Sudan University of Science and Technology

College of Graduate Studies

Performance Analysis of Ad-hoc On-demand Distance Victor and Destination Sequenced Distance Vector protocols

تحليل أداء بروتوكولات التوجيه المخصص حسب الطلب اعتمادا على المسافة
والوجهات المتسلسلة ذات متجه المسافة

Thesis Submitted in Partial Fulfillment of the Requirements the Degree
of M.Sc. in Electronics Engineering (Computer and Networks)

By:

Elaf Karrar Gamil Abdulrahman

Supervisor:

Dr. Fath Elrahman Ismael Khalifa

JULY 2019

الآيـــــــــة

بسم الله الرحمن الرحيم

قال تعالى:

۞ اللَّهُ نُورُ السَّمَاوَاتِ وَالْأَرْضِ مَثَلُ نُورِهِ كَمِشْكَاةٍ فِيهَا مصْبَاحٌ الْمِصْبَاحُ
فِي زُجَاجَةٍ الزُّجَاجَةُ كَأَنَّهَا كَوْكَبٌ دُرِّيٌّ يُوقَدُ مِن شَجَرَةٍ مُّبَارَكَةٍ زَيْتُونَةٍ لَّا
شَرْقِيَّةٍ وَلَا غَرْبِيَّةٍ يَكَادُ زَيْتُهَا يُضِيءُ وَلَوْ لَمْ تَمْسَسْهُ نَارٌ نُّورٌ عَلَىٰ نُورٍ يَهْدِي
اللَّهُ لِنُورِهِ مَن يَشَاءُ وَيَضْرِبُ اللَّهُ الْأَمْثَالَ لِلنَّاسِ وَاللَّهُ بِكُلِّ شَيْءٍ عَلِيمٌ ۞

سورة النور(35)

DEDICATION

To my lovely parents who are never too busy to encourage me...

To my sisters, brothers …

To my husband...

To my lovely daughters..

Without their knowledge, wisdom and guidance, I should not have the goals I have to strive and to be the best to reach my dreams…

For every one helped me…

For every one I love…

ACKNOWLEDGEMENT

Firstly, praise to ALLAH for everything and for providing me to present this thesis in this way.

I would like to express my gratitude for everyone who helped me during this thesis starting with endless thanks to my supervisor Dr. Fatah Elrahman Ismael for providing me with valuable information to do better each time. Thanks for the kind communication and continuous support which had a great effect to feel interesting about what I am working on.

I extend my sincere gratitude to my parents, brothers, sisters and friends for their encouragements and endless advices and support.

Special thanks to my husband Ibnouf who didn’t keep any effort in encouraging me to do a great job.

ABSTRACT

A mobile ad hoc network (MANET) can be defined as a set of wireless nodes or routers coming together to form a network in which every node acts as a router, the mobile nodes are free to move randomly. There are some challenges that face these networks such as energy efficiency and power consumption duo to limited energy of the nodes, difficulty lies in replacing the batteries, lack of central coordination and constraints on the battery source. So in this thesis the problem of energy is considered and it will focus on two protocols; Ad-hoc On-demand Distance Vector Protocol (AODV) and Destination Sequenced Distance Vector Protocol (DSDV). The protocols are implemented using ns-2.35. This thesis compares two protocols while considering Packet Delivery Ratio (PDR), packet loss, Average end to end delay (E2E), Throughput, power consumption and number of nodes as performance metrics.

The simulation results indicate that; packet delivery ratio (PDR) in AODV is better than DSDV. In AODV it is better by 76.5% in 5m/s, in 10m/s AODV is better by 69.8% and in 15m/s it is 60.26% in the average. AODV has more throughput as compared to DSDV. At 5m/s AODV is better than DSDV by 82.4%. While at 10m/s and 15m/s AODV it is better than DSDV by 72% in the average. The AODV achieves high End-to-End delay due to its hop-by-hop routing methodology and DSDV losses packet more than AODV; at 5m/s and at 10m/s DSDV losses more packets than AODV by 96.9% and at 15m/s DSDV losses more packets than AODV by 88.5% in the average. Although AODV has achieved a higher throughput, higher PDR and lower packet losses; for energy consumption DSDV has consumed less energy; with 5m/s as mobility speed to both sources; AODV consumes more energy by 35.2%. In both destinations with 5m/s as mobility speed AODV consumes 64.2% more energy than DSDV in the average.

المستخلص

يمكن تعريف الشبكة المتنقلة المخصصة كمجموعة من العقد أو الموجهات اللاسلكية تتجمع معاً لتشكيل شبكة تعمل فيها كل عقدة كموجه, العُقد المتنقلة حرة في التحرك بشكل عشوائي. هناك بعض التحديات التي تواجه هذه الشبكات مثل كفاءة الطاقة واستهلاك الطاقة وذلك لمحدودية الطاقة في العقد ، و تكمن التحديات في صعوبة استبدال البطاريات, نقص التنسيق المركزي و القيود على مصدر البطارية. لذا هذه الأطروحة, تأخذ في الإعتبار مشكلة الطاقة وسوف تركز على بروتوكولين التوجيه المخصص حسب الطلب اعتمادا على المسافة والوجهات المتسلسلة ذات متجه المسافة. يتم تنفيذ البروتوكولات باستخدام محاكي الشبكة 2.35. وتقارن هذه الأطروحة البروتوكولين من حيث النظر في نسبة تسليم الحزمة, فقدان الحزمة, متوسط التأخير من نهاية إلى نهاية, الإنتاجية , استهلاك الطاقة وعدد العقد كمقاييس الأداء.

تشير نتائج برنامج المحاكاة إلى أن نسبة تسليم الحزمة في بروتوكول التوجيه المخصص حسب الطلب اعتمادا على المسافة أفضل من برتوكول الوجهات المتسلسلة ذات متجه المسافات بنسبة 76.5% عندما كانت السرعة 5م/ث, وفي السرعة 10 م/ث كانت 69.72% , وفي السرعة 15م/ث كان أفضل بنسبة 60.26% في المتوسط. برتوكول التوجيه المخصص حسب الطلب اعتمادا على المسافة لديه إنتاجية أعلى بالمقارنة ببروتوكول الوجهات المتسلسلة ذات متجه المسافات . عند السرعة 5 م/ث أعلى بنسبة 82.4%. بينما في السرعة 10 م/ث و 15 م/ث كانت أعلى بنسبة 72% في المتوسط. يحقق برتوكول التوجيه المخصص حسب الطلب اعتمادا على المسافة تأخيرًا كبيرًا من النهاية إلى النهاية بسبب منهجية توجيه القفزة بواسطة القفزة ويعرض بروتوكول الوجهات المتسلسلة ذات متجه المسافات مزيدًا من خسائر الحزمة من بروتوكول التوجيه المخصص حسب الطلب اعتمادا على المسافة بنسبة 96.9 % في السرعة 5 م/ث و 10 م/ث , وعند السرعة 15 م/ث كانت النسبة 88.5% في المتوسط. وعلى الرغم من أن بروتوكول التوجيه المخصص حسب الطلب اعتمادا على المسافة قد حقق معدل إنتاج أعلى وخسائر أقل في نسبة تسليم الحزمة ؛إلا ان وبرتوكول الوجهات المتسلسلة ذات متجه المسافات يستهلك طاقة أقل من التوجيه المخصص حسب الطلب اعتمادا على المسافة .

في 5 م/ث كسرعة للتنقل لمصدري البرتوكولين ؛ يستهلك التوجيه المخصص حسب الطلب اعتمادا على المسافة طاقة أكثر بنسبة 35.2٪ .و في كلا الوجهتين بسرعة5 م/ث يستهلك طاقة أكثر بنسبة 64.2 ٪ في المتوسط.

TABLE OF CONTENTS

Contents

LIST OF FIGURES

LIST OF TABLES

LIST OF ABBREVIATIONS

ABR	Associativity Based Routing
AODV	Ad-hoc On demand Distance Vector
CBR	Continues Bit Rate
CBRP	Cluster Based Routing Protocol
CCK	Complementary Code Keying
DOS	Denial of Service
DSDV	Destination Sequenced Distance-Vector routing protocol
DSR	Dynamic Source Routing
E2E	End to End delay
GloMoSim	Global Mobile Information System Simulator
IEEE	Institute of Electrical and Electronic Engineers
iMANET	Internet based Mobile Ad hoc Networks
InVANET	Intelligent Vehicular Ad hoc Networks
IP	Internet Protocol
LAR	Location Aided Routing
MAC	Media Access Control
MANET	Mobile Ad-hoc Network
MBWA	Mobile Broadband Wireless Access
NAM	Network Animator
NetSim	Network Simulator
NS2	Network Simulator version2
OLSR	Optimized Link State Routing Protocol
OORP	Order One Network Protocol
OSI	Open System Interconnection
OTCL	Object Oriented Command Language

PAN	Personal Area Network
PDA	Personal Digital Assistant
PDR	Packet Delivery Ratio
RERR	Route Error
RET	Route Expiry Time
RREP	Route Reply
RREQ	Route Request
SSA	Serial Storage Architecture
SR	Selective Repeat
SSR	Signal Stability Routing
TORA	Temporally Ordered Routing Algorithm
TTL	Time to Live
VANET	Vehicular Ad hoc Network
WLAN	Wireless Local Area Network
WMAN	Wireless Metropolain Area Network
WPAN	Wireless Personal Area Network
WRP	Wireless Routing Protocol
ZRP	Zone Routing Protocol

Chapter One
Introduction

Chapter One
Introduction

1.1 Overview

A mobile ad hoc network (MANET) is a network formed without any central administration, which consists of mobile nodes that use a wireless interface to send and receive packet data. Since the nodes are mobile, the network topology dynamically changes in an unpredictable manner. The traditional routing methods for wired network cannot be directly applied to these networks as there is no established infrastructure for central administration. [1].

The most widely used routing protocol in MANETs is the ad-hoc On Demand Distance Vector (AODV). AODV routing protocol is an on-demand protocol that is it discovers routes on an as needed basis using route discovery process. It uses traditional routing tables, one entry per destination to maintain routing information.

Destination Sequenced Distance Vector protocol (DSDV) is a proactive routing protocol based on the Bellman-Ford algorithm with certain improvements that address the poor looping properties of the algorithm. Every mobile node has a routing table that contains the number of hops to all available destinations within the ad-hoc network. Each routing table entry has a sequence number associated with [2]. There are other famous routing protocols like Dynamic Source Routing (DSR), Optimized Link State Routing protocol (OLSR) and Zone Routing Protocol (ZRP) etc.

In this study we evaluate and compare the performance of Ad hoc on Demand Distance Vector (AODV), and Destination-Sequenced Distance-Vector (DSDV), in different number of nodes to bring out their relative advantages.

1.2 Problem Statement

In MANET, the increasing number of mobile nodes under dynamic mobility affects the performance of routing protocol. It also needs high battery life; the routing protocols do not consider energy of nodes while selecting routes.

1.3 Proposed Solution

In this thesis AODV and DSDV are evaluated using NS-2 simulation tool under different network conditions. The performance of both protocols varies under different parameters.

1.4 Aim and Objectives

The main aim of this thesis is to evaluate the performance of AODV and DSDV protocols in Mobile Ad -Hoc Networks.

The objectives of the thesis are:

- To implement different network scenarios using the NS2 simulator for AODV and DSDV protocols.
- To understand their internal working mechanism.
- To analyze and compare the performance of both protocols implemented in a mobile ad hoc environment with different performance metrics.

1.5 Methodology

In this thesis, set of networks which are randomly distributed AODV and DSDV protocols are simulated. Network Simulator 2 is chosen as a simulation environment. It is used to evaluate the performance metrics of both protocols. The output of the NS-2 simulation, trace file, is studied to measure the performance by using throughput, packet delivery ratio and packet lost as performance metrics in different number of nodes. The trace file is analyzed using the AWK script. The NS2 simulator gives two files as output; NAM (Network Animator) generates NAM file, which is used for graphical visualization and other file called trace file is used for calculating the results.

1.6 Thesis Outlines

The document of the thesis is composed of five chapters; their outlines are as follow:

- **Chapter one** is the introduction to the thesis, which introduces the thesis, the problem, objectives and the proposed solution.
- **Chapter Two** gives an overview of mobile ad hoc networks, describes its characteristics in general, challenges, types, application and routing protocols. Finally, AODV and DSDV Protocols discussed and described. And then this chapter provides the latest trends of research going in the field of power saving in MANET.
- **Chapter Three** gives an overview of the simulation environment in where a network model is run and the performance metrics that are chosen for evaluating the performance technique and the evaluation techniques.
- **Chapter Four** shows the simulation results of AODV and DSDV protocol and numbers of experiments were performed using the performance metrics.
- **Chapter Five** include the conclusion and future works.

Chapter Two

Background and Related Works

Chapter Two

Background and Related Works

2.1 Mobile Ad-hoc Networks MANET

A mobile ad hoc networks as shown in Figure 2-1 is an autonomous system of mobile nodes (also serving as routers) connected by wireless link. Since the nodes are mobile, the network topology dynamically changes in an unpredictable manner. The traditional routing methods for wired network cannot be directly applied to these networks as there is no established infrastructure for central administration [3].

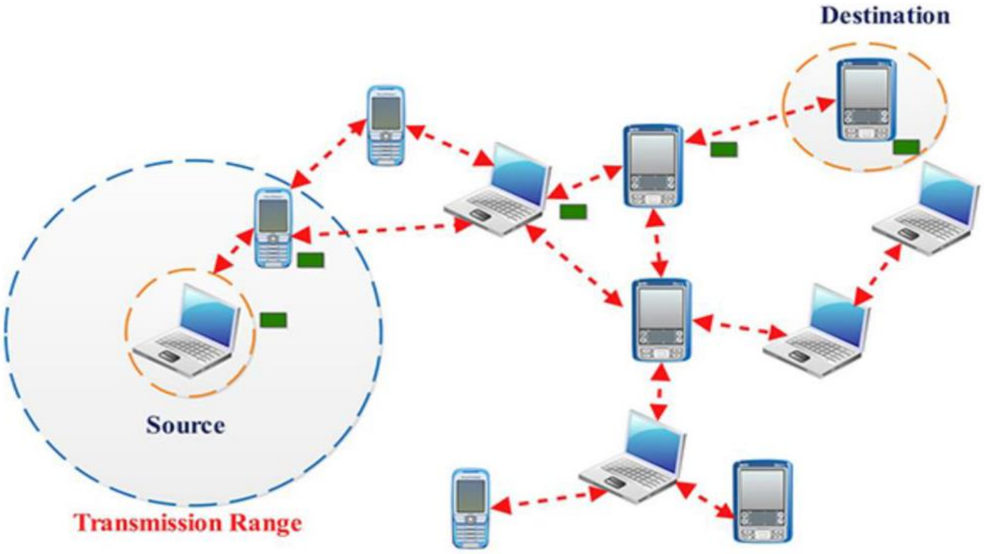


Figure 2-1: A Mobile Ad-hoc network [4]

Mobile devices coupled with wireless network interfaces will become an essential part of future computing environment consisting of infrastructured and infrastructure-less mobile networks. Wireless local area network based on IEEE 802.11 technology is the most prevalent infrastructured mobile network, where a mobile node communicates with a fixed base station, and thus a wireless link is limited to one hop between the node and the base station. MANET is an infrastructure-less multi hop network where each node communicates with other nodes directly or indirectly through intermediate nodes. Thus, all nodes in a MANET basically function as mobile routers participating in some routing protocol required for deciding and maintaining the routes [5].

2.1.1 Characteristics of MANETs

MANET is characterized by some specific features as the nodes are connected by wireless links and the communication among nodes is wirelessly. Network is self-organizing and is independent of any fixed infrastructure or centralized control. The operation mode of each node is distributed peer-to-peer capable of acting as an independent router as well as generating independent data also there is no dedicated router and every node acts as a router to pass packets to other nodes. Due to arbitrary movement of nodes at varying speed; the topology of network may change unpredictably and randomly. Energy conservation becomes the major design issue as nodes in the MANET rely on batteries or some other exhaustible source of energy. Infrastructure less networks have lower capacity as well as less throughput than the infrastructure based network and there are higher chances of physical security threats like eavesdropping, spoofing and Denial of Service (DoS) in wireless networks as compared to wired networks [6].

