the expected time for a given packet traversing the link necessary to reach its destination

IV. BABEL Routing Protocol

BABEL is a proactive protocol based on the dis-tance-vector routing protocol. During the process of selection of tracks, it takes advantage of some historical information available, including the error statistics for individual links. Within this process, links that have been used earlier and their quality satisfies the assumed criteria are favored in selection. The BABEL protocol performs simultaneously updating of the state of neighboring nodes (in the reactive way) and can make an exchange of routing information (e.g. following a failure of a link) effective.

W. Better Approach To Mobile Ad Hoc (B.A.T.M.A.N.)

A proactive protocol that shows a different approach to the selection of a connection path. Here, nodes find only the appropriate (adequate) link towards the source without taking into consideration the end-to-end route. Data are forwarded to the next node along the route, while the procedure is repeated according to the same assumption. The pro-cess is regarded to be completed when the destination node is reached. Each of nodes recurrently sends broadcasts to let the neighbouring nodes about its existence. The neighbouring nodes forward this information on until all the nodes in the net-work receive appropriate information on the other nodes in the network.

END-TO-END QOS ROUTING

I.**Quality Aware Routing Protocol**

This protocol makes it possible to maintain a given loss ratio along the end-to-end connection path through appropriate use of the ETX and ENT metrics. During the selection process of feasible connection routes, the number of retransmissions is checked and then this number is compared with the maximum admissible value in the protocols of the link layer. So long as the ENT value is higher than the admissible value, the link cost is deemed as infinitely high. At the same time, the ETX metric is also used to estimate the cost of individual links and, following that, links that do not satisfy the assumed parameters are eliminated from the connection route. The most important in this protocol

II. **Ring-Mesh Routing Protocol**

The protocol is based on the Token Ring protocol for wireless LAN networks. The protocol assumes that many concurrent rings are emerging to maintain a secure service of the WMN network with a large number of hops. Individual rings are implemented in the direction from the gateway to the rest of nodes, similarly as in the case of the Spaning Tree. Another assumption is that neighboring rings use different radio frequencies. The ring that spans the gateway is treated as the root ring, whereas other rings are the so-called child rings. Individual rings always include a common node called the pseudo gateway. Subsequent nodes of the network implement further rings created according to the procedure described above and to the transmission delay criterion opposite the source node.

Table 2. Characteristic features of particular groups of routing protocols [9]

Lp	Category of routing protocols	Features
1	Hop-count routing	Simple in routing metric; easy to be integrated with complicated schemes of routing path selection
2	Link-quality based routing	A certain metric for link quality is used to select routing path
3	Interference based routing	Interference or contention is directly considered in routing
4	Load-balanced routing	Congestion or network capacity is explicitly considered
5	Stability based routing	Stability has higher priority
6	End-toEnd QoS Routing	End-to-end QoS is ensured

3.1.3 Proactive and Reactive Protocols

Routing protocols in wireless mesh networks can be divided into two categories: proactive and reactive. Proactive protocols involve a situation where network nodes continuously maintain one, or a number, of routing tables that store routes to each of the nodes of a network and, at the same time, recurrently send them along the network to exchange and update information in neighboring nodes. Reactive protocols, in turn, receive information on the route to the destination (node) of a packet only at the moment when data transmission is to be effected (on demand). These protocols do not generate additional traffic in the network, but the time needed for data to be forwarded is prolonged by the time necessary to effect the exchange of information concerning the available route.

3.2 FOCUS

3.2.1Table-Driven (or Proactive)

The nodes maintain a table of routes to every destination in the network, for this reason they periodically exchange messages. At all times the routes to all destinations are ready to use and as a consequence initial delays before sending data are small. Keeping routes to all destinations up-to-date, even if they are not used, is a disadvantage with regard to the usage of bandwidth and of network resources.

a) DSDV (Destination-Sequence Distance Vector)

DSDV has one routing table, each entry in the table contains: destination address, number of hops toward destination, next hop address. Routing table contains all the destinations that one node can communicate. When a source A communicates with a destination B, it looks up routing table for the entry which contains *destination* address as B. Next hop address C was taken from that entry. A then sends its packets to C and asks C to forward to B. C and other intermediate nodes will work in a similar way until the packets reach B. DSDV marks each entry by sequence number to distinguish between old and new route for preventing loop.

DSDV use two types of packet to transfer routing information: full dump and incremental packet. The first time two DSDV nodes meet, they exchange all of their available routing information in full dump packet. From that time, they only use incremental packets to notice about change in the routing table to reduce the packet size. Every node in DSDV has to send update routing information periodically. When two routes are discovered, route with larger sequence number will be chosen. If two routes have the same sequence number, route with smaller hop count to destination will be chosen.

DSDV has advantages of simple routing table format, simple routing operation and guarantee loop-freedom. The disadvantages are

(i)a large overhead caused by periodical update

(ii)waste resource for finding all possible routes between each pair, but only one route is used.

3.2.3 On-Demand (or Reactive)

These protocols were designed to overcome the wasted effort in maintaining unused routes. Routing information is acquired only when there is a need for it. The needed routes are calculated on demand. This saves the overhead of maintaining unused routes at each node, but on the other hand the latency for sending data packets will considerably increase.

In on-demand trend, routing information is only created to requested destination. Link is also monitored by periodical Hello messages. If a link in the path is broken, the source needs to rediscovery the path. On-demand strategy causes less overhead and easier to scalability. However, there is more delay because the path is not always ready. The following part will present AODV, DSR, TORA and ABR as characteristic protocols of on-demand trend.

b) AODV Routing

Ad hoc on demand distance vector routing (AODV) is the combination of DSDV and DSR. In AODV, each node maintains one routing table. Each routing table entry contains:

- Active neighbor list: a list of neighbor nodes that are actively using this route entry. Once the link in the entry is broken, neighbor nodes in this list will be informed.
- Destination address
- Next-hop address toward that destination
- Number of hops to destination
- Sequence number: for choosing route and prevent loop
- Lifetime: time when that entry expires

Routing in AODV consists of two phases: Route Discovery and Route Maintenance.When a node wants to communicate with a destination, it looks up in the routing table. If the destination is found, node transmits data in the same way as in DSDV. If not, it start Route Discovery mechanism: Source node broadcast the Route Request packet to its neighbor nodes, which in turns rebroadcast this request to their neighbor nodes until finding possible way to the destination. When intermediate node receives a RREQ, it updates the route to previous node and checks whether it satisfies the two conditions: (i) there is an available entry which has the same destination with RREQ (ii) its sequence number is greater or equal to sequence number of RREQ. If no, it rebroadcast RREQ. If yes, it generates a RREP message to the source node. When RREP is routed back, node in the reverse path updates their routing table with the added next hop information. If a node receives a RREQ that it has seen before (checked by the sequence number), it discards the RREQ for preventing loop. If source node receives more than one RREP, the one with greater sequence number will be chosen. For two RREPs with the same sequence number, the one will less number of hops to destination will be chosen. When a route is found, it is maintained by Route Maintenance mechanism: Each node periodically send Hello packet to its neighbors for proving its availability. When Hello packet is not received from a node in a time, link to that node is considered to be broken.

