UNIVERSITY of ZAWIA

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DATA DELIVERY PERFORMANCE ALGHORITHMS APPLICABLE TO (AODV&DSR) ROUTING PROTOCOLS

Thesis submitted as a partial fulfillment of the requirement
for the degree of Master of Science in Computer Science

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Abstract

The mobile network is the key features of communication scenario in the real world nowadays. Mobile Ad-hoc Networks (MANET) are the self-configuring networks and they acted without any internal infrastructure. The routing protocols are the deciding factor of the sending and receiving routes. Since the nodes are mobiles, connections in the network can change dynamically and nodes can be added and removed at any time. This research compares the efficiency of two routing protocols Ad hoc On-Demand Distance Vector (AODV) and Dynamic Source Routing (DSR), to judge the critical criteria of performance, for both routing protocols, due to the fact that, data are vital, and important to users and their specific applications, in order to select the most reliable routing protocol, and this decision will be directly effect the level of security, reliability and cost. The performance comparison is carried out by values of performance matrix of PDR (Packet Delivery Ratio), End to End Delay and number of hops. The performance of both the protocols are reported in results.

Simulation tool will be OPNET modeler. The performance of these routing protocols is analyzed by three metrics: network load, capacity and mobility. The routing protocols are explained in a deep way with metrics.

Comparing AODV and DSR the results can be seen that AODV perform better than DSR in network with varying load, capacity and speed. The DSR performs well compared to the AODV protocols in terms of delay and number of hops.

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List of Abbreviations

DSR	Dynamic Source Routing
AODV	Ad Hoc On-Demand Distance Vector Routing
MAC	Media Access Control Layer
MANET	Mobile Ad Hoc Network
RREQ	Route Request
RREP	Route Replay
RWP	Random Way Point
PAN	Personal Area Network
LAN	Local Area Network
MAN	Motropolitan Area Network
WAN	Wide Area Network
IEEE	Institute of Electrical and Electronics Engineers
NFC N	Near Field Communication
Wi Max	Worldwide Interoperability for Microwave Access
UMTS	Universal Mobile Telecommunication System
LTE	Long Term Evolution
NIC	Network Interface Card
AP	Access Point
PCMCIA	Personal Computer Memory Card International association
PCI	Peripheral Component Interconnect
PCs	Personal Computer
PRNET	Packet Radio Network
DARPA	Defence Advanced Research Project Agency
PRNET	Provide Reliable Communication
ALOHA	Area Location Of Hazardous Atmospheres
CSMA	Carrier-sense multiple access
TDMA	Time Division multiple Access
IETF	Internet Engineering Task Force
PDA	Personal digital assistant
CPU	Central Processing Unit
DSDV	Destination-Sequenced Distance-Vector
PDR	Packet Delivery Ratio
OPNET	Optimized Network Engineering Tool

Chapter One

Introduction

Chapter One

1 Introduction

Ad hoc networks are helpful in many situations where unprepared communication facilities are required, such as disaster relief missions and battlefield communication facilities [3].

In order to achieve both high saved broadcast and high reachability when network topology changes frequently, the rebroadcast probability should be set high for nodes located in sparse areas and low for nodes located in dense areas [1,3]. These issues motivate the investigation of techniques for enhancing the performance of the routing protocol.

Data delivery will be taken in to consideration. This metric will tack the vital importance of performance, classifications, and application domains. These system parameters are, directly connected to system metric and environment metric. However, the investigations, and simulations effect, the reliability, durability and cost effectiveness, in order to take a proper decision, to decide the proper, method in data application domain [1].

In this work an attempt has been made to compare the performance of two prominent on demand reactive routing protocols for mobile ad hoc networks: DSR and AODV. A simulation model with MAC and physical layer models is used to study interlayer interactions and their performance implications. Although DSR and AODV share similar on-demand behavior, the differences in the protocol mechanisms can lead to significant performance differentials.

The performance differentials using varying parameters such as network load, mobility, and speed. These parameters are carried out using the OPNET network simulator, which is used to run ad hoc simulations.

1.1 Research Aims

The main aims of this work, can be categorize as;

- To investigate and compare the AODV routing protocol with DSR in MANETs in traffic modes performance.
- To investigate the performance impact of a number of important parameters in MANETs, including node speed, traffic load and network density, using extensive simulations.
- To study and analyses the topological characteristics of a MANET when nodes move according to the widely adopted Random Waypoint (RWP) mobility model using a short Hello interval messages so as to keep up-to-date neighbourhood information in the dynamic network environment.