2.1.2 Types of MANETs

There are different types of MANET including Intelligent Vehicular Ad-hoc Networks (InVANETs) makes use of artificial intelligence to tackle unexpected situations like vehicle collision and accidents. Vehicular ad hoc networks (VANETs) which Enable effective communication with another vehicle or help to communicate with roadside equipments. And Internet Based Mobile Ad hoc Networks (iMANET) helps to link fixed as well as mobile nodes [5].

2.1.3 MANETs Applications

The applications of MANET had become wide and varied from email to ftp to web services. Some common MANET applications are Personal Area Networking (PAN) in devices like laptops, PDAs; mobile phones create a temporary network of short range to share data among each other. In Military Environments since it is not possible to install base station in the enemy territories or inhospitable terrain MANET provides communication services where soldiers act like nodes. The required coordination among the soldiers and in military objects can be seen as another application of MANET in military services. In Civilian Environments MANETs are used in many civilian activities like taxi cab network, meeting rooms, sports stadiums, boats, small aircraft, etc. And in Emergency Operations due to its easy deployment, the use of MANET in situations like search and rescue, crowd control, disaster recovery and command operations, the use of mobile ad hoc networks is very much suitable. MANET can also be established when conventional infrastructure based communication is damaged due to any calamities [6].

2.1.4 MANETs Challenges

A MANET environment has to overcome certain issues of limitation and inefficiency such as fewer infrastructures that mobile ad hoc networks do not have links between nodes, which introduces issues with routing and complex routing techniques must be developed for this purpose. Each node has a limited communication range (transmission power) because each node has limited available power so the processing power of each node must be considered, especially because each node acts as an individual router that performs network control. Security in ad hoc networks is limited, since mobile ad hoc networks are highly dynamic, a security solution that is equivalently dynamic must be designed. Nodes need to forward or transmit packets of other nodes as well as their own packets, which creates scarce bandwidth. This has been addressed by the research community, and a number of optimal bandwidth utilization techniques have been developed. Mobility of the nodes causes frequent link failures, which in turn decrease the performance of the network. In wired networks, routing protocols are successful to efficiently transmit data between two endpoints because the topology is, by definition, fixed. Because all the nodes are stationary, the links are more reliable. However, this is not possible in mobile ad hoc networks [7].

2.2 IEEE 802 Wireless Networking Standards

IEEE 802 refers to a family of IEEE standards dealing with local area networks and metropolitan area networks .IEEE 802 specifications are focus on the data link layer and physical layer of the Open System Interconnection (OSI) reference model. Some of the main members of IEEE 802 are listed in Table 2-1 [8].

Table2-1: IEEE 802 Standards

IEEE Standard	Network Definition	Known As
802.3	Wired Local Area Network	Ethernet
802.11	Wireless Local Area Network (WLAN)	Wi FI
802.15.1	Wireless personal Area Network (WPAN)	Bluetooth
802.15.4	Low Rate-Wireless Personal Area Network (LR-WPAN)	ZigBee
802.16	Wireless Metropolain Area Network (WMAN)	Wi Max
802.20	Mobile Broadband Wireless Access (MBWA)	
802.22	Wireless Regional Area Network (WRAN)	

2.3 MANET Routing Protocols

The function of ad hoc routing protocol is to control the node decisions when routing packets between devices in MANET. When a node joins or tries to join the network it does not know about the network topology. By announcing its presence or by listening from the neighbor nodes it discovers the topology. In a network route discovery process depends on the routing protocol implementation. Also Routing Protocol is needed whenever a packet needs to be transmitted to a destination via number of nodes. The routing protocols for wired networks cannot be used for mobile ad hoc networks because the nodes can move randomly and can also join or leave the network. This means that an optimal route at a certain time may not work seconds later. For mobile ad hoc networks, several routing protocols have been designed and these protocols are classified as shown in Figure 2-2 under two major fields of protocols called reactive or proactive. An ad hoc routing protocol with the combination of these two is called a hybrid protocol [9].

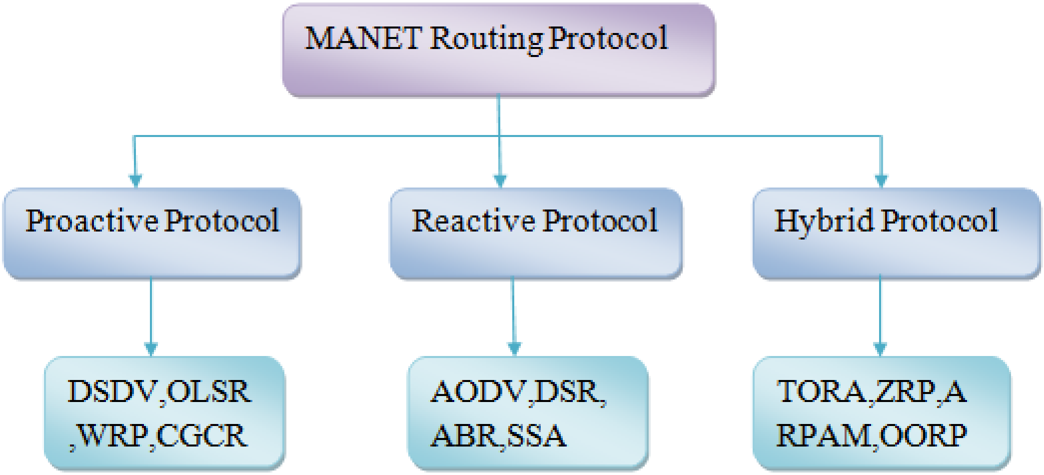


Figure 2-2: MANET routing protocols classifications

2.3.1 Table Driven Routing Protocols

Table Driven Routing Protocols also known as Proactive Protocols, work out routes in the background independent of traffic demands. Each node uses routing information to store the location information of other nodes in the network and this information is then used to move data among different nodes in the network. This type of protocol is slow to converge and may be prone to routing loops. These protocols keep a constant overview of the network and this can be a disadvantage as they may react to change in the network topology even if no traffic is affected by the topology modification which could create unnecessary overhead. Even in a network with little data traffic, Table Driven Protocols will use limited resources such as power and link bandwidth therefore they might not be considered an effective routing solution for Ad-hoc Networks. Some of the used proactive routing protocols used in ad hoc networks are Optimized Link State Routing protocol (OLSR), Destination Sequenced Distance-Vector routing protocol (DSDV), and Wireless Routing Protocol (WRP).

2.3.2 On Demand Routing Protocols

On Demand Routing Protocols also known as Reactive Protocols, establish routes between nodes only when they are required to route data packets. There is no updating of every possible route in the network instead it focuses on routes that are being used or being set up. When a route is required by a source node to a destination for which it does not have route information, it starts a route discovery process which goes from one node to the other until it arrives at the destination or a node in-between has a route to the destination. On Demand protocols are generally considered efficient when the route discovery is less frequent than the data transfer because the network traffic caused by the route discovery step is low compared to the total communication bandwidth. This makes On

Demand Protocols more suited to large networks with light traffic and low mobility. Some Reactive Protocols are Cluster Based Routing Protocol (CBRP), AODV, DSR, TORA, Associatively-Based Routing (ABR), Signal Stability Routing (SSR) and Location Aided Routing (LAR).

2.3.3 Hybrid Routing Protocols

Hybrid Routing Protocols combine Table Based Routing Protocols with On Demand Routing Protocols. They use distance-vectors for more precise metrics to establish the best paths to destination networks, and report routing information only when there is a change in the topology of the network. Each node in the network has its own routing zone, the size of which is defined by a zone radius, which is defined by a metric such as the number of hops. Each node keeps a record of routing information for its own zone. Zone Routing Protocol (ZRP) is an example of a Hybrid routing protocol [10].

2.4 AODV Routing Protocol

Ad-hoc On-demand Distance Vector (AODV) routing protocol is an on demand routing protocol which routes are established when they are required in the routing table of AODV, the station only has the information of the next hop and destination pair.

2.4.1 Characteristics of AODV

AODV protocol is characterized by some specific features as Unicast, Broadcast, and Multicast communication. It also had another features like On-demand route establishment with small delay, Multicast trees connecting group members maintained for lifetime of multicast group, Link breakages in active routes efficiently repaired, all routes are loop-free through use of sequence numbers, Use of Sequence numbers to track accuracy of information, only keeps track of next hop for a route instead of the entire route and Use of periodic HELLO messages to track neighbors.

2.4.2 AODV Message Types

The message types that AODV protocol defines are Route Requests messages (RREQs)which are used to initiate the route finding process, Route Replies messages (RREPs)which are used to finalize the routes and Route Errors messages (RERRs) breakage in an active route.

2.4.2.1 Route Discovery Generate RREQs

When a node wishes to send a packet to some destination, it checks its routing table to determine if it has a current route to the destination If Yes, forwards the packet to next hop node If No, it initiates a route discovery process. Route discovery process begins with the creation of a Route Request (RREQ) packet source node creates it as shown in Figure2-3. The packet contains source node’s IP address, source node’s current sequence number, destination IP address, and destination sequence number. Packet also contains broadcast ID number; Broadcast ID gets incremented each time a source node uses RREQ. Broadcast ID and source IP address form a unique identifier for the RREQ. Broadcasting as shown in Figure2-4 is done via Flooding. Once an intermediate node receives a RREQ, the node sets up a reverse route entry for the source node in its route table. Reverse route entry consists of Source IP address, Source seq. number, number of hops to source node, IP address of node from which RREQ was received. Using the reverse route, a node can send a RREP (Route Reply packet) to the source. Reverse route entry also contains lifetime field. RREQ reaches destination in order to respond to RREQ a node should have in its route table unexpired entry for the destination and seq. number of destination at least as great as in RREQ (for loop prevention) [11].

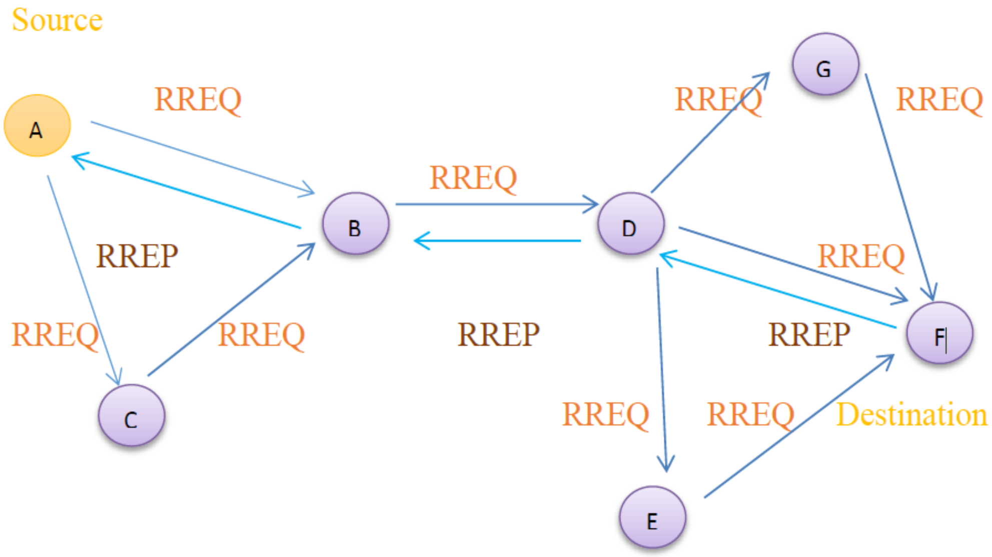
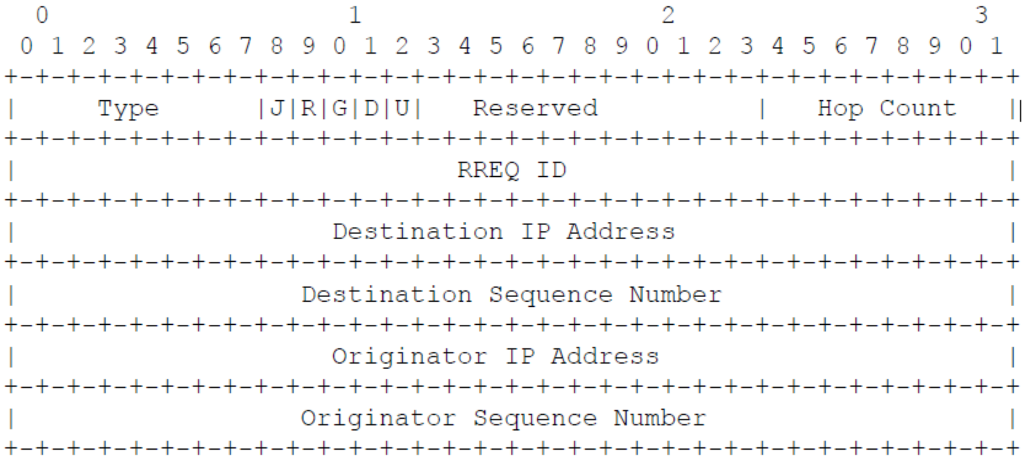