The node which does not receive Hello message will invalidate all of its related routes to the failed node and inform other neighbor using this node by Route Error packet. The source if still want to transmit data to the destination should restart Route Discovery to get a new path. AODV has advantages of decreasing the overhead control messages, low processing, quick adapt to net work topology change, more scalable up to 10000 mobile nodes . However, the disadvantages are that AODV only accepts bi-directional link and has much delay when it initiates a route and repairs the broken link.

c) DYNAMIC SOURCE ROUTING PROTOCOL

DSR is a reactive routing protocol which is able to manage a MANET without using periodic table-update messages like table-driven routing protocols do. DSR was specifically designed for use in multi-hop wireless ad hoc networks. Ad-hoc protocol allows the network to be completely self-organizing and self-configuring which means that there is no need for an existing network infrastructure or administration.

For restricting the bandwidth, the process to find a path is only executed when a path is required by a node (On-Demand-Routing). In DSR the sender (source, initiator) determines the whole path from the source to the destination node (Source-Routing) and deposits the addresses of the intermediate nodes of the route in the packets.

Compared to other reactive routing protocols like ABR or SSA, DSR is beacon-less which means that there are no hello-messages used between the nodes to notify their neighbours about her presence.

DSR was developed for MANETs with a small diameter between 5 and 10 hops and the nodes should only move around at a moderate speed. DSR is based on the Link-State-Algorithms which mean that each node is capable to save the best way to a destination. Also if a change appears in the network topology, then the whole network will get this information by flooding.

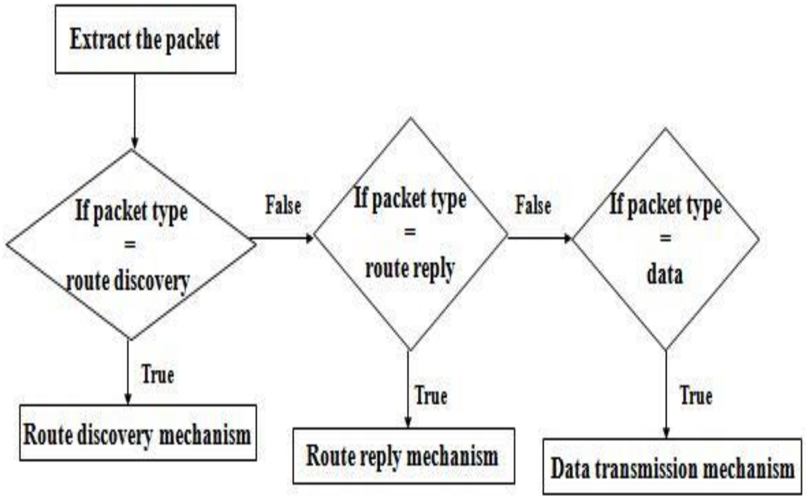


Fig 3.1: Basic operation- Flow chart of Dynamic Source routing protocol

DSR contains 2 phases

1.Route Discovery(find a path)

2.Route Maintenance (maintain a path)

Route Discovery

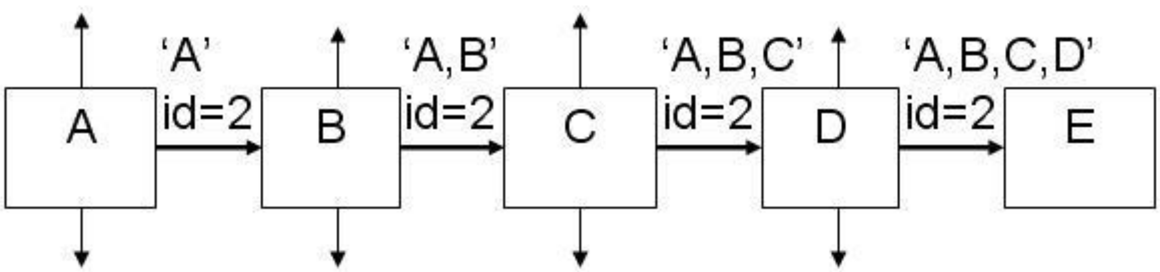


Fig 3.2 Route Discovery

If node A has in his Route Cache a route to the destination E, this route is immediately used. If not, the Route Discovery protocol is started:

5. Node A (initiator) sends a RouteRequest packet by flooding the network
6. If node B has recently seen another RouteRequest from the same target or if the address of node B is already listed in the Route Record, Then node B discards the request!

7. If node B is the target of the Route Discovery, it returns a RouteReply to the initiator.

The RouteReply contains a list of the "best" path from the initiator to the target. When the initiator receives this RouteReply, it caches this route in its Route Cache for use in sending subsequent packets to this destination.

8. Otherwise node B isn't the target and it forwards the Route Request to his neighbors

(except to the initiator).

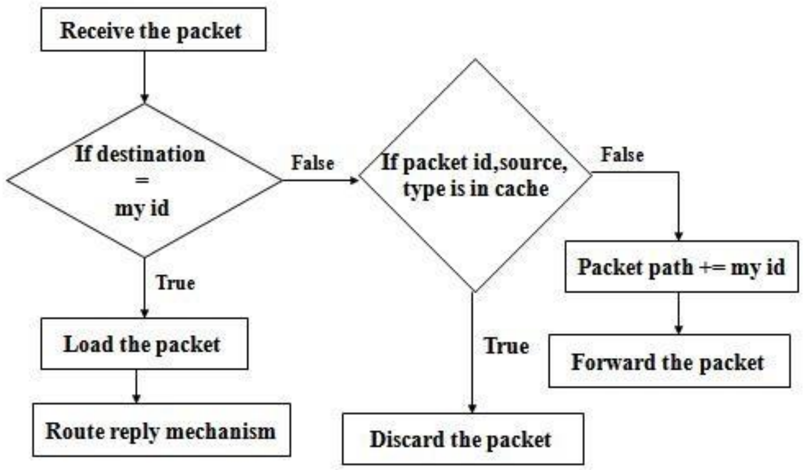


Fig 3.3 : Path Request

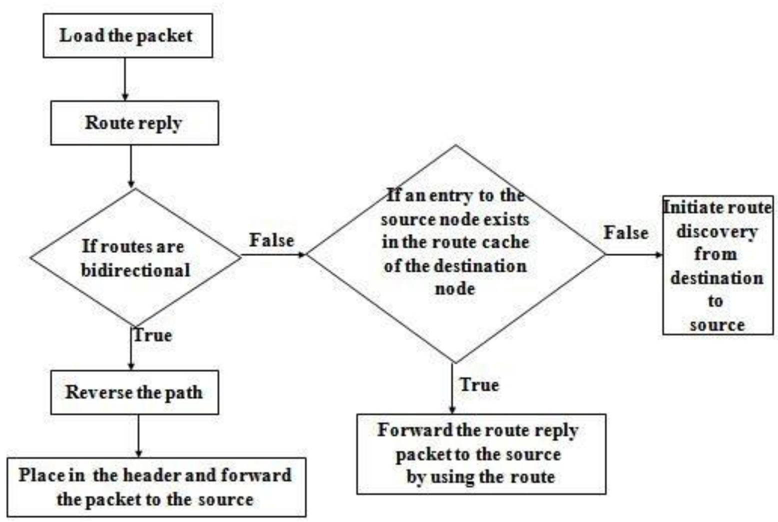


Fig 3.4 Path Reply

Route Maintenance

In DSR every node is responsible for confirming that the next hop in the Source Route receives the packet. Also each packet is only forwarded once by a node (hop-by-hop routing). If a packet can't be received by a node, it is retransmitted up to some maximum number of times until a confirmation is received from the next hop.

Only if retransmission results then in a failure, a Route Error message is sent to the initiator that can remove that Source Route from its Route Cache. So the initiator can check his Route Cache for another route to the target. If there is no route in the cache, a RouteRequest packet is broadcasted.

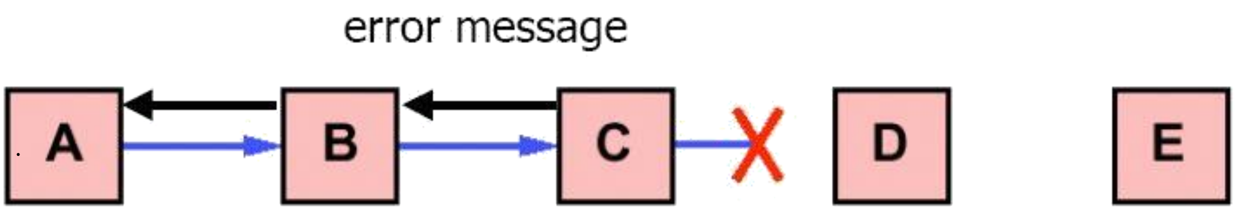


Fig 3.5 Error occurred between node C and D

4. If node C does not receive an acknowledgement from node D after some number of requests, it returns a RouteError to the initiator A.
5. As soon as node receives the RouteError message, it deletes the broken-link-route from its cache. If A has another route to E, it sends the packet immediately using this new route.
6. Otherwise the initiator A is starting the Route Discovery process again.

Advantages

Reactive routing protocols have no need to periodically flood the network for updating the routing tables like table-driven routing protocols do. Intermediate nodes are able to utilize the Route Cache information efficiently to reduce the control overhead. The initiator only tries to find a route (path) if actually no route is known (in cache). Current and bandwidth saving because there are no hello messages needed (beacon-less).

Disadvantages

The Route Maintenance protocol does not locally repair a broken link. The broken link is only communicated to the initiator. The DSR protocol is only efficient in MANETs with less then 200 nodes. Problems appear by fast moving of more hosts, so that the nodes can only move around in this case with a moderate speed. Flooding the network can cause collusions between the packets. Also there is always a small time delay at the begin of a new connection because the initiator must first find the route to the target.

3.3 Pseudo code :For a simple mesh topology

```
************************************************************************#
#Aim : To monitor traffic for Mesh topology using NS2
#************************************************************************#

#Create a simulator object
set ns [new Simulator]

#Open the nam trace file
set nf [open out.nam w]
$ns namtrace-all $nf

#Define a 'finish' procedure
proc finish {} {
   global ns nf
   $ns flush-trace
   #Close the trace file
   close $nf
   #Executenam on the trace file
   exec nam out.nam &
   exit 0
}

#Create four nodes
set n0 [$ns node]
set n1 [$ns node]
set n2 [$ns node]
set n3 [$ns node]

#Create links between the nodes
$ns duplex-link $n0 $n1 1Mb 10ms DropTail
$ns duplex-link $n0 $n2 1Mb 10ms DropTail
$ns duplex-link $n0 $n3 1Mb 10ms DropTail
$ns duplex-link $n1 $n2 1Mb 10ms DropTail
$ns duplex-link $n1 $n3 1Mb 10ms DropTail
$ns duplex-link $n2 $n3 1Mb 10ms DropTail

#Create a TCP agent and attach it to node n0
set tcp0 [new Agent/TCP]
$tcp0 set class_ 1
$ns attach-agent $n1 $tcp0
```

#Create a TCP Sink agent (a traffic sink) for TCP and attach it to node n3
set sink0 [new Agent/TCPSink]
$ns attach-agent $n3 $sink0
#Connect the traffic sources with the traffic sink
$ns connect $tcp0 $sink0

 # Create a CBR traffic source and attach it to tcp0
set cbr0 [new Application/Traffic/CBR]
$cbr0 set packetSize_ 500
$cbr0 set interval_ 0.01
$cbr0 attach-agent $tcp0

#Schedule events for the CBR agents
$ns at 0.5 "$cbr0 start"
$ns at 4.5 "$cbr0 stop"

#Call the finish procedure after 5 seconds of simulation time
$ns at 5.0 "finish"

#Run the simulation
$ns run

3.4 Pseudo code(algorithm) for transmission using LQSR Protocol.

(1) Monitoring period(tm)

for every link j **do**

measure link-quality (lq) using passive monitoring;

end for

send monitoring results to a gateway g;

(2) Failure detection and group formation period (tx)

if link l violates link requirements r **then**

request a group formation on channel c of link l ;

end if

participate in a leader election if a request is received;

(3) Planning period (M ,tp)

if node i is elected as a leader **then**
send a planning request message (c ,M) to a

gateway; **else if** node is a gateway **then**

synchronize requests from reconfiguration groups Mn
generate a reconfiguration plan (p) for Mi ;

send a reconfiguration plan to a leader of Mi;

end if

(4) Reconfiguration period (p ,tx)

if p includes changes of node i **then**

apply the changes to links at t;

end if

relay to neighboring members, if any

3.5 Performance Metrics

The performance metrics helps to characterize the network that is substantially affected by the routing algorithm to achieve the required Quality of Service (QoS). In this work, the following metrics are considered.