Figure 2-3 : AODV Route Discovery [11]



```
 0                   1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|     Type      |J|R|G|D|U|   Reserved          |   Hop Count   ||
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                            RREQ ID                            |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                    Destination IP Address                     |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                  Destination Sequence Number                  |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                    Originator IP Address                      |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                  Originator Sequence Number                   |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

Figure 2-4: AODV Route request packet format [12]

2.4.2.2 RREQ Reaches Destination

If both conditions are met and the IP address of the destination matches with that in RREQ the node responds to RREQ by sending a RREP back using unicasting and not flooding to the source using reverse path. If conditions are not satisfied, then node increments the hop count in RREQ and broadcasts to its neighbors. Ultimately, the RREQ will make to the destination.

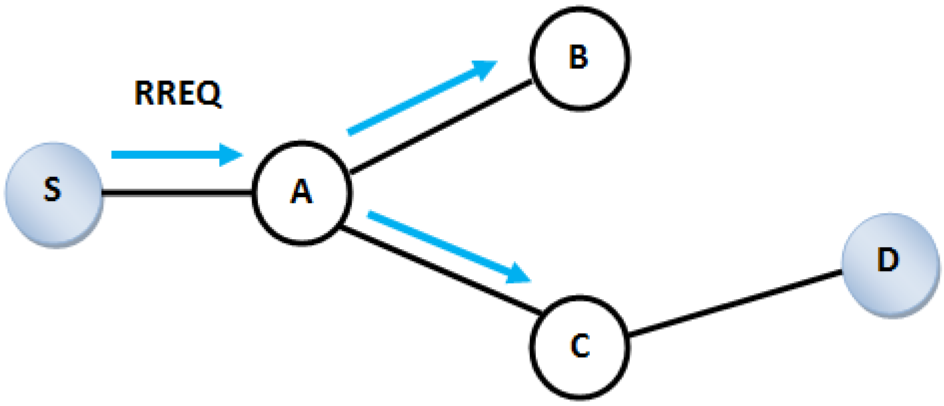


Figure 2-5: AODV Route Discovery - RREQ

In Figure 2-5 node S needs a route to D and creates a Route Request (RREQ) enters D's IP addr, seq#, S's IP addr, seq#, hopcount (=0). Node S broadcasts RREQ to neighbors. Node A receives RREQ and makes a reverse route entery for S dest=S, nexthop=S, hopcount=1. It has no routes to D, so it rebroadcasts RREQ. Node C receives RREQ makes a reverse route entry for S dest=S, nexthop=A, hopcount=2 It has a route to D, and the seq# for route to D is D's seq# in RREQ. C creates a Route Reply (RREP) Enters D's IP addr, seq#, S's IP addr, hopcount to D (=1) and unicasts RREP to A [13].

2.4.2.3 Receives RREP

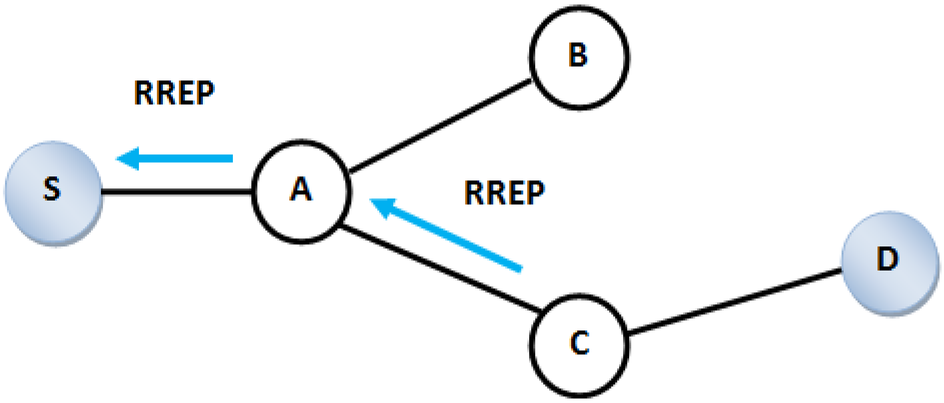


Figure 2-6: AODV Route Discovery - RREP

In Figure 2-6 node A receives RREP makes a forward route entry to D dest=D, nexthop=C, hopcount=2 and unicasts RREP to S. When a node determines that it has a current route to respond to RREQ i.e. has a path to destination it creates RREP (Route Reply). RREP contains <IP

address of source and destination>. If RREP is being sent by destination it will also contain the <current sqn # of destination, hopcount= 0, life-time>. If RREP is sent by an intermediate node it will contain its record of the <destination sequence number, hop-count=its distance to destination, its value of the life-time>. When an intermediate node receives the RREP, it sets up a forward path entry to the destination in its route table. Forward path entry contains<IP Address of destination, IP address of node from which the entry arrived, hop-count to destination, life-time>. To obtain its distance to destination i.e. hop-count, a node increments its distance by 1 if route is not used within the life time, its deleted. After processing the RREP, the node forwards it towards the source.Node S receives RREP Makes a forward route entry to D dest=D, nexthop =A, hopcount = 3. A node may receive multiple RREP for a given destination from more than one neighbor. The node only forwards the first RREP it receives may forward another RREP if that has greater destination sequence number or a smaller hop count. Rest are discarded reduces the number of RREP propagating towards the source. Source can begin data transmission upon receiving the first RREP.

Lifetime can be defined as the time for which the route is expected to be active. It is usually updated to the constant value ACTIVE_ROUTE_TIMEOUT. This value will be updated in the lifetime field of the route entry in the routing table.

In Delivery of Data as shown in Figure2-7, node S receives RREP Makes a forward route entry to D dest=D, nexthop =A, hopcount = 3 sends data packet on route to D.

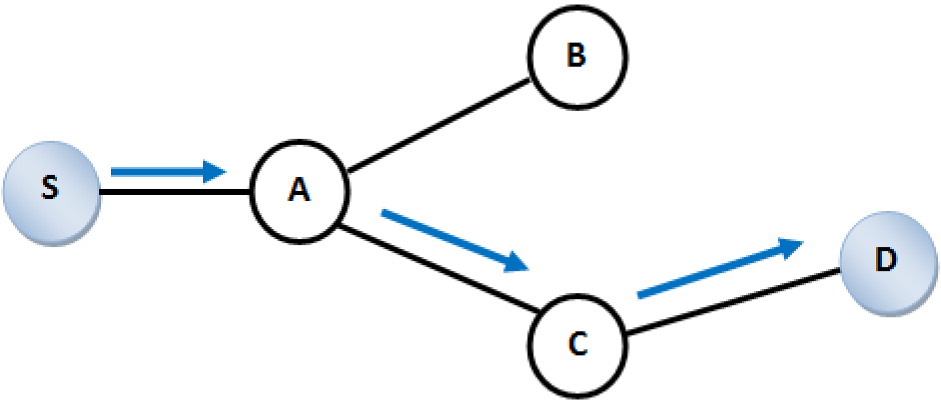


Figure 2-7: Data Delivery

A routing table entry maintaining a reverse path is purged after a timeout interval, timeout should be long enough to allow RREP to come back. A routing table entry maintaining a forward path is purged if not used for a active_route_timeout interval. If no is data being sent using a particular routing table entry, that entry will be deleted from the routing table (even if the route may actually still be valid)

A neighbor of node X is considered active for a routing table entry if the neighbor sent a packet within active_route_timeout interval and was forwarded using that entry. If a source node moves, a new route discovery process is initiated. If intermediate nodes or the destination move, the next hop links break resulting in link failures. Routing tables are updated for the link failures. All active neighbors are informed by RERR message. When a route is not used for a period of time, the route times out and is deleted from the route table. This time period is called the Route Expiry Time (RET) or the lifetime of the route.

2.4.2.4 Route Maintenance - RERR

RERR is initiated by the node upstream (closer to the source) of the break. Its propagated to all the affected destinations. RERR lists all the nodes affected by the link failure nodes that were using the link to route messages (precursor nodes). When a node receives an RERR, it marks its route to the destination as invalid setting distance to the destination as infinity in the route table. When a source node receives an RRER, it can reinitiate the route discovery. Link between C and D breaks as shown in Figure 2-8. Node C invalidates route to D in route table and C creates Route Error message lists all destinations that are now unreachable sends to upstream neighbors. Also node A receives RERR checks whether C is its next hop on route to D and deletes route to D (makes distance infinity) then forwards RERR to S. finally node S receives RERR checks whether A is its next hop on route to D, deletes route to D and rediscovers route if still needed.

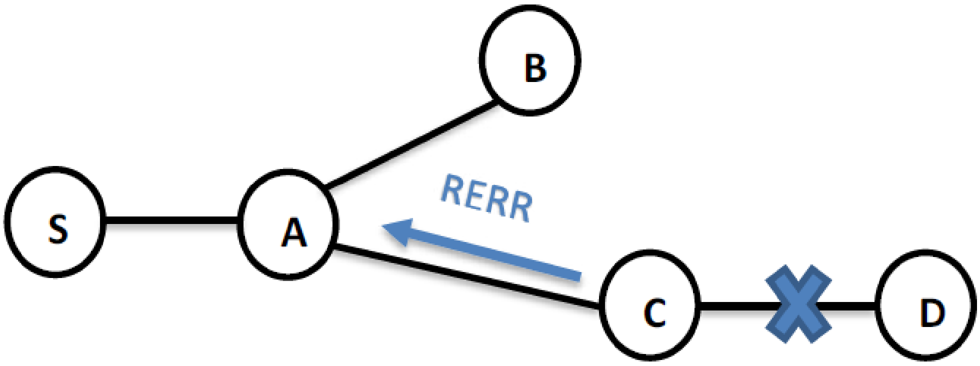


Figure 2-8: AODV Route maintenance

2.4.2.5 Route Error

When node X is unable to forward packet P (from node S to node D) on link (X, Y), it generates a RERR message. Node X increments the destination sequence number for D cached at node X. The incremented sequence number N is included in the RERR. When node S receives the RERR, it initiates a new route discovery for D using destination sequence number at least as large as N, Figure 2-9 shows AODV protocol messaging.

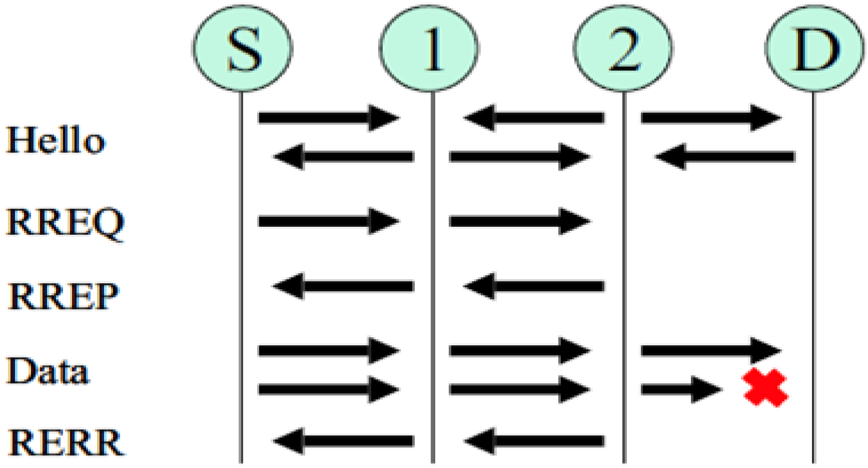


Figure 2-9: AODV protocol messaging [14]

Route Requests are initially sent with small Time-to-Live (TTL) field, to limit their propagation. If no Route Reply is received, then larger TTL tried [13].

2.4.3 AODV Routing

AODV protocol follows two major phases. The first one is Route set-up phase; in this phase, as demand arises a route is set up between the source and the destination. Then, the following process takes place: The network is initially flooded with requests for the route; then the request is flooded until the TTL becomes 0; after that, the request packet is discarded. The next stage involves caching a route that is set up. The route will be cached for a specified period of time. And the second phase is Route maintenance; this phase is responsible for maintaining the routes. If the route is not available, then an error message will be sent, and all the nodes will be notified.

2.4.3.1 Factors Affecting Route Decisions

A node decides which route to update in the routing table based on the two values, the first value is the Destination Sequence Number; the feature that distinguishes AODV from the other ad hoc routing protocols is the use of a destination sequence number for every entry in the routing table. This number is generated by the destination node to be included in the routing table. Use of destination sequence numbers ensures no loops are formed in the network. A node that requests a route updates the routing table only with a route that has a higher destination sequence number. When a node receives an AODV control packet from a neighbor, the first step is to check the routing table to determine if an entry exists for the destination IP address. If the route does not exist in the routing table, then an entry is created. The sequence number is determined from the information in the control packet. If no information is present then, the valid sequence number field is set to false. An entry in the routing table is updated only if the new sequence number is either higher than the destination sequence number in the routing table, or the sequence numbers are equal but the hop count in the control packet plus one is less than the existing hop count in the routing table, or the sequence number is unknown. And the second value is the Hop Count; AODV is designed to select routes that have the shortest hop count metric. The first RREP packet that is received with a shorter hop count and a greater sequence number will be used by the node, and the route entry to that destination will be updated [14].

2.4.4 Limitations of AODV

AODV protocol has to overcome certain issues of limitation and inefficiency such as requirement on broadcast medium; the algorithm expects/ requires that the nodes in the broadcast medium can detect each other's broadcasts. Overhead on the bandwidth will be occurred compared to other protocols, when an RREQ travels from node to node in the process of discovering the route info on demand, it sets up the reverse path in itself with the addresses of all the nodes through which it is passing and it carries all this info all its way. No reuse of routing info; AODV lacks an efficient route maintenance technique. The routing info is always obtained on demand, including for common case traffic. It is vulnerable to misuse so the messages can be misused for insider attacks including route disruption, route invasion, node isolation, and resource consumption. AODV lacks support for high throughput routing metrics; it is designed to support the shortest hop count metric. This metric favors long, low bandwidth links over short, high bandwidth links. And High route discovery latency; AODV is a reactive routing protocol. This means that AODV does not discover a route until a flow is initiated. This route discovery latency result can be high in large-scale mesh networks [11].

2.5 Destination Sequenced Distance Vector Protocol (DSDV)

Perkins et. al. proposed destination sequence distance vector routing protocol based on the traditional Bellman Ford algorithm with some improvements to prevent count to infinity problem. Each node maintains routing table having entries corresponding to all other nodes in the network. Each node maintains a set of distances to reach the destination via its neighbors and chooses the neighbor as next hop having a minimum distance for packet delivery to that destination. It is a proactive protocol so the nodes periodically transmit their routing tables to their immediate neighbors or whenever the change in topology occurs. While sending an update message, a node has to increment its sequence number. Whenever a node receives a broadcasted routing message from its neighborhood, it compares received message’s sequence number and hop count fields with the corresponding value stored in its routing table and updates its routing table depending on larger sequence number and smaller hop count by re-computing the distances. DSDV responds to RERR messages by invalidating all routes in their routing table containing broken link. These routes are immediately assigned an infinite metric and an incremented sequence number [15].

To reduce the amount of information in these packets there are two types of update messages defined; full and incremental dump. The full dump carries all available routing information and incremental dump that only carries the information that has changed since the last dump [16].

2.5.1 DSDV Advantages

The advantages of this protocol are route discovery latency is very low as a route is always available, generates loop-free paths and count to infinity problem of distance vector routing is also removed. And extra traffic can be avoided using incremental update strategy than sending full updates [15].

2.5.2 Routing Table of DSDV

The structure of the routing table for this protocol is simple. Each table entry has a sequence number that is incremented every time a node sends an updated message. Routing tables are periodically updated when the topology of the network changes and are propagated throughout the network to keep consistent information throughout the network.

Each DSDV node maintains two routing tables; one for forwarding packets and one for advertising incremental routing packets. The routing information sent periodically by a node contains a new sequence number, the destination address, the number of hops to the destination node, and the sequence number of the destination. When the topology of a network changes, a detecting node sends an update packet to its neighboring nodes. On receipt of an update packet from a neighboring node, a node extracts the information from the packet and updates its routing table.

2.5.3 DSDV Packet Process

If the new address has a higher sequence number, the node chooses the route with the higher sequence number and discards the old sequence number. If the incoming sequence number is identical to the one belonging to the existing route, a route with the least cost is chosen. All the metrics chosen from the new routing information are incremented. This process continues until all the nodes are updated. If there are duplicate updated packets, the node considers keeping the one with the least-cost metric and discards the rest.

In case of a broken link, a cost of metric with a new sequence number (incremented) is assigned to it to ensure that the sequence number of that metric is always greater than or equal to the sequence number of that node. Figure 2-10 shows node 2 communications in the network, whose neighbors are nodes 1, 3, 4, and 8. The dashed lines indicate no communications between any corresponding pair of nodes. Therefore, node 2 has no information about node 8.

Table 2-2: Routing table for node 2

Destination	Next hop	Metric	Dest.Seq.No
1	1	1	123
2	0	0	516
3	3	1	212
4	4	1	168
5	4	2	372
8	1	INF	432

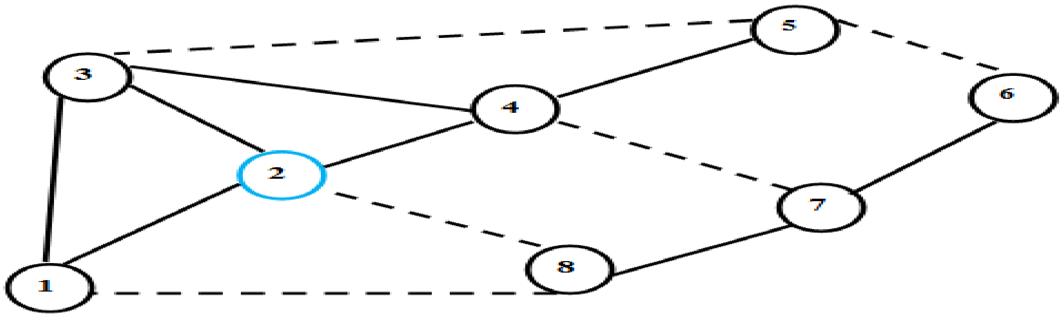


Figure2-10: node 2 communications in DSDV network

The packet overhead of the DSDV protocol increases the total number of nodes in the ad-hoc network. This fact makes DSDV suitable for small networks. In large ad-hoc networks, the mobility rate and therefore the overhead increase, making the network unstable to the point that updated packets might not reach nodes on time [17].

2.5.4 DSDV Disadvantages

Disadvantages of DSDV are wastage of bandwidth and a large amount of network overhead while transmitting periodic route update messages. So, DSDV does not scale well in large and dense networks and it doesn’t support multipath routing since the single path to the destination is maintained [15].

2.6 Comparison between AODV and DSDV Protocols

There are a few differences between AODV and DSDV routing protocols. Firstly, AODV does not update the routing information as like DSDV, it will update the information only if it is needed. DSDV will update routing table in the nodes every time. All the nodes are changing their position often. In AODV**,** there is no periodic updating. In DSDV, there is no topology occurs periodically, then the constant propagation in the routing information. In DSDV packet delivery latency is very less when compared to the on-demand protocols. In AODV First packet delivery latency is more when compare to the table driven protocols. In DSDV there is a route to all other neighbor node which not available in the AODV.

2.7 Related Works

In [18], Distance Vector protocol actually not well suited for Ad hoc network therefore, DSDV protocol is discussed which overcomes problems of distance vector protocol. From the overall analysis, AODV protocol is better than DSDV, because DSDV consumes more bandwidth as it periodically broadcast routing information, whereas in AODV there is no need to maintain route table, which results in less bandwidth consumption as well as less overhead. For small network, DSDV works well and AODV is best suited for larger network. Even the throughput is less in DSDV as it continuously broadcast route information, but in case of AODV throughput is stable as it doesn’t need to maintain any route information. But in their study, they didn’t consider much metrics as average end to end delay and packet loss.

Energy Efficiency proposed in [19] for MANET by improving OLSR (EM-OLSR) which is an improvement for the OLSR protocol for better energy conservation in MANET. Authors added the nodes number, the distance of the communication, the mobility of nodes, the type of application, the rate of interference to the MPR technique used by the protocol. They studied its incidences on a MANET performance, more particularly on power consumption in the network. Obtained results are very conclusive; reduced data loss rates, significant power saving up to 14% and an increase in an average lifetime of a mobile node as high as 22%.

A model proposed in [3] which take care of energy features based on priority of data for communication from source to destination. The authors used delivery ratio, the end to end delay and throughput and battery oriented parameters for nodes as metrics. The results show that the AODV-PP protocol has better network lifetime with minor change in throughput in Wi-MAX Ad-hoc network. In this study the two on-demand routing protocols AODV & AODV-PP are analyzed and their performances have been evaluated.

In [2] work aims proposed at discovering an efficient energy aware routing scheme in MANETs that not only uses the node energy effectively but also finds the best route. The results show that the proposed scheme outperforms in terms of different energy related parameters over AODV even in high mobility scenarios. At the time of route selection, the algorithm takes care of battery status of the path, and number of drained nodes in the path. Energy of the network is also reduced using variable transmission power when data transmission is done. The results for the chosen parameters in this study show that in low traffic scenario, the average residual energy of the network is increased by 30-40%. For high traffic scenarios this goes up by 45%.

In [20] the various energy efficient models of OLSR and AODV routing protocols are compared. The results show that the lesser the mobility speed the lesser the energy consumed for both AODV and OLSR protocols. It also shows that having energy threshold for route selection has a better performance than having an energy threshold on the MPR selection in OLSR protocol. This shows that in a constantly mobile network route selection consumes larger energy than the MPR selection and hence having an energy threshold for route selection increases the network lifetime. Thus in the OLSR models ETOLSR has a better performance compared to EE-OLSR model. In this study the AODV results show that in a constant moving network with constant network traffic forwarding RREQ consumes larger energy and hence an energy threshold for forwarding RREQ reduces the energy consumption and increases the network lifetime. Thus in AODV model OOAODV has a much better performance than LEARAODV and EEAODR models.

Chapter Three
Simulation Setup

Chapter Three
Simulation Setup

This chapter gives the overview of tool, performance metrics which are chosen for evaluating the performance of technique.

3.1 Simulation Environment

There are many simulators such as OPNET, NetSim, GloMoSim, NS3, OMNET++ and NS2 etc. NS2 is used for simulation due to it is free, open source, support different types of networks such as wired Network, wireless ad-hoc mode, wireless managed mode and wired cum wireless [21]. Also NS-2 comes closer to reality than other simulators, NS-2 has the rich collection of models than others simulators and a good simulation design, good results can be achieved with NS-2. It is a discrete event simulator developed at UC Berkeley and written in C++ and Object Oriented Tool Command Language (OTCL). It is suitable for comparing different protocols, traffics and developing new protocols [22]. The latest version, ns-allinone-2.35, supports simulation for routing protocols for ad hoc wireless networks such as AODV, TORA, DSDV, and DSR. Although NS.2.35 can be built on various platforms, in this thesis a Linux platform [Ubuntu] is chosen, as Linux offers a number of programming development tools that can be used along with the simulation process. To run a simulation with ns-2.35, the user must write the simulation script in OTCL, get the simulation results in an output trace file. The performance metrics are graphically visualized in ns-wireless and excel application. Ns-2 also offers a visual representation of the simulated network by tracing nodes movements and events and writing them in a network animator (NAM) file, as can be seen from Figure 3-1.

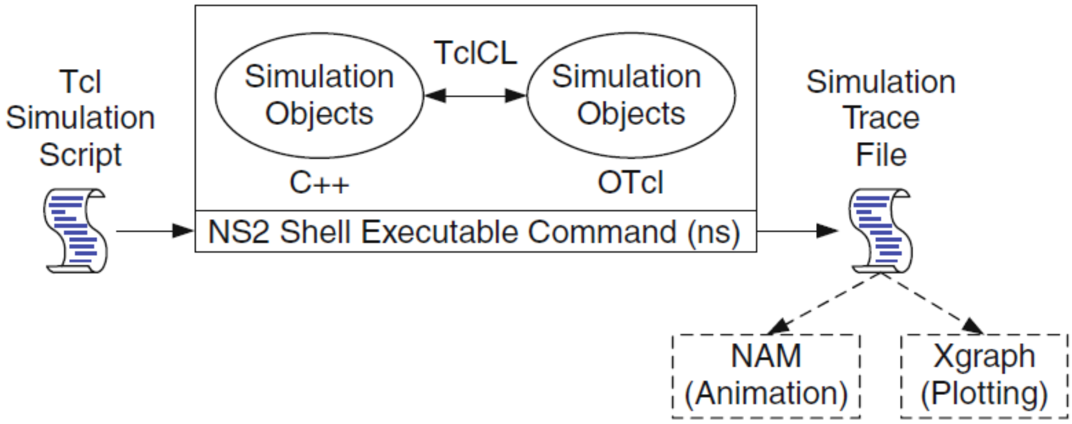


Figure 3-1: Basic architecture of NS [23]

3.2 Performance Metrics

The parameters considered while designing this model were Packet Delivery Ratio (PDR), Throughput, packet loss, Average End to End delay (E2E) and number of nodes.

3.2.1 Packet Delivery Ratio (PDR)

The ratio of the number of data packets successfully delivered to the destinations to those generated by CBR sources. The higher the delivery ratio better is the performance of the routing protocol [24].

PDR is determined as Equation 3.1:

$$\text{Packet delivery Ratio} = \frac{\text{Received packets}}{\text{Sent packets}} \times 100 \qquad (3.1)$$

3.2.2 Throughput

Throughput is defined as; the ratio of the total data reaches a receiver from the sender. The time it takes by the receiver to receive the last message is called as throughput. Throughput is expressed as bytes or bits per sec (byte/sec or bit/sec). A high throughput is absolute choice in every network [25].

3.2.3 Packet Loss

Mobility-related packet loss may occur at both the network layer and the MAC layer. Here packet loss concentrates for network layer. When a packet arrives at the network layer, the routing protocol forwards the packet if a valid route to the destination is known. Otherwise, the packet is buffered until a route is available. A packet is dropped in two cases: the buffer is full when the packet needs to be buffered and the time that the packet has been buffered exceeds the limit.

Packet loss is determined as Equation 3.2:

$$\text{PER} = \text{Total Packet Sent} - \text{Total Packet received} \qquad (3.2)$$

3.2.4 Average End to End delay

It is the time interval between sending the packet by the source node and receiving it at the destination node, which includes buffering of data packets during route discovery, queuing at the interface queue and retransmission delays at the MAC [24].

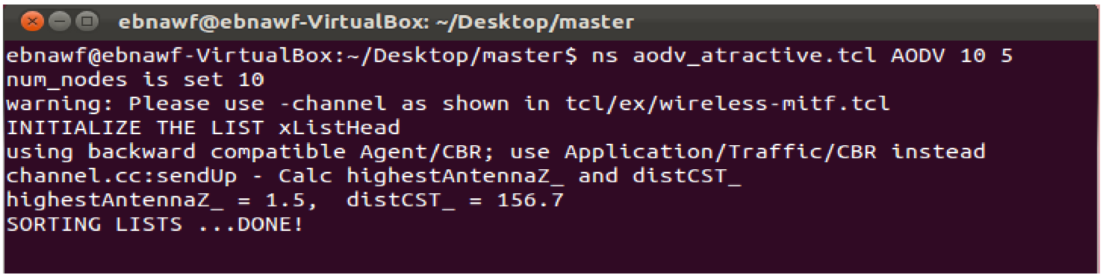
3.3 Evaluation Technique

The simulation setup consists of square flat topology and a test bed of 10,20,30,40 and 50 nodes randomly and uniformly distributed in the entire area. The random waypoint model is used to model mobility. All random scenarios have been generated for a maximum speed of 15 m/s. Traffic sources are chosen as TCP with a packet size of 50 bytes. All traffic sessions are established at random times near the beginning of the simulation run and they remain active until the end of the simulation period. The transmission range and power varies with distance between two nodes when actual data transfer occurs after route establishment. The simulations are run for 50 seconds. Each of nodes has 1000 Joules of energy at the start of every simulation. Identical mobility and traffic scenarios are used across the protocol variations. Track of residual energy of a node is done by using in an inbuilt energy model of NS - 2 that uses a traditional method of keeping track of the residual energy of a node. Once the trace file is generated, AWK scripts extract the information from the trace file. Based on the output of these AWK scripts graphs were plotted for average residual energy vs time for the network using Xgraph.

Table 3-1: Simulation Parameters

PARAMETER	VALUE
Number of nodes	10,20,30,40,50
Simulation Time	50s
Network Size	500m X 500m
Packet Size	50 bytes
Initial Energy Of Node	1000 Joules
Simulator	NS-2.35
Antenna Type	Omni directional
MAC type	IEEE 802.11
Agent	TCP
Routing Protocol	AODV and DSDV

In NS2, the steps for getting trace and NAM files after the simulation are as follows; writing of the program in OTCL. OTCL is used to write the program for generate a network, network environment, and trajectory of mobile nodes. Then run the **.tcl** file on the terminal under the Linux Ubuntu as shown in Figure 3-2.