End-to-End Delay(EED): It is the time taken for an entire message to completely arrive at the destination from the source. Evaluation of end-to-end delay mostly depends on the following components i.e. propagation time (PT), transmission time (TT), queuing time (QT) and processing delay (PD). Therefore, EED is evaluated as:

EED = PT + TT + QT + PD. (1)

Throughput: It is the measure of how fast a node can actually sent the data through a network. So throughput is the average rate of successful message delivery over a communication channel.

Control Overhead: It is ratio of the control information sent to the actual data received at each node.

Packet Delivery Ratio (PDR): It is the ratio of the total data bits received to total data bits sent from source to destination

Parameter	Value
Simulator	NS-2 (Version 2.34)
Channel type	Channel/Wireless channel
Radio-propagation model	Propagation/Two ray round wave
Network interface type	Phy/WirelessPhy
MAC Type	Mac /802.11
Interface queue Type	Queue/Drop Tail
Link Layer Type	LL
Antenna	Antenna/Omni Antenna
Maximum packet in ifq	60
Area (M*M)	500 5 900
Number of mobile node	16
Source Type	UDP, TCP
Simulation Time	350 sec
Routing Protocols	AODV, DSDR& DSR

Table. 3.3 Simulation parameters

3. 6 Hardware and Software Specification

3.6.1 Hardware Specification

Main processor	Intel(R) Core(TM) i5-2410M CPU @ 2.30GHz
Hard disk capacity	500 GB
Cache memory	512 MB

3.6.2 Software specification:

- The Software Used for Simulation of Protocols would be NS2(Network Simulator 2)
- NS is a discrete event simulator targeted at network research.
  - Physical activities are translated to events.
  - Events are queued and processed in the order of their scheduled occurrences.

- Time progresses as the events are processed.

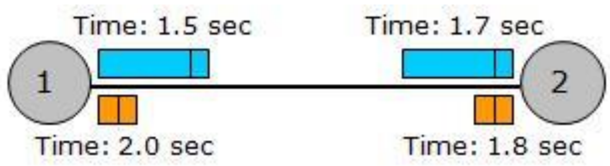


Fig.3.6 NS2 Discrete event simulation

Provides substantial support for simulation of TCP, routing and multicast protocols over wired and wireless networks.

- NS2 Languages:
  Uses Two Languages:

1.Otcl: Used to build network structure and topology which is the surface of simulation.

- quickly exploring a number of scenarios.
- iteration time (change the model and re-run) is more important.

2.C++: Used to Implement new protocols in NS2.

- byte manipulation, packet processing, algorithm implementation.
- Run time speed is important.
- Turn around time (run simulation, find bug, fix bug, recompile, re-run) is slower.

 NS-2 : Components:

3. NS – Simulator
4. NAM – Network AniMator

- visual demonstration of NS output

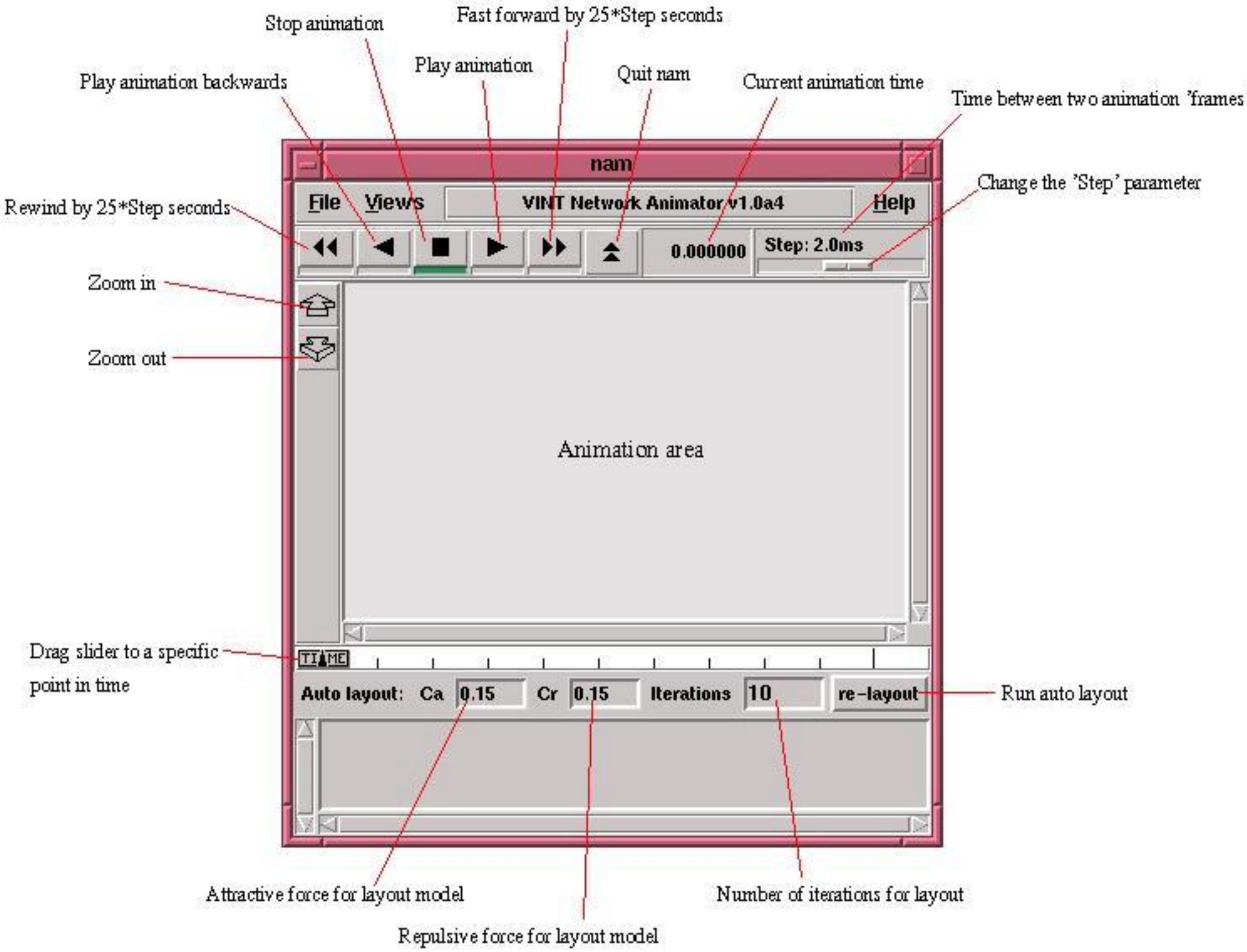


Fig 3.7 NAM(network Animator tool)

5. Preprocessing
   - Handwritten TCL or
   - Topology generator
6. Post analysis
   - Trace analysis using Perl/TCL/AWK/MATLAB

 NS-2 : Environment:

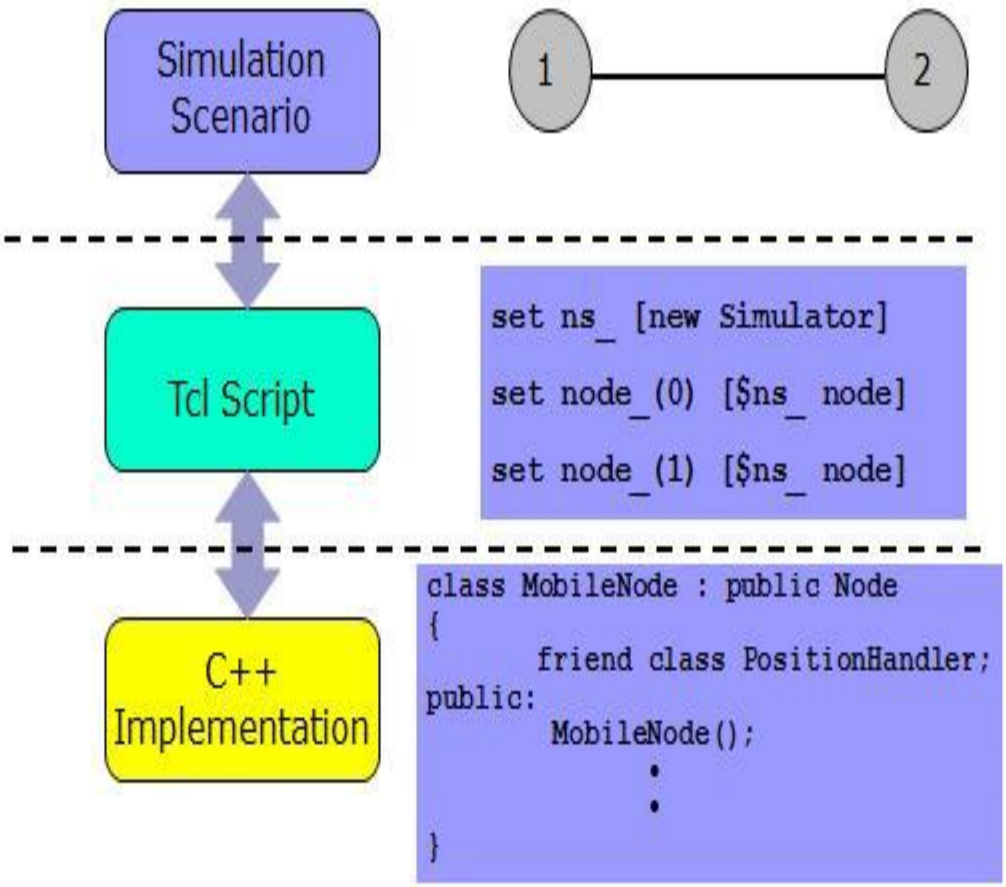


Fig. 3.7 NS-2 Environment

CHAPTER 4 -PERFORMANCE ANALYSIS

4.1 SIMULATION

Simulation model

The performance evaluation of three routing protocol for mobile ad hoc networks by using an open-source network simulation tool called NS-2. Three routing protocols: AODV, DSDV and DSR have been considered for performance evaluation in this work. The simulation environment has been conducted with the LINUX operating system, because NS-2 works with Linux platform only.

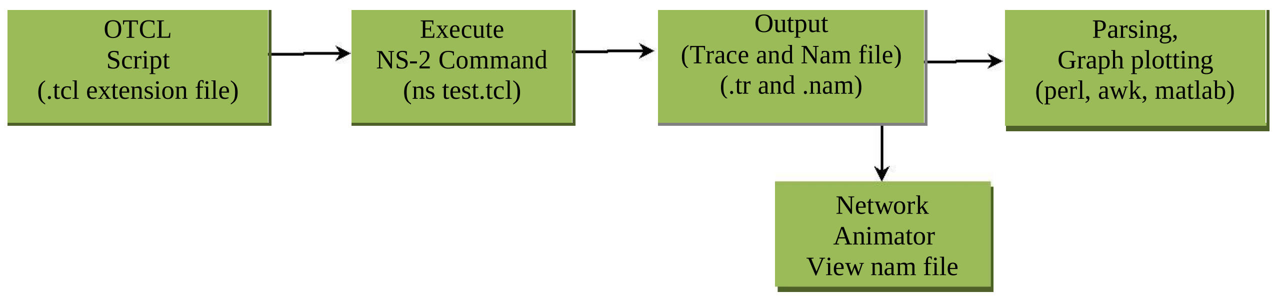


Figure 4.1: Simulation Overview

Whole simulation study is divided into two part one is create the node (that may be cell phone, internet or any other devices) i.e. NS-2 output. It"s called NAM (Network Animator) file, which shows the nodes movement and communication occurs between various nodes in various conditions or to allow the users to visually appreciate the movement as well as the interactions of the mobile nodes. And another one is graphical analysis of trace file (.tr). Trace files contain the traces of event that can be further processed to understand the performance of the network.

Figure 5 depicts the overall process of how a network simulation is conducted under NS-2. Output files such as trace files have to be parsed to extract useful information. The parsing can be done using the *awk* command (in UNIX and LINUX, it is necessary to use gwak for the windows environment) or *perl* script. The results have been analyzed using Excel or Matlab. A software program which can shorten the process of parsing trace files (Xgraph and TraceGraph) has also been used in this paper. However, it doesn"t work well when the trace file is too large. By varying the simulation parameter shown in table 1, we can see the graphical variation between various performance metrics like throughput, drop, delay, jitter etc.

Major assumption

Random waypoint mobility scenario creates random mobility scene every time it is executed by using setdest command in ns-2 tool. So that compares a protocol with themself, we use the same mobility scenario for each modification. At same time using the random way point model we have the two cases for performance analyzes of wireless routing protocols. Finally, by varying the number of nodes (30,40 and 50) and also by varying the speed(5ms,10ms,20ms) of the nodes then calculate the parameter values such as throughput, control overhead, average end to end delay and packet delivery ratio.