```
ebnawf@ebnawf-VirtualBox:~/Desktop/master$ ns aodv_atractive.tcl AODV 10 5
num_nodes is set 10
warning: Please use -channel as shown in tcl/ex/wireless-mitf.tcl
INITIALIZE THE LIST xListHead
using backward compatible Agent/CBR; use Application/Traffic/CBR instead
channel.cc:sendUp - Calc highestAntennaZ_ and distCST_
highestAntennaZ_ = 1.5,  distCST_ = 156.7
SORTING LISTS ...DONE!
```

Figure 3-2: Run of ns Command in Terminal

Running ns is following below formula; $ns filename.tcl   P   N   S Where; P is protocol type (e.g. AODV DSDV), N is number of nodes (e.g. 10, 20,

30) and S is the mobility speed (e.g. 5, 10, 15), so writing above command in terminal and for each evaluating case and press Enter key. In all cases nodes distributed randomly but with fixed position for the node to evaluate AODV and DSDV performance.

Figure 3-3 shows nam output of 10 nodes

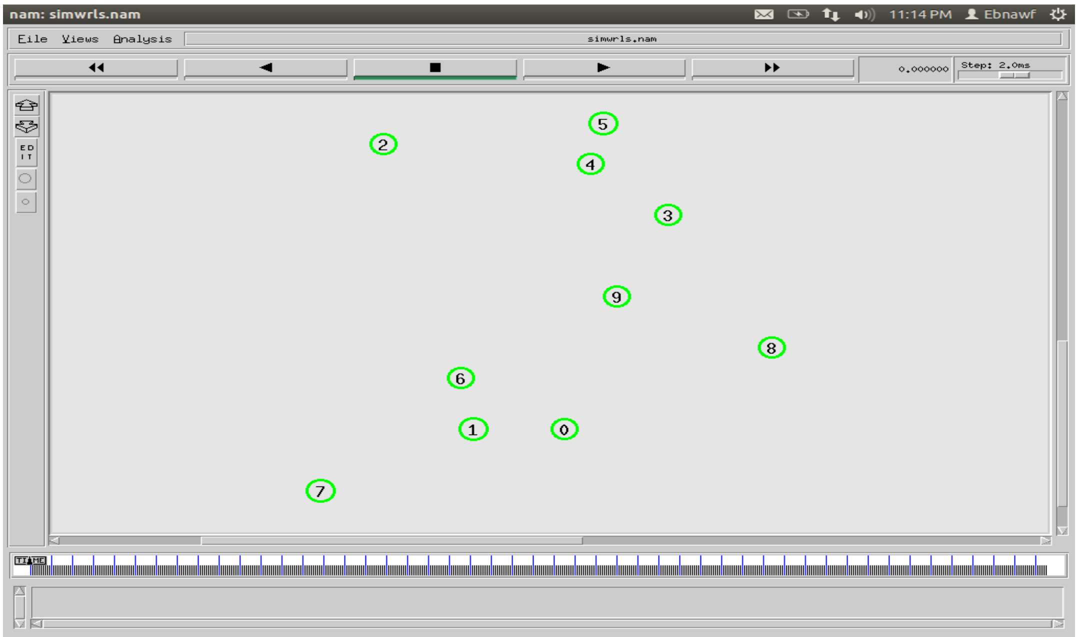


Figure 3-3: Nam output with 10 nodes

Figure 3-4 shows nam output of 20 nodes

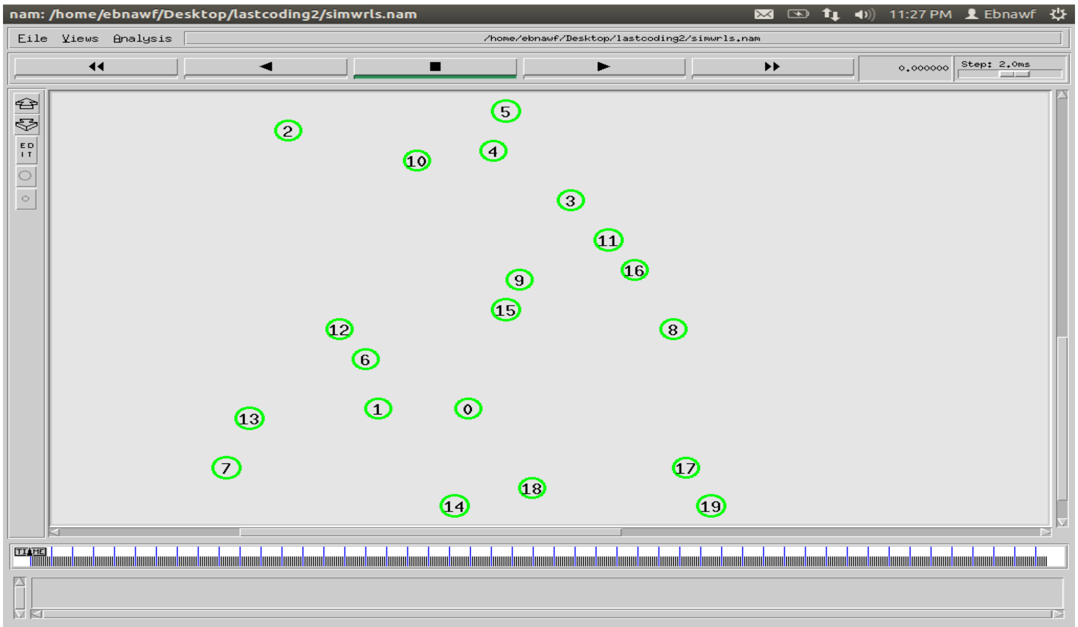


Figure3-4: Nam output with 20 nodes

Figure 3-5 shows nam output of 30 nodes.

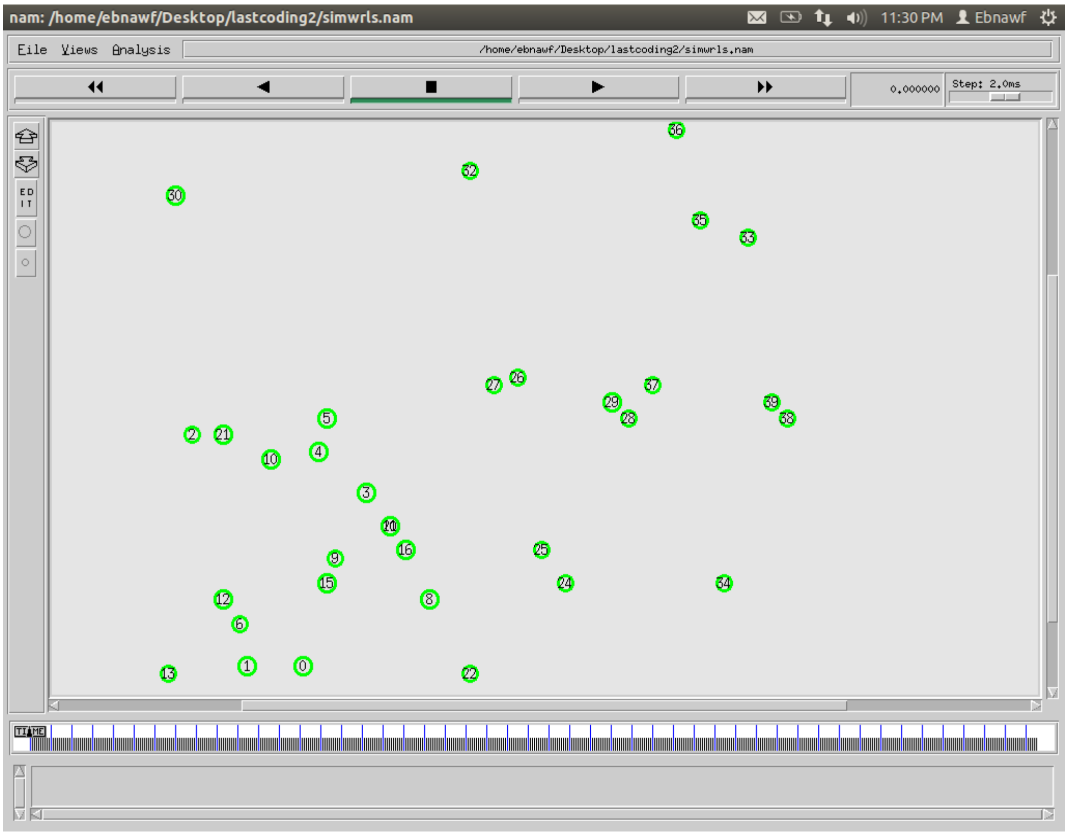


Figure 3-5: Nam output with 30 nodes

Figure 3-6 shows nam output of 40 nodes

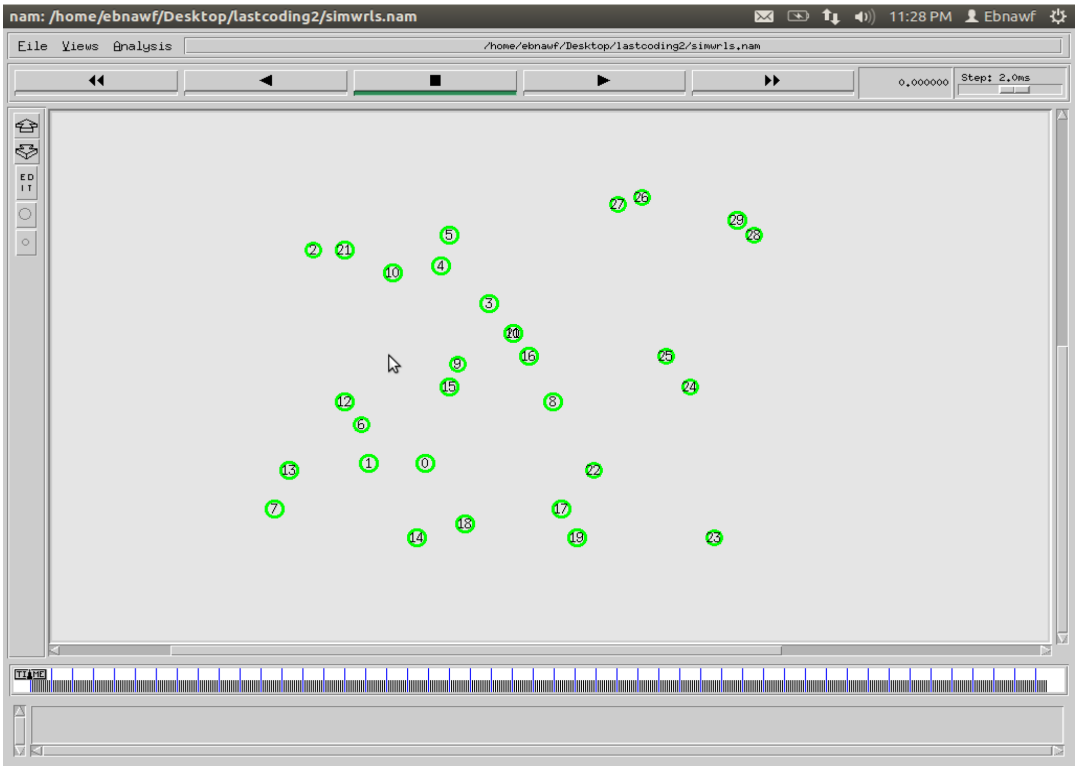


Figure 3-6: Nam output with 40 nodes

Figure 3-7 shows nam output of 50 nodes

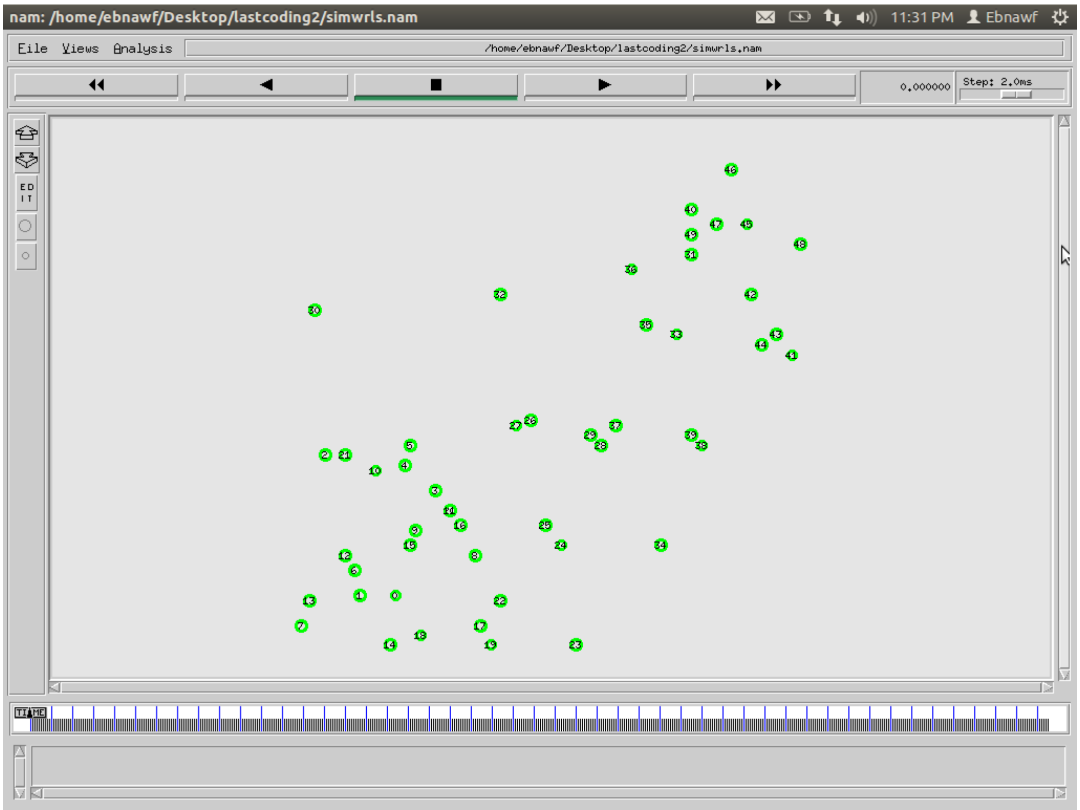


Figure 3-7: Nam output with 50 nodes

After that AWK analyzer is use to analyses trace file obtained during simulation and according to trace file generate the respective Figures.

Chapter Four

Results and Discussion

Chapter Four
Results and Discussion

In this chapter, AODV and DSDV performance metrics are compared using simulation. A number of experiments were performed by changing the nodes number in order to evaluate power consumption in these protocols.

4.1 Simulation Results

In this model set of networks which are randomly distributed in a rectangular region of 500*500 unit square. AODV and DSDV protocols are simulated and the trace files generated by the simulations were processing using AWK. Figures were plotted by the values of packet delivery ratio(PDR), throughput, packet loss and end to end delay under varying the number of nodes and the speed (5,10 and 15 m/s) as obtained in tables 4-1, 4-2, and 4-3.

Table 4-1: The results at speed of 5 m/s

# Nodes	PDR[%]		Throughput [kbps]		E2E [ms]		Packet loss	
	AODV	DSDV	AODV	DSDV	AODV	DSDV	AODV	DSDV
10	100	5.66	544.11	30.81	6.13	4.13	0	3082
20	98.71	28.5	537.13	155.06	20.39	4.02	42	2336
30	90.85	2.75	494	28.2	25.19	4.13	299	3177
40	69.12	34.04	376.06	185.21	55.58	4.16	1009	2155
50	98.04	3.49	533.44	37.72	34.33	4.16	64	3153

Table 4-2: The results at speed of 10 m/s

# Nodes	PDR[%]		Throughput [kbps]		E2E [ms]		Packet loss	
	AODV	DSDV	AODV	DSDV	AODV	DSDV	AODV	DSDV
10	100	24.15	544.11	131.41	6.13	4	0	2478
20	99.91	28.34	543.6	154.23	6.14	4.02	3	2341
30	90.85	33.09	494.3	180.04	25.19	4.13	299	2186
40	98.13	24.4	533.94	138.41	24.84	4.05	61	2470
50	94.89	24.92	533.94	135.57	24.84	5.46	61	2435

Table 4-3: The results at speed of 15m/s

# Nodes	PDR[%]		Throughput [kbps]		E2E [ms]		Packet loss	
	AODV	DSDV	AODV	DSDV	AODV	DSDV	AODV	DSDV
10	100	24.15	544.11	131.4	6.13	4.33	0	2478
20	99.85	28.9	543.44	157.22	4.65	4.84	5	2323
30	90.85	5.05	494.3	91.75	25.19	4.01	299	3102
40	95.35	52.95	518.76	288.12	43.04	4.24	152	1537
50	75.91	49.15	413.01	267.56	51.63	4.15	787	1380

4.1.1 Packet Delivery Ratio

From the observations of the table 4-1, 4-2 and 4-3 the Packet Delivery Ratio against varying number of nodes in different speeds has shown in Figures 4-1, 4-2 and 4-3.

Figures 4-1, 4-2 and 4-3 show that, AODV achieves better values than DSDV; at 5m/s OADV achieves in the average 91.34% and DSDV 14.88%, although this values decreases from 96.75% to 92.39 in OADV, it increases from 26.98% to 32.04% in DSDV when speed varies from 10m/s to 15m/s. PDR decreases with increasing number of nodes as congestion in network increases resulting in more dropped packets due to collisions. AODV has higher PDR. Highest PDR value indicates the good performance.

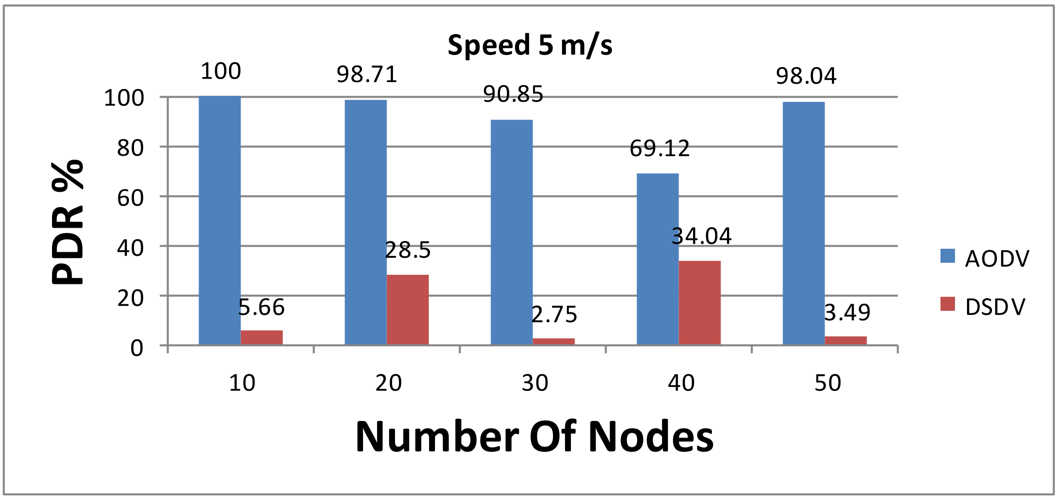


Figure 4-1: PDR at speed of 5m/s

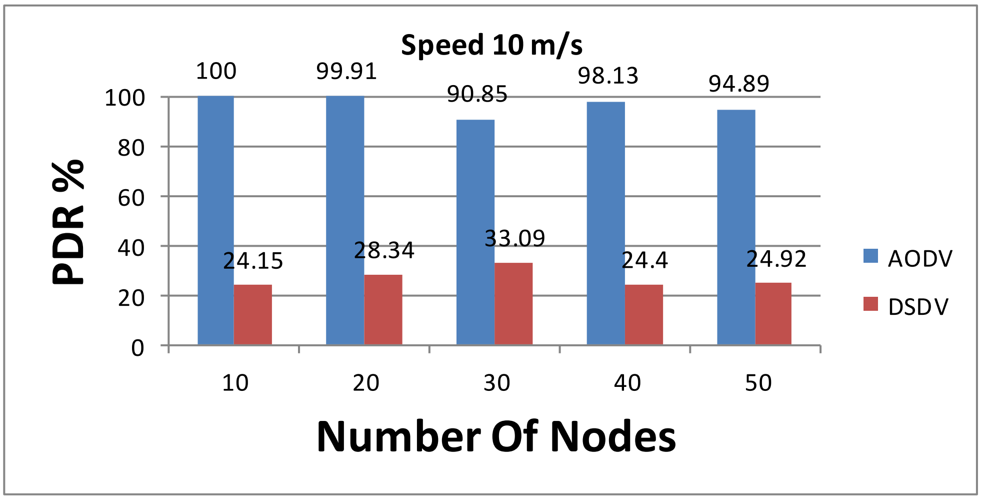


Figure 4-2: PDR at speed of 10m/s

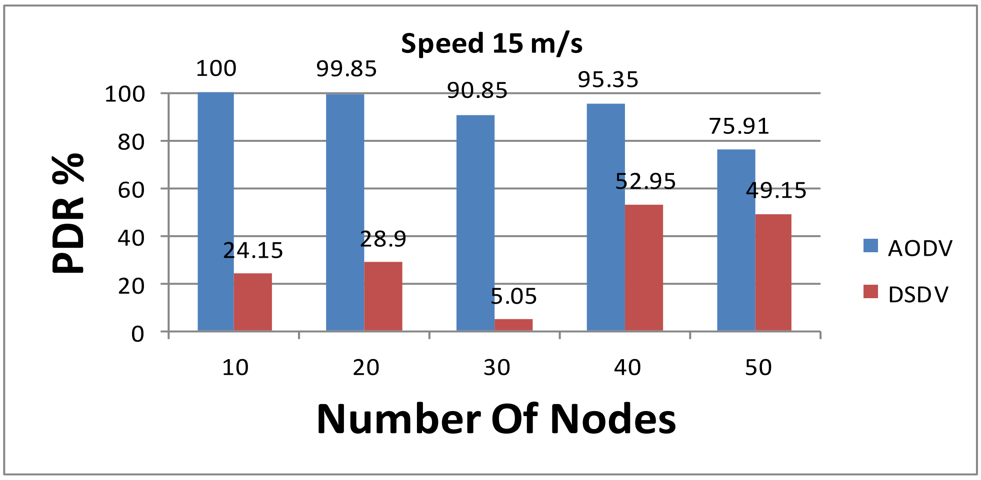


Figure 4-3: PDR at speed of 15m/s

4.1.2 Throughput

From the observations of the tables 4-1, 4-2 and 4-3 the Packet Delivery Ratio against varying number of nodes in different speeds shown in Figures 4-4, 4-5 and 4-6.

It can be seen at Figures 4-4, 4-5 and 4-6, AODV has more throughput as compared to DSDV. At 5m/s AODV has 497kb/s and DSDV has 87.4kb/s. While at 10m/s it is 529.97 kb/s in AODV and 147.93kb/s in DSDV. And at 15m/s it is 509.98kb/s in AODV and 140.84kb/s in DSDV in the average. Throughput in case of DSDV decreases because of DSDV routing protocol is table driven protocol and requires more control overhead to maintain the route to every other node.

The AODV routing protocol showing best throughput because its routing table established at every node, so there is no need to carry entire route information along with data packet that will decrease the control overhead.

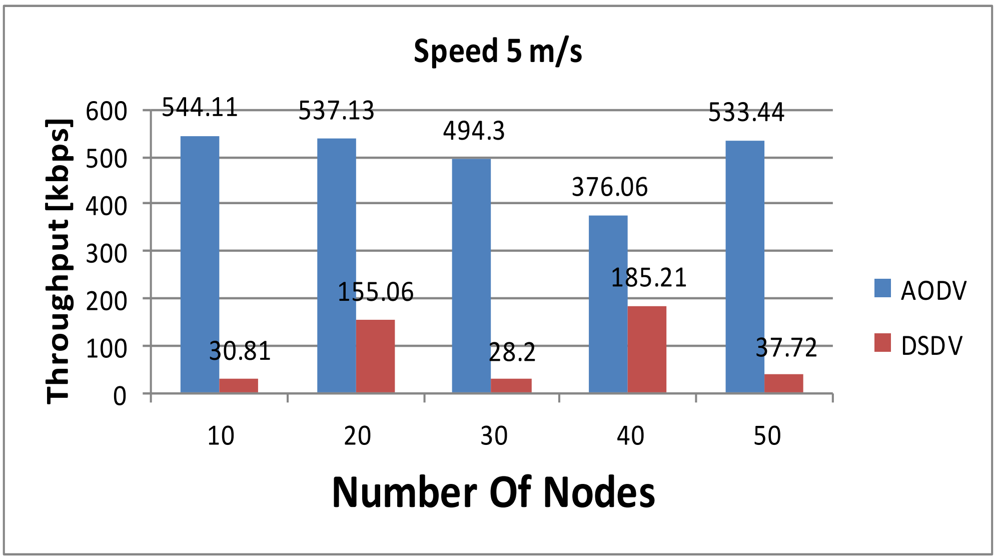


Figure 4-4: Throughput at speed of 5 m/s