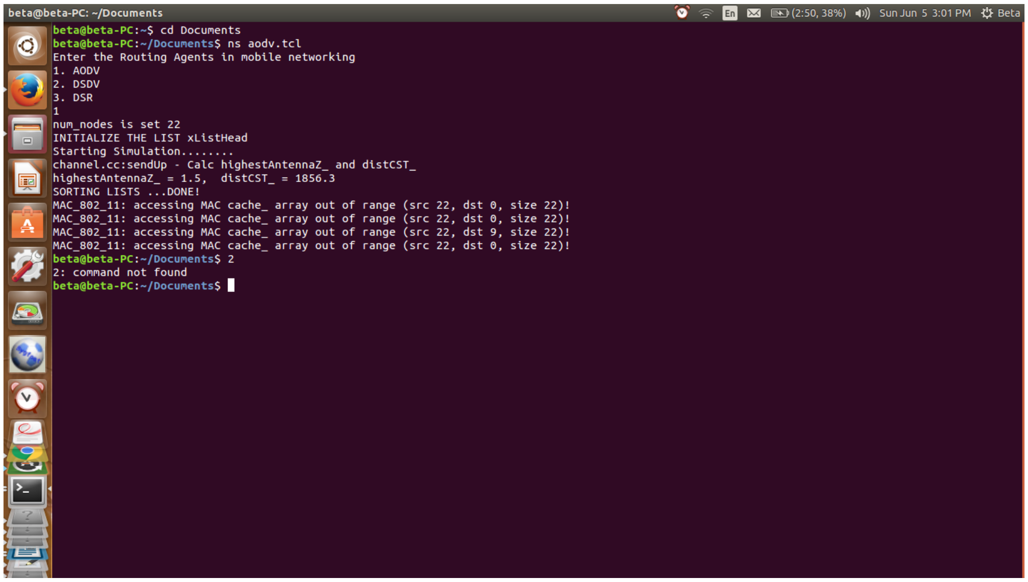


Figure4.1 : Running TCL script in Terminal

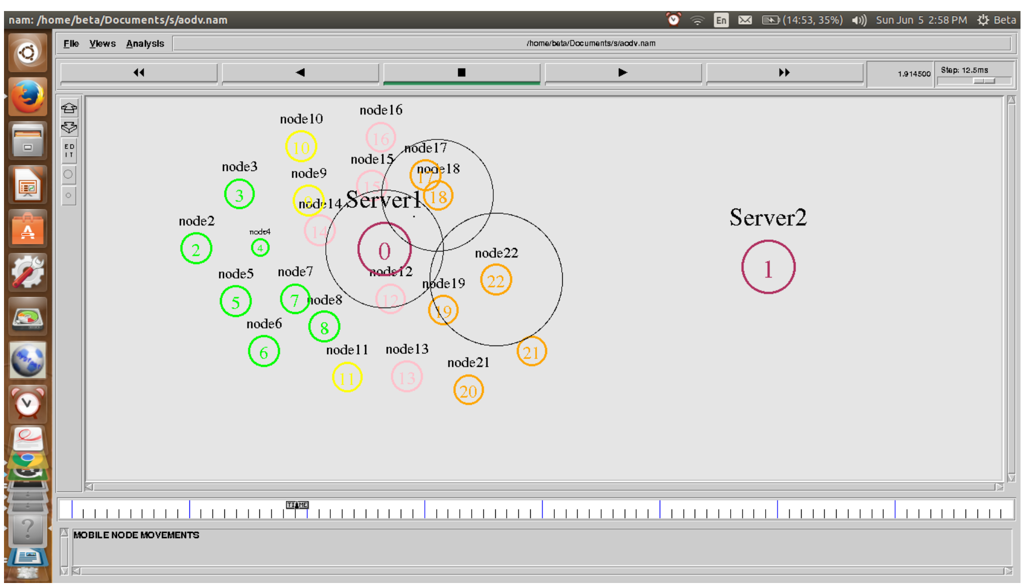


Figure4.2 : A snapshot of the simulation topology in NAM

4.1 PERFORMANCE ANALYSIS

Case 1: By varying speed of nodes

Topology area	500 x 500 m	Max. Speed	20ms
Pause time	10s	UDP traffic	3 conn

Table5.1.Simulation parameter

By changing number of nodes then measure the parametervalues such as control overhead, normalized routingoverhead, delay, packet delivery ratio, throughput andjitter by keeping the speed of the node is constant.

Parameter measured	**25 Nodes**			**40 Nodes**			**50 Nodes**		
	AODV	**DSR**	**DSDV**	**AODV**	**DSR**	**DSDV**	**AODV**	**DSR**	**DSDV**
No. of packets send	557	560	578	573	572	555	568	558	562
No. of Packets Received	549	557	351	567	571	390	565	558	497
Packet delivery ratio	98.56	99.46	60.72	98.95	99.82	70.27	99.47	100	88.43
Control Overhead	399	88	444	285	107	585	253	46	780
Delay	0.03299	0.01291	0.01044	0.01011	0.01204	0.00762	0.00929	0.0090	0.0074
Throughput	23984	23425	15377	24766	24034	17057	24691	23479	21741
Jitter	0.1742	0.1748	0.2465	0.1718	0.1705	0.2256	0.1726	0.1747	0.1961
No. of packets dropped	8	3	227	6	1	165	3	0	65

Table5.2 Simulation parameter values by varying number of nodes

Case (2) By varying speed of the nodes:

Topology	500 x 500 m	No.of	40

area		nodes	
Pause time	10s	UDP traffic	3 conn

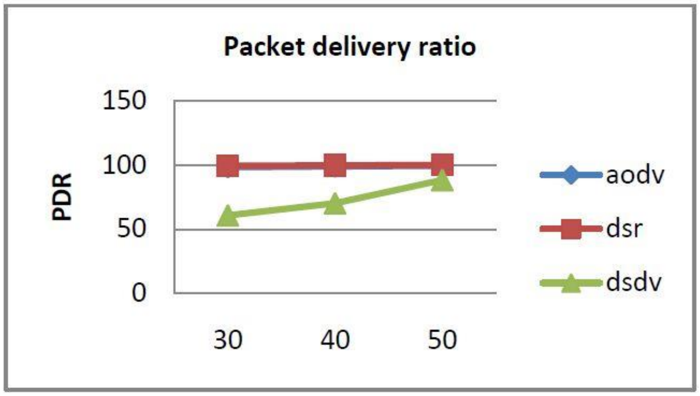
Table5.3 Simulation parameter

In this circumstance by varying the speed(5ms,10ms,20ms) of the node then measure the parameter values such as packet delivery ratio, control overhead, normalized routing overhead, delay, throughput and jitter by keeping the number (40nodes) of the node is constant.

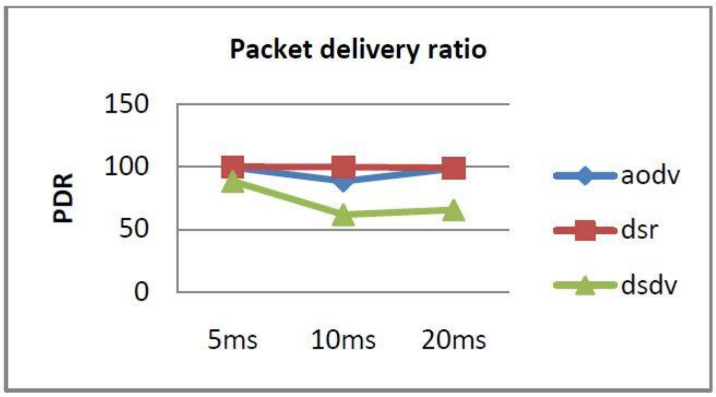
Parameter measured	**5ms**			**10ms**			**20ms**		
	AODV	**DSR**	**DSDV**	**AODV**	**DSR**	**DSDV**	**AODV**	**DSR**	**DSDV**
No. of packets send	579	567	558	570	554	561	557	561	559
No. of packets received	576	568	494	566	553	347	550	556	367
Packet delivery ratio	99.4819	100.176	88.5305	99.298	99.81	61.85	98.74	99.10	65.65
Control Overhead	242	50	590	324	61	607	525	92	624
Delay	0.01163	0.01003	0.00885	0.01432	0.0142	0.00988	0.01969	0.0103	0.00658
Throughput	25170.1	23903.7	21607	24728	23247	15172	24067	23376	16038
Jitter	0.169339	0.17164	0.19737	0.17232	0.1764	0.2813	0.17710	0.1755	0.2657
No. of packets dropped	3	-1	64	4	1	214	7	5	192

Table5.4 Simulation parameter values by varying speed of the mobile nodes

Comparison based on Packet Delivery Ratio



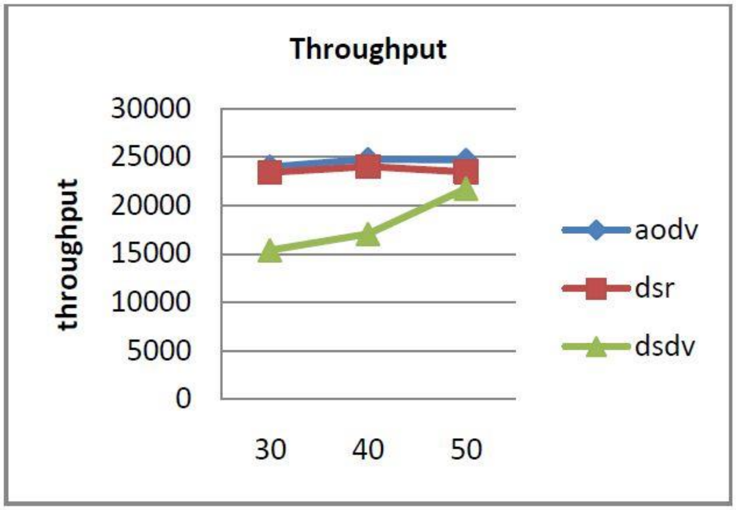
Graph4.1 By varying number of nodes



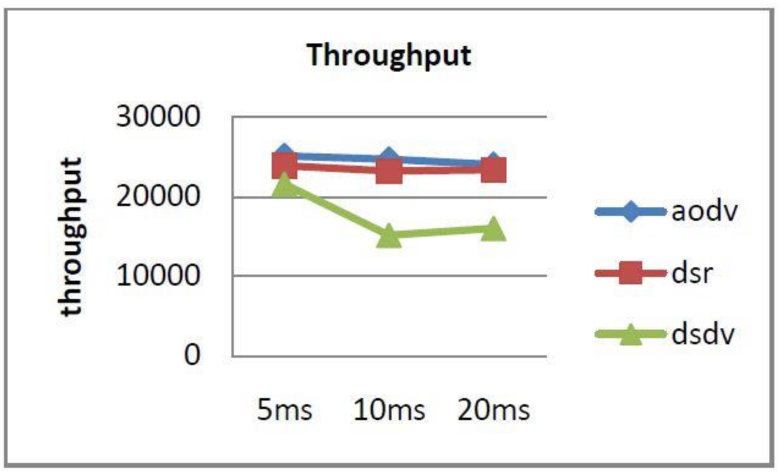
Graph4.2 By varying speed of the nodes

As it can be seen from the above results ,the pdr remains the same in all the scenario despite the increase the number of nodes and increase in the speed of nodes which could be due to the multihop characteristics of the Ad hoc Routing protocol.DSR has slight higher pdr than AODV and Table driven routing protocol(DSDV) lower pdr than reactive protocols(AODV,DSR).Among these three protocols DSR is better pdr than AODV and DSDV.

Comparison based on Throughput

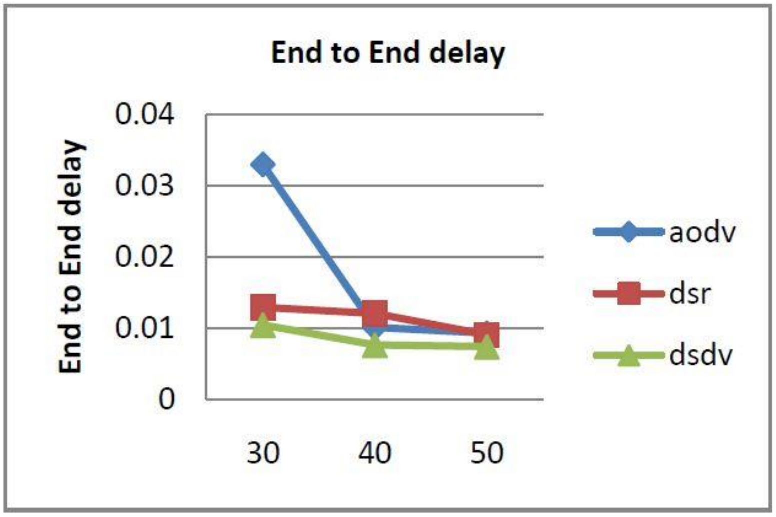


Graph 4.3.By varying number of nodes



Graph 4.4 By varying speed of the nodes

The number of nodes was varied (30, 40, 50) each time in Fig. 6. and the throughput was calculated at destination node during entire AODV shows higher throughput than the DSR and DSDV. The AODV has much more routing packets than DSR because the AODV avoids loop and freshness of routes while DSR uses stale routes. Its throughput is higher than other two routing protocols at high mobility simulation period. As it can be clearly show that simulation and expected throughput can be obtained in AODV routing protocol. Among these three routing protocols AODV is better than other two routing protocols and DSR have slightly lower throughput than AODV. The DSDV have lower throughput than other routing protocols.
Comparison based on End to End delay