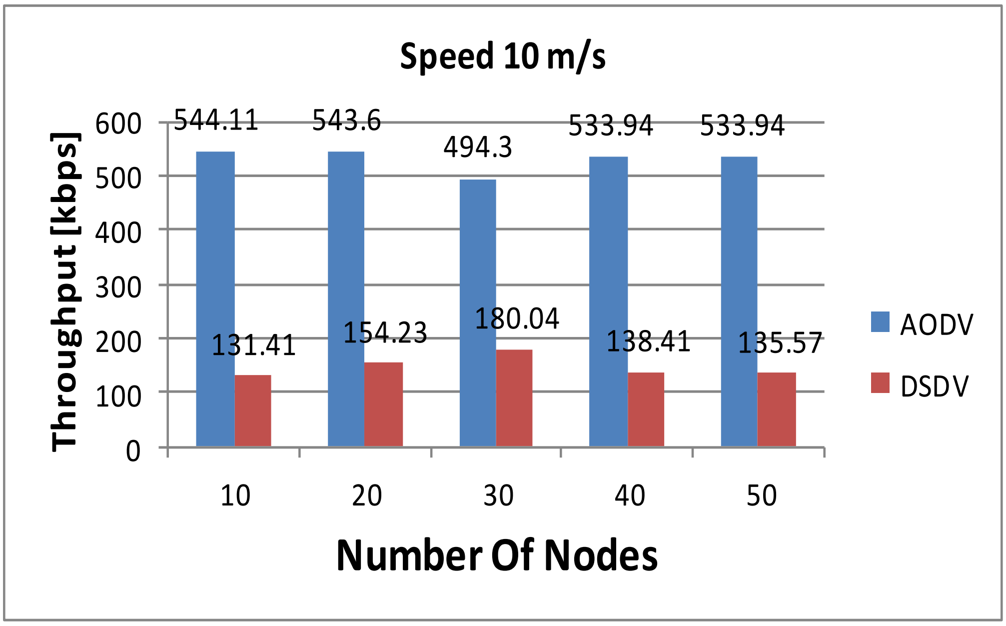


Figure 4-5: Throughput at speed of 10 m/s

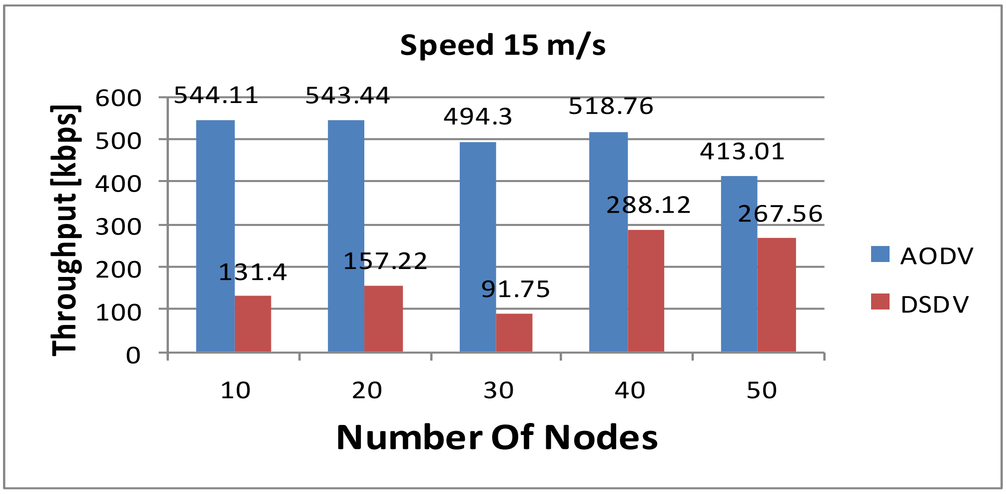


Figure 4-6 : Throughput at speed of 15m/s

4.1.3 Average End to End Delay

From the observations of the tables 4-1,4-2 and 4-3 the average End to End Delay against varying number of nodes in different speeds shown in Figures 4-7, 4-8 and 4-9. Figure 4-7 shows that in AODV 10nodes delay is less and at 40 nodes average delay achieves maximum delay. In case if node density is increasing, the calculation part is less after route establishment, so delay reduces. In DSDV the values are semi-fixed.

Figures 4-7, 4-8 and 4-9 show that DSDV has low end to end delay compared to AODV in the simulation scenarios. At 5m/s OADV delayed 28.32s and DSDV 4.12S, at 10m/s OADV delayed 17.42s and DSDV delayed 4.33, and at 15 m/s OADV delayed 26.12s and DSDV delayed 4.31s in the average. Due to in DSDV protocol, routes to every destination were always available and up-to-date. The AODV achieves high end-to-end delay due to its hop-by-hop routing methodology. But with referring to packet delivery ratio, DSDV small delay values doesn’t make sense because it had a small PDR and big packet loss.

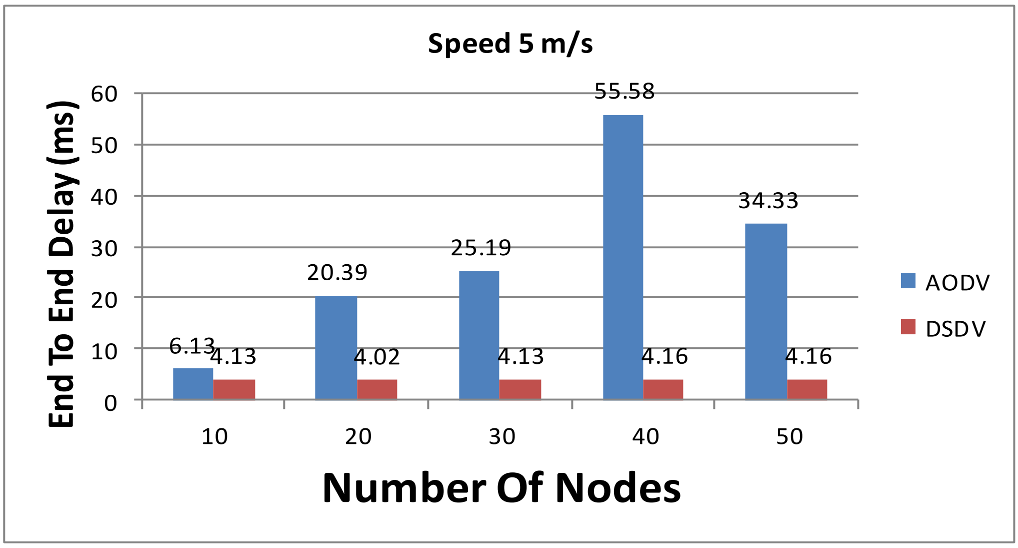


Figure 4-7: End to End delay Average at speed of 5m/s

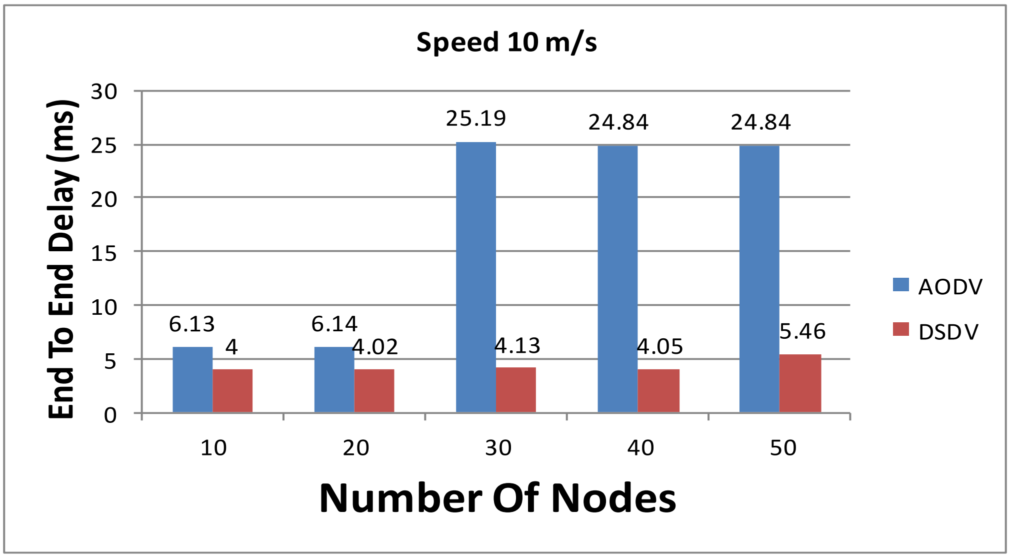


Figure 4-8: End to End delay Average at speed of 10m/s

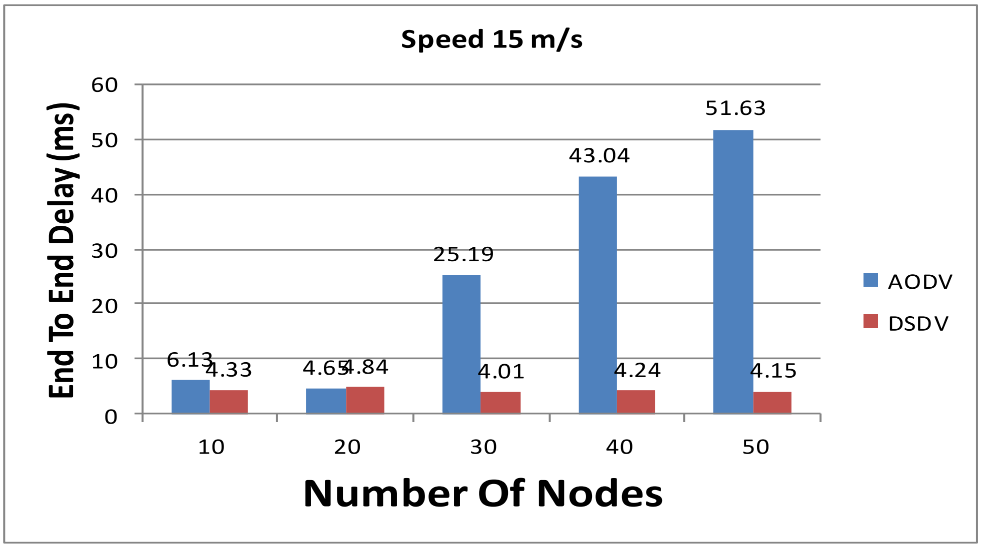


Figure 4-9: End to End delay Average at speed of 15 m/s

4.1.4 Packet loss

From the observations of the tables 4-1,4-2 and 4-3 the Packet Delivery Ratio against varying number of nodes in different speeds as shown in Figures 4-10, 4-11 and 4-12.

Figures 4-10, 4-11 and 4-12 show that DSDV losses packet more than AODV; at 5m/s AODV loses 282 packets when DSDV loses 2780 packets, at 10m/s AODV loses 84 packets, DSDV loses 2382 packets and at 15m/s AODV loses 248 packets and DSDV loses 2164 packets. Loss decreased with increasing of the number of nodes as congestion in network increases resulting in more dropped packets due to collisions.

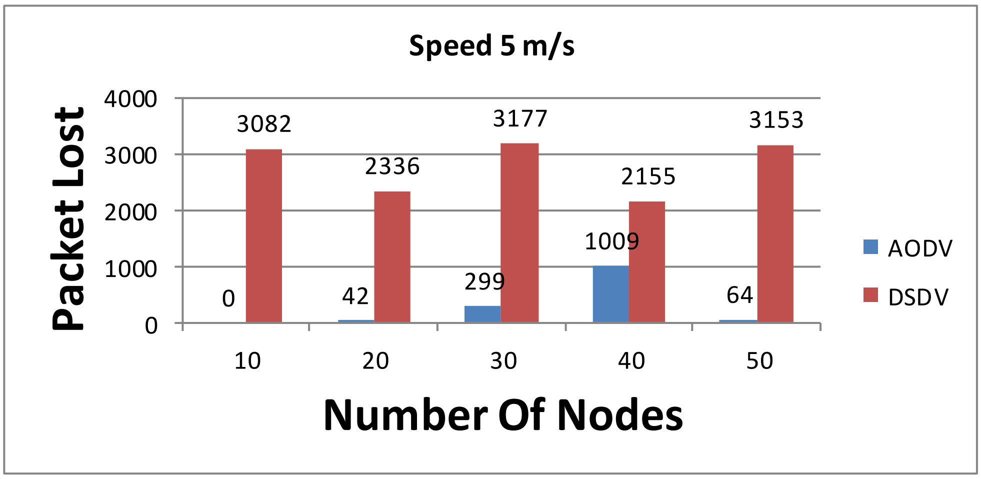


Figure 4-10: Packet loss at speed of 5 m/s

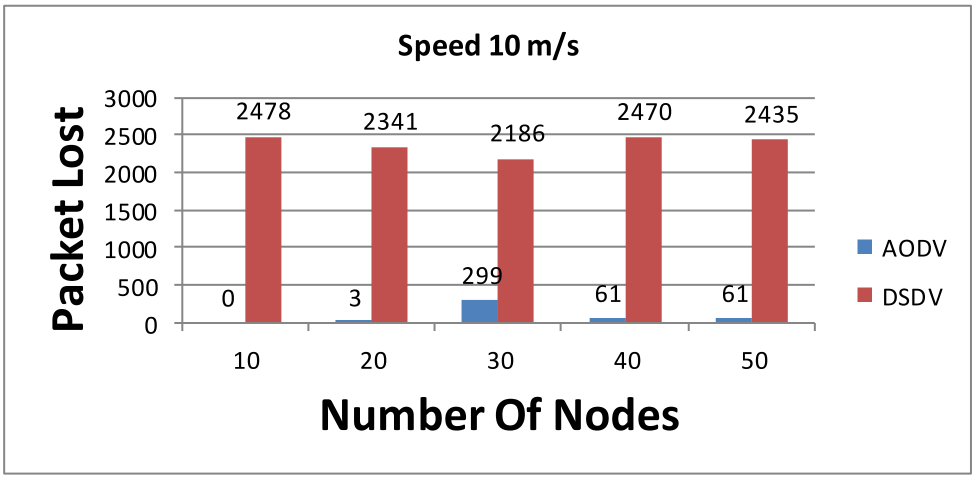


Figure 4-11: Packet loss at speed of 10 m/s

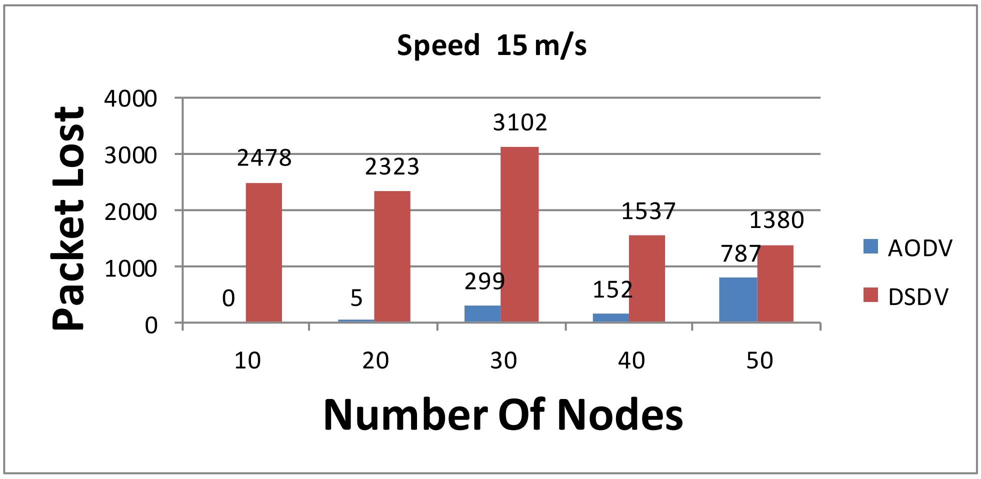


Figure 4-12: Packet loss at speed of 15 m/s

4.1.5 Power Consumption

The figurers below show power consumption at speed 5 m/s and speed 15 m/s in AODV and DSDV sources and destinations in different number of nodes.

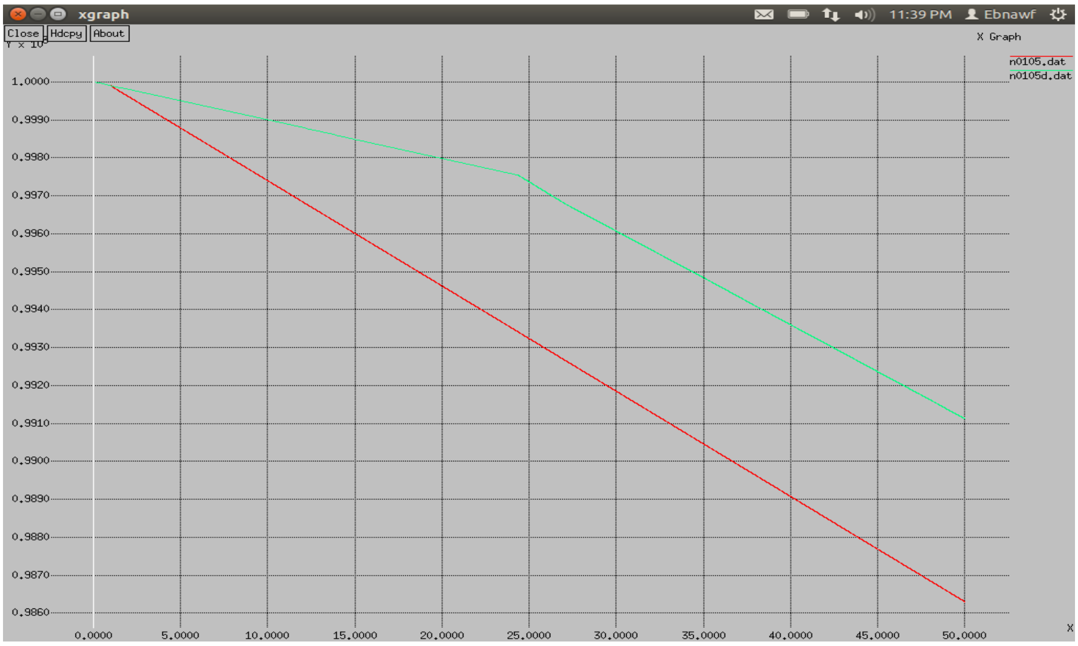


Figure 4-13: AODV vs. DSDV Source power consumption at speed 5 m/s

In Figure 4-13, network of 10 nodes with 5m/s as mobility speed and initial power (1000 joule) to both sources; AODV consumes 13.6 joule and DSDV consumes 8.8 joule.

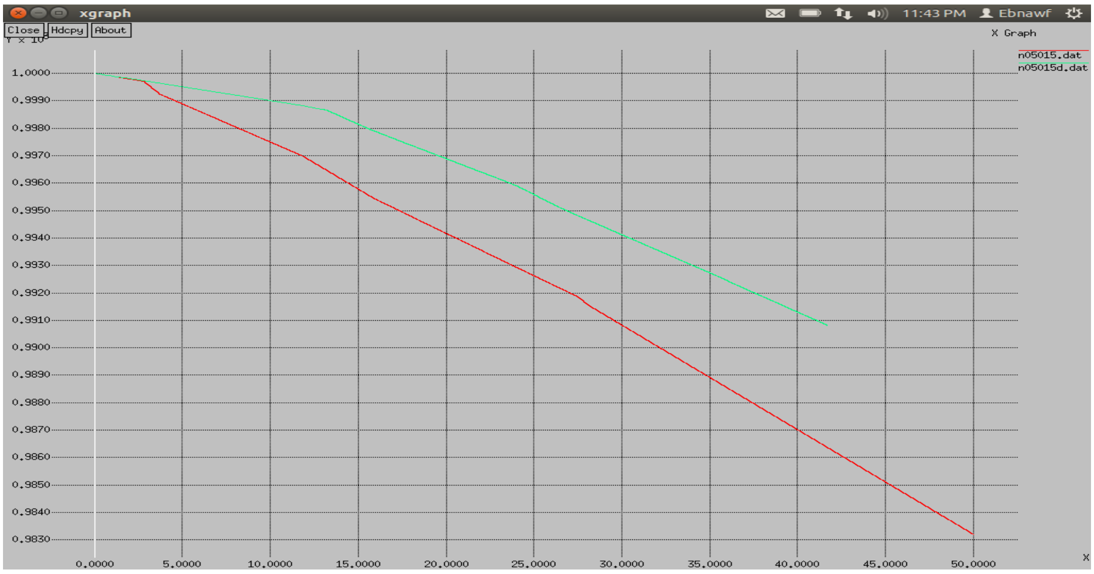


Figure 4-14: AODV vs. DSDV Source power consumption at speed 15 m/s

In the Figure 4-14, network of 50 nodes with 15m/s as mobility speed and initial power (1000 joule) to both sources; AODV consumes 16.7 joule and DSDV consumes 9.2 joule.

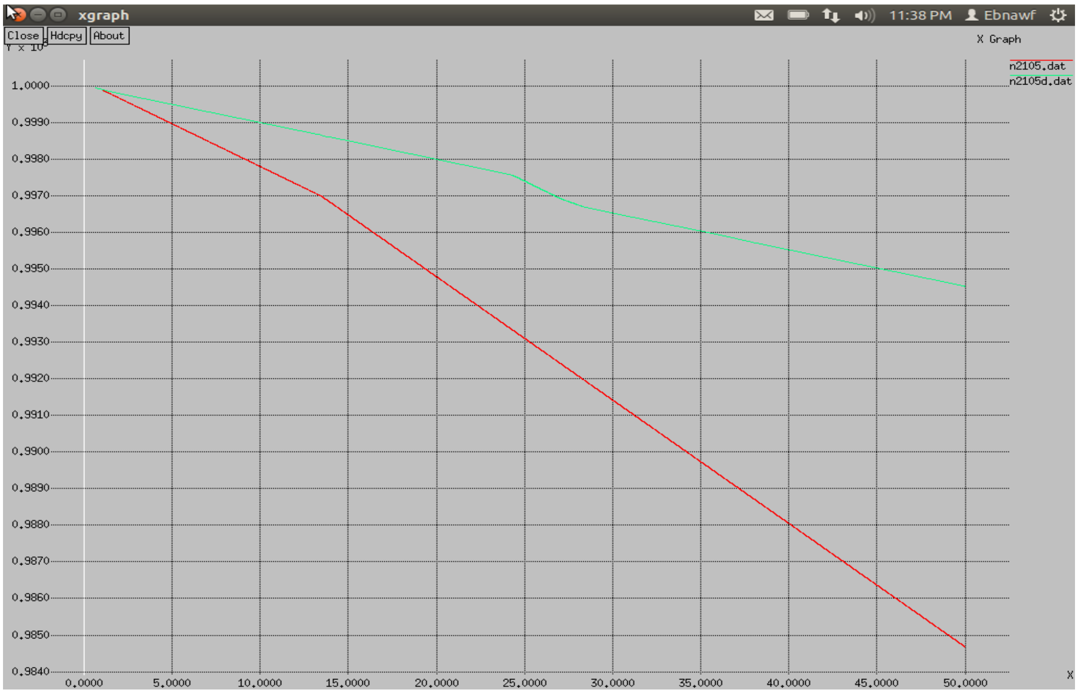


Figure 4-15: AODV vs. DSDV Destination Energy consumption at speed 5 m/s

In Figure 4-15, network of 10 nodes with 5m/s as mobility speed and initial power (1000 joule) to both destinations; AODV consumes 15.1 joule and DSDV consumes 5.4 joule.

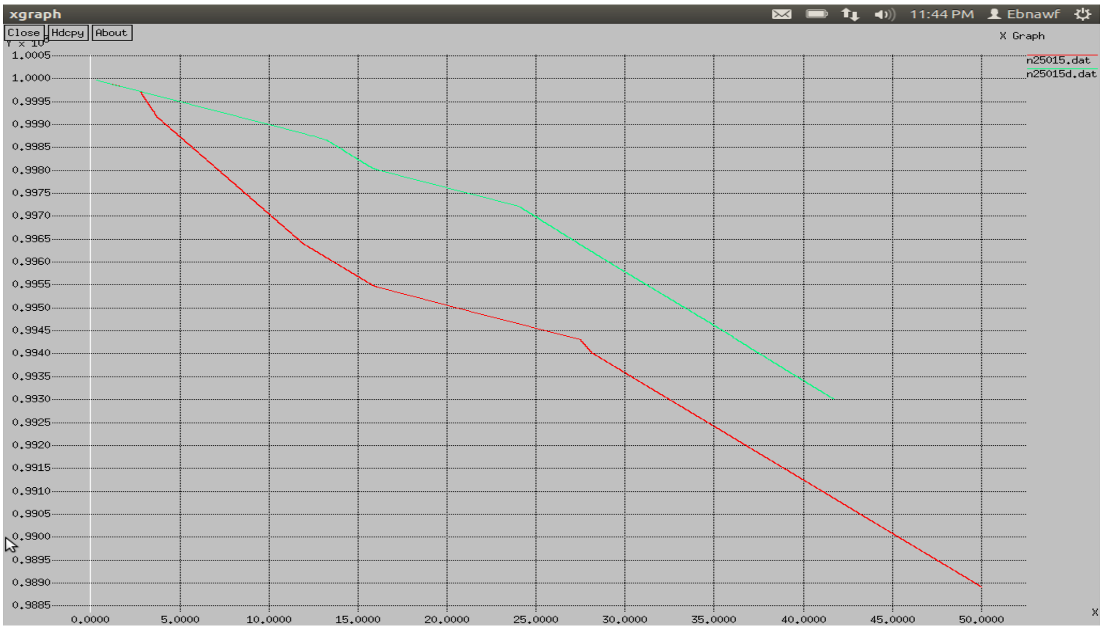


Figure 4-16: AODV vs. DSDV Destination Energy consumption at speed 15 m/s

In Figure 4-16, network of 50 nodes with 15m/s as mobility speed and initial power (1000 joule) to both destinations; AODV consumes 10.8 joule and DSDV consumes 7 joules.

According to the figures, DSDV has consumed lower average power compared to AODV.

Chapter Five

Conclusion and Recommendations

Chapter Five
Conclusion and Recommendations

4.2 Conclusion

This thesis presents set of networks which are randomly distributed to evaluate AODV and DSDV routing protocols under packet delivery ratio, throughput, average end-to-end delay and packet loss with different number of nodes as performance metrics. These metrics have been studied using simulations ran in Network Simulator 2 (NS2). The output of the NS-2 simulation; trace file. The trace file is used for calculating the results and is analyzed using the AWK script. The NS2 simulator gives another file as output; NAM generates NAM file, which is used for graphical visualization.

From the results of the simulations, observations and analysis done in the thesis, found that; packet delivery ratio (PDR) in AODV is better than DSDV. It is 91.3% in AODV and 14.8% in DSDV in 5m/s, in 10m/s AODV is 96.7% and DSDV is 26.98% and in 15m/s AODV is 92.3% and DSDV is 32.04% in the average. AODV has more throughput as compared to DSDV. At 5m/s AODV is better than DSDV by 82.4%. While at 10m/s and 15m/s AODV it is better than DSDV by 72% in the average. The AODV achieves high End-to-End delay due to its hop-by-hop routing methodology and DSDV losses packet more than AODV; at 5m/s and at 10m/s DSDV losses more packets than AODV by 96.9% and at 15m/s DSDV losses more packets than AODV by 88.5% in the average.

Although AODV has achieved a higher throughput, higher PDR and lower packet losses; for energy consumption DSDV has consumed less energy; with 5m/s as mobility speed to both sources; AODV consumes more energy by 35.2%. In both destinations with 5m/s as mobility speed AODV consumes 64.2% more energy than DSDV in the average.