Graph 4.5 By varying number of nodes

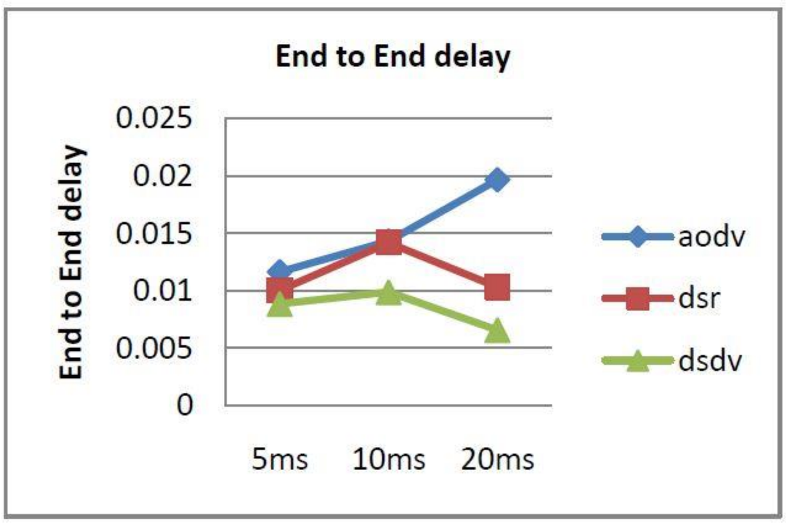


Fig4.6. By varying speed of the nodes

As it can be seen from the above simulation, end to end delay is higher in AODV followed by DSR and DSDV having the lowest and most stable End to End Delay in mobility. By increasing number of nodes in small area then reduce the end to end delay in AODV and increasing speed of the node then increase the delay in AODV. In DSR and DSDV slightly lower delay compared to AODV.

CHAPTER 5- CONCLUSION

5.1 Conclusions

Our simulation work illustrates the performance of three routing protocols AODV, DSR and DSDV. The paper presents a study of the performance of routing protocols, used in WMNs, in high mobility case under low, medium and high density scenario. We vary the number of nodes from 30 (low density) to 50 (high density) in a fixed topography of 500*500 meters. Moreover, since Random Waypoint Mobility Model has been used in this study to generate node mobility. We find that the performance varies widely across different number of nodes and different types of speed in node mobility.

AODV performance is the best considering its ability to maintain connection by periodic exchange of data's. As far as Throughput is concerned, AODV and DSR perform better than the DSDV even when the network has a large number of nodes. Overall, our simulation work shows that AODV performs better in a network with a larger number of nodes whereas DSR performs better when the number of nodes is slight. Average End-to-End Delay is the least for DSDV and does not change if the no of nodes are increased. Thus, we find that AODV is a viable choice for MANETs

5.2 Future Work

future plan is to evaluate security issues in AODV and DSDV..

REFERENCES

[1]. F. Kaabi,S. Ghannay, and F. Filali "Channel Allocation and Routing in Wireless Mesh Networks: A survey and qualitative comparison between schemes" International Journal of Wireless and Mobile Networks(IJWMN),Vol.2,No.1,February 2010.

[2]. Kyu-Han Kim, *Member, IEEE*, and Kang G. Shin*, Fellow, IEEE, ACM "*Self-Reconfigurable Wireless Mesh Networks*"* IEEE/ACM TRANSACTIONS ON NETWORKING, VOL. 19, NO. 2, APRIL 2011.

[3]. Xiaoqin Chen, Haley M. Jones, and Dhammika Jayalath, Senior Member, IEEE, "Channel-Aware Routing in MANETs with Route Handoff" IEEE TRANSACTIONS ON MOBILE COMPUTING, VOL. 10, NO. 1, JANUARY 2011.

[4]. Majid Ghaderi, Member, IEEE, Ashwin Sridharan, Member, IEEE, Hui Zang, Senior Member, IEEE,Don Towsley, Fellow, IEEE, and Rene Cruz, Fellow, IEEE "TCP-Aware Channel Allocation in CDMA Networks" IEEE TRANSACTIONS ON MOBILE COMPUTING, VOL. 8, NO. 1, JANUARY 2009.

[7]. I. Akyildiz, X. Wang, and W. Wang, "Wireless mesh networks: A survey," *Comput. Netw.*, vol. 47, no. 4, pp. 445–487, Mar. 2005.

[8]. P. Kyasanur and N. Vaidya, "Capacity of multi-channel wireless networks: Impact of number of channels and interfaces," in *Proc. ACM MobiCom*, Cologne, Germany, Aug. 2005

[7]. A. Brzezinski, G. Zussman, and E. Modiano, "Enabling distributed throughput maximization in wireless mesh networks: A partitioning approach," in *Proc. ACM MobiCom*, Los Angeles, CA, Sep. 2006, pp.26–37.

[8]. A. Raniwala and T. Chiueh, “Architecture and algorithms for an IEEE 802.11-based multi-channel wireless mesh network,” in *Proc. IEEE INFOCOM*, Miami, FL, Mar. 2005, vol. 3.

[9]. A. P. Subramanian, H. Gupta, S. R. Das, and J. Cao, “Minimum interference channel assignment in multiradio wireless mesh networks,” *IEEE Trans. Mobile Comput.*, vol. 7, no. 12, pp. 1459–1473, Dec. 2008.

[10]. LuyaoWanga, Kwan-WuChina, SietengSohb,RaadRaada, “Novel joint routing and scheduling algorithms forminimizing end-to-end delays in multi Tx-Rx wireless mesh networks”

Department ofComputing,Curtin University of Technology, W A, Australia, 27 May 2015.

[13]. Comparative analysis of link quality metrics and routing protocols for optimal route construction in wireless mesh networks Seongkwan Kim, Okhwan Lee , Sunghyun Choi , Sung-Ju Lee.

Probing-based anypath forwarding routing algorithms in wireless mesh networks Fajun Chen , Yijie Wang , Jiangchuan Liu , Zongpeng Li. Key Laboratory of Science and Technology for National Defence of Parallel and Distributed Processing, School of Computer, National University of Defense Technology, China. April, 2011.