4.3 Recommendations

A future study could be conducted on comparison the performance of more protocols (like OLSR). Pause time and routing overhead could be additional metrics. The simulation environment (NS-2) could be improved to enable future using to check high values of the parameters.

Also study the power status of the next hop in the transmission, and considering power consumption at device level.

References

References

[1] V. Kanakaris, D. Ndzi and D. Azzi, “Ad-hoc Networks Energy Consumption: A review of the Ad-Hoc Routing Protocols, 2014.

[2] Dr. S. Sharma and P. S. Patheja, “Improving AODV Routing Protocol with Priority and Power Efficiency in Mobile Ad hoc WiMAX Network” International Journal of Computer Technology and Electronics Engineering (IJCTEE) Volume 2, Issue 1.ISSN 2249-6343.

[3] S. Verma, P. Nayak and R. Agarwal “Energy Efficient Routing in Mobile Adhoc Networks based on AODV Protocol” IJCSI International Journal of Computer Science Issues, Vol. 9, Issue 6, No 2, November 2012 .ISSN (Online): 1694-0814 www.IJCSI.org

[4] T. M. Mahmoud, A. Aly, O. Makram, “A Modified AODV Routing Protocol to Avoid Black Hole Attack in MANETs”, International Journal of Computer Applications, Volume 109 – No. 6, January 2015.

[5] C. Yu, y. B. Lee and H. Y. Youn, “Energy efficient routing protocols for mobile ad hoc networks” WIRELESS COMMUNICATIONS AND MOBILE COMPUTING Wireless”. Commun. Mob. Comput. 2003; 3:959–973 (DOI: 10.1002/wcm.119), Copyright # 2003 John Wiley & Sons, Ltd.

[6] A. Choudhary “ Modified Adhoc on Demand Routing Protocol in Mobile Ad hoc Network”. Master of Technology, Department of Computer Science and Engineering,National Institute of Technology Rourkela Rourkela, Odisha, 769008, India Jun 2013

[7] H. Yangcheng, G. Kannan, S. Bhatti, S.N. Merchant, and U.B. Desai, “Route dynamics for shortest path first routing in mobile ad hoc networks,” in Proc. Wireless Telecommunications Symposium, 2008, pp. 24-26, 236-242.

[8] IEEE Std. 802.11,”Part 11: Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) specifications”, IEEE Std. 802.11, 2010.

[9] H. Nishat, V. Krishna K, D. S. Rao, S. Ahmed, "Performance Evaluation of On Demand Routing Protocols AODV and Modified AODV (R-AODV) in MANETS," International Journal of Distributed and Parallel Systems (IJDPS), vol. 2, no. 1, Jan 2011.

[10] V. Nazari, K. Ziarati, “Performance Comparison of Routing Protocols for Mobile Ad hoc Networks”, IEEE 2006.

[11] C.V. Anchugam , K. Thangadurai, Detection of Black Hole Attack in Mobile Ad-hoc Networks using Ant Colony Optimization – simulation Analysis, Indian Journal of Science and Technology, Vol 8(13), , July 2015.

[12] C. Perkins, E. Royer and S. Das “Ad hoc on-demand distance vector (AODV) routing,” , in Proc. of IEEE WMCSA, February, 2000, pp. 90-100.

[13] P. Mani and D.W. Petr, “Development and performance characterization of enhanced AODV routing for CBR and TCP traffic,” in Proc. Wireless Telecommunications Symposium, May, 2004, pp. 44-51, 14-15.

[14] C. E. Perkins, E. M. Belding-Royer, and S. Das. Ad hoc On-Demand Distance Vector (AODV) Routing. RFC 3561, July 2003.

[15] A.K. Verma, Tarunpreet Bhatia, "QoS Comparison of MANET Routing Protocols," I.J. Computer Network and Information Security, vol. 7, no. 9, pp. 64-73, August 2015.

[16] http://elearningatria.files.wordpress.com/2013/10/cse-vi-computer-networks-ii-10cs64-notes.pdf

[17] Charles E. Perkins and Pravin Bhagwat, “Higly dynamic Destinatiion – Seqquenced Distance-Vector routing (DSDV) for mobile computers”. In the processing of the SIGOM ’02 Conference on Communication Architecture, protocols and Application, pages234-244, August 2000.

[18] Prof. B.N. Jagdale1, Prof. Pragati Patil2, Prof. P. Lahane3, Prof. D. Javale4,” Analysis and Comparison of Distance Vector, DSDV and AODV Protocol of MANET” International Journal of Distributed and Parallel Systems (IJDPS) Vol.3, No.2, March 2012.

[19] Sofiane Hamrioui , Mustapha Lalam, and Pascal Lorenz “A new approach for energy efficiency in MANET based on the OLSR protocol”, Int. J. Wireless and Mobile Computing, Vol. 5, No. 3, 2012.

[20]Ramya Narayanan Benchmark of Routing Protocols Regarding Green Considerations, University of Lorraine Information and Communications Technology PERCCOM Master Program,2015.

[21] Network Simulator 2. [Online]. www.isi.edu/nsnam/ns.

[22] Teerawat Issariyakul and Ekram Hossain, “Introduction to Network Simulator NS2, 2009 Spring

[23]Mangesh M. Ghonge, Parag D. Thakare, P. M. Jawandhiya Suraj G. Gupta, "Open-Source Network Simulation Tools: An Overview," International Journal of

Advanced Research in Computer Engineering & Technology (IJARCET), vol. 2, no. 4, April 2013.

[24] Arti Sharma and Satendra Jain”A Behavioral Study of AODV with and without Blackhole Attack in MANET” International Journal of Modern Engineering Research (IJMER) Vol.1, Issue.2, pp-391-395 ISSN: 2249-6645.

[25] Rai, v. (2010). simulation of Ad-hoc Networks using DSDV , AODV and DSR protocols and their performance comparation. Delhi: Bharati Vidyapeeth’s Institute of Computer Applications and Management]

Appendices

Appendix A

AODV-DSDV TCL code

```
Phy/WirelessPhy set freq_ 2.472e9
Phy/WirelessPhy set RXThresh_ 2.62861e-09; #100m radius
Phy/WirelessPhy set CSThresh_ [expr 0.9*[Phy/WirelessPhy set RXThresh_]]
Phy/WirelessPhy set bandwidth_ 11.0e6
Mac/802_11 set dataRate_ 11Mb
Mac/802_11 set basicRate_ 2Mb
set par1 [lindex $argv 0]
if { $par1=="DSR"} {
  set val(ifq)          CMUPriQueue
} else {
  set val(ifq)         Queue/DropTail/PriQueue    ;# interface queue type
}
set val(chan) Channel/WirelessChannel ;
set val(prop) Propagation/TwoRayGround ;
set val(netif) Phy/WirelessPhy ;
set val(mac) Mac/802_11 ;
set val(ll) LL ;
set val(ant) Antenna/OmniAntenna ;
set val(ifqlen) 50 ;
set val(nn) 10 ;
set val(rp) $par1  ;
set val(x) 800 ;
set val(y) 800 ;
set val(stop) 50 ;
set ns  [new Simulator]
```

```
set tracefd [open AODV_10.tr w]
set winFile [open CwMaodv_10 w]
set windowVsTime2 [open win.tr w]
set namtrace      [open simwrls.nam w]
set f0 [open packets10_received.tr w]
set f1 [open packets10_lost.tr w]
set f2 [open proj_out2.tr w]
set f3 [open proj_out3.tr w]
$ns trace-all $tracefd
$ns namtrace-all-wireless $namtrace $val(x) $val(y)
# set up topography object
set topo       [new Topography]
$topo load_flatgrid $val(x) $val(y)
create-god $val(nn)
#  Create nn mobilenodes [$val(nn)] and attach them to the channel.
# configure the nodes
        $ns node-config -adhocRouting $val(rp) \
                             -llType $val(ll) \
                             -macType $val(mac) \
                             -ifqType $val(ifq) \
                             -ifqLen $val(ifqlen) \
                             -antType $val(ant) \
                             -propType $val(prop) \
                             -phyType $val(netif) \
                             -channelType $val(chan) \
                             -topoInstance $topo \
                             -agentTrace ON \
```

```
                              -routerTrace ON \
                              -macTrace OFF \
                              -movementTrace ON \
                              -energyModel "EnergyModel" \
                              -rxPower 1.0 \
                              -txPower 1.0 \
                              -initialEnergy 1000 \
                              -sleepPower .5 \
                              -transitionPower .2 \
                              -transitionTime .001 \
                              -idlePower .1
                    $ns set WirelessNewTrace_ ON
          for {set i 0} {$i < $val(nn) } { incr i } {
                    set node_($i) [$ns node]
          }
# Provide initial location of mobilenodes
$node_(0) set X_ 1.0
$node_(0) set Y_ 50.0
$node_(0) set Z_ 0.0
$node_(1) set X_ 60.0
$node_(1) set Y_ 50.0
$node_(1) set Z_ 0.0
$node_(2) set X_ 25.0
$node_(2) set Y_ 65.0
$node_(2) set Z_ 0.0
$node_(3) set X_ 70.0
$node_(3) set Y_ 40.0
```

```
$node_(3) set Z_ 0.0
$node_(4) set X_ 80.0
$node_(4) set Y_ 30.0
$node_(4) set Z_ 0.0
$node_(5) set X_ 90.0
$node_(5) set Y_ 20.0
$node_(5) set Z_ 0.0
$node_(6) set X_ 100.0
$node_(6) set Y_ 10.0
$node_(6) set Z_ 0.0
$node_(7) set X_ 110.0
$node_(7) set Y_ 100.0
$node_(7) set Z_ 0.0
$node_(8) set X_ 120.0
$node_(8) set Y_ 1.0
$node_(8) set Z_ 0.0
$node_(9) set X_ 130.0
$node_(9) set Y_ 5.0
$node_(9) set Z_ 0.0
$ns at 10.0 "$node_(2) setdest 135.0 65.0 40.0"
$ns at 10.0 "$node_(4) setdest 140.0 70.0 40.0"
$ns at 10.0 "$node_(8) setdest 125.0 100.0 40.0"
# CONFIGURE AND SET UP A FLOW

set sink0 [new Agent/LossMonitor]
set sink1 [new Agent/LossMonitor]
set sink2 [new Agent/LossMonitor]
```

```
set sink3 [new Agent/LossMonitor]

set sink4 [new Agent/LossMonitor]

set sink5 [new Agent/LossMonitor]

$ns attach-agent $node_(0) $sink0

$ns attach-agent $node_(1) $sink1

$ns attach-agent $node_(2) $sink2

$ns attach-agent $node_(3) $sink3

$ns attach-agent $node_(4) $sink4

$ns attach-agent $node_(5) $sink5

#$ns attach-agent $sink2 $sink3

set tcp0 [new Agent/TCP]

$ns attach-agent $node_(0) $tcp0

set tcp1 [new Agent/TCP]

$ns attach-agent $node_(1) $tcp1

set tcp2 [new Agent/TCP]

$ns attach-agent $node_(2) $tcp2

set tcp3 [new Agent/TCP]

$ns attach-agent $node_(3) $tcp3

set tcp4 [new Agent/TCP]

$ns attach-agent $node_(4) $tcp4

set tcp5 [new Agent/TCP]

$ns attach-agent $node_(5) $tcp5

proc attach-CBR-traffic { node sink size interval } {

   #Get an instance of the simulator

   set ns [Simulator instance]

   #Create a CBR  agent and attach it to the node

   set cbr [new Agent/CBR]
```

```
   $ns attach-agent $node $cbr
   $cbr set packetSize_ $size
   $cbr set interval_ $interval
   #Attach CBR source to sink;
   $ns connect $cbr $sink
   return $cbr
  }
set cbr0 [attach-CBR-traffic $node_(0) $sink2 1000 .015]
$ns at 0.0 "record"
$ns at 1.0 "$cbr0 start"
# Define node initial position in nam
for {set i 0} {$i < $val(nn)} {incr i} {
            $ns initial_node_pos $node_($i) 10
}
# Telling nodes when the simulation ends
for {set i 0} {$i < $val(nn) } { incr i } {
    $ns at $val(stop) "$node_($i) reset";
}
# ending nam and the simulation
$ns at $val(stop) "$ns nam-end-wireless $val(stop)"
$ns at $val(stop) "stop"
$ns at 50.01 "puts \"end simulation\" ; $ns halt"
proc stop {} {
  global ns f0 f1 f2 f3 tracefd namtrace
    $ns flush-trace
 close $tracefd
 close $namtrace
```

```
    close $f0
        close $f1
     close $f2
        close $f3
    exec nam simwrls.nam &
    exec xgraph packets10_received.tr packets10_lost.tr &
    exit 0
}
proc record {} {
  global sink0 sink1 sink2 sink3 sink4 sink5 f0 f1 f2 f3
   #Get An Instance Of The Simulator
   set ns [Simulator instance]
   #Set The Time After Which The Procedure Should Be Called Again
   set time 0.05
   #How Many Bytes Have Been Received By The Traffic Sinks?
   set bw0 [$sink2 set npkts_]
   set bw1 [$sink2 set nlost_]
   #set bw2 [$sink2 set npkts_]
   #set bw3 [$sink3 set npkts_]
   #Get The Current Time
   set now [$ns now]
   #Save Data To The Files
   puts $f0 "$now [expr $bw0]"
   puts $f1 "$now [expr $bw1]"
   #puts $f2 "$now [expr $bw2]"
   #puts $f3 "$now [expr $bw3]"
```

```
   #Re-Schedule The Procedure

   $ns at [expr $now+$time] "record"

  }

$ns run
```

Appendix B \

AWK Analysis

```
BEGIN {
        sendLine = 0;
        recvLine = 0;
        fowardLine = 0;
            recvdSize = 0
       startTime = 400
       stopTime = 0
            seqno = -1;
        count = 0;
}
# PDF% calculation
$0 ~/^s.* AGT/ {
        sendLine ++ ;
}
$0 ~/^r.* AGT/ {
        recvLine ++ ;
}
$0 ~/^f.* RTR/ {
        fowardLine ++ ;
}
# throughput calculation
{
             event = $1
             time = $2
             node_id = $3
```

```
        pkt_size = $8
        level = $4
 # Store start time
 if ((level == "AGT" || level == "IFQ") && (event == "s") && pkt_size >= 512) {
  if (time < startTime) {
        startTime = time
        }
    }
 # Update total received packets' size and store packets arrival time
 if ((level == "AGT" || level == "IFQ") && (event == "r") && pkt_size >= 512) {
    if (time > stopTime) {
        stopTime = time
        }
    # Store received packet's size
    recvdSize += pkt_size
    }
 }
# e2e Delay calculations
{
  if($4 == "AGT" && $1 == "s" && seqno < $6) {
      seqno = $6;
  }
  #end-to-end delay
  if($4 == "AGT" && $1 == "s") {
      start_time[$6] = $2;
  } else if(($7 == "cbr") && ($1 == "r")) {
     end_time[$6] = $2;
```

```
    } else if($1 == "D" && $7 == "cbr") {

          end_time[$6] = -1;

    }

}

END {

        printf ("s:%d r:%d, r/s Ratio:%.4f,Packet Lost:%d, f:%d \n", sendLine,
recvLine, (recvLine/sendLine),(sendLine - recvLine),fowardLine);

 printf("Average Throughput[kbps] = %.2f\t
StartTime=%.2f\tStopTime=%.2f\n",(recvdSize/(stopTime-
startTime))*(8/1000),startTime,stopTime);

for(i=0; i<=seqno; i++) {

          if(end_time[i] > 0) {

              delay[i] = end_time[i] - start_time[i];

                  count++;

        }

            else

            {

                  delay[i] = -1;

            }

    }

    for(i=0; i<=seqno; i++) {

          if(delay[i] > 0) {

              n_to_n_delay = n_to_n_delay + delay[i];

        }

    }

 n_to_n_delay = n_to_n_delay/count;

    print "Average End-to-End Delay    = " n_to_n_delay * 1000 " ms";

}
```