1.2 Motivations

In order to reach to final goal of these thesis, in terms of reliability, durability, and cost effectiveness, the power of knowledge about performance, classifications and application domain, should be enhanced. Spares distributions low cost, small size, an light weight of the wireless nodes and setup, mode and the motivation, to use and implement, as well as, deploy them, quite easily. Another motivation is to do with required high throughput, and best results towards data delivery as a desirable case to be motivated.

1.3 Scope and Proposed Solutions

The AODV and DSR protocols are both selected as on- demand driven reactive protocols, to give some credibility of the performance, comparison between them.

The OPNET have been used as friendly to user environment.

Investigations in to total throughput and data delivery have been made a tractable case study. The results for both routing protocols, have been laid down and well documented and discussed.

However, the proposed solutions for this research topic constitutes itself in the quality of link and performance criteria. The routing capabilities have been performed with the simulation studies.

The same scenarios have been applied to both routing protocols (AODV and DSR), to facilitate the direct comparisons. Multiple metric investigation, in terms of system parameters, and environmental parameters have been adopted through out the simulation study.

1.4 Related Works

Many research work has been done in the field of MANET routing protocols. Different routing protocols were simulated in different kind of simulators. Here we will discuss different research about MANET routing protocols. In this thesis work simulated two MANET routing protocols in the OPNET modeler 14.5 such as AODV and DSR against three different parameters i.e. delay, network load and mobility.

Below we will study now different simulators with different routing protocols and their Performance evaluation.

These routing protocols DSDV, AODV, DSR and TORA were simulated using NS2 [33]. Analysis gives different results for every parameter differently. In finding shortest path between the source and destination nodes, delay, DSDV performs well than AODV, DSR and TORA. DSR perform well in network load balancing than DSDV, AODV and TORA. DSDV has good jitter than AODV, TORA and DSR respectively.

Many routing protocols have been proposed, but few comparisons between the different protocols have been made. Of the work that has been done in this field, the work done by the Monarch1 project at Carnegie Mellon University (CMU) [29] has compared some of the different proposed routing protocols and evaluated them based on the same quantitative metrics. The results given in [31] analyze DSR and DSDV in idealized and realistic simulation environments on their performance. Another paper in reference [30] gives conclusion in mobile ad hoc network that reactive protocols i.e. AODV and DSR perform well when the network load is moderate. In reference [30] the reactive protocols are saving many resources like energy and bandwidth. It analyze that the proactive protocols perform well in heavy network traffic load.

In [32] the author give different kind of conclusions about the MANET routing protocols i.e. DSDV, AODV and DSR were simulated in NS2. The reactive protocol AODV outperforms than DSDV and DSR in maintaining connection by sequentially exchange of information for TCP based traffic. The packets were delivered when the node mobility is low and failed to deliver at high mobility. DSR perform well than DSDV at all mobility. In [32] DSR performs well than DSDV and AODV for packet dropping rate (PDR), delay and throughput. DSR generates less network load than AODV.

1.5 Organization of The Thesis

The thesis have been organized as such; chapter 2, represents an overview to wireless networks. advantages and disadvantages of these networks, as well as performance.

Chapter 3, deals with mobile ad hoc networks, their advantages and characteristics, performance, and types as well as configurations.

Chapter 4, presents the methodology of the current research topic, as a procedure method towards, helpfully successful simulations for case studies.

Chapter 5, explains the simulations setup and different scenarios preparation for the cases, under study.

Chapter 6, presents the simulation results, including DSR, AODV protocols for send and receive throughput, and data delivery metric results. This chapter show direct comparison sort of results between both protocols. The chapter also, concludes with discussion of the results.

Chapter 7, concludes the end of these investigations, and summarized the vital contributions, and finding of the results, followed by possible future work.

1.6 Methodology

In this research, the methodology followed is the classical approach where it started with data collections and literature review to understood the topic and to know what software packages has been used in the simulation work.

The second stage was to decide which software to use and OPNET software is selected in this thesis. After that, the research compares the efficiency of two routing protocols Ad hoc On-Demand Distance Vector (AODV) and Dynamic Source Routing (DSR), to judge the critical criteria of performance, for both routing protocols. The performance comparison is carried out by values of performance matrix of PDR (Packet Delivery Ratio), End to End Delay and number of hops. The performance of both the protocols are reported in results section. The performance of these routing protocols is analyzed by three metrics: network load, capacity and mobility.

Chapter Two

Wireless Network

Chapter Two

2 Wireless Networks

2.1 Introduction

A wireless network is a flexible data communications system, and a type of computer network that transmits information between nodes without the use of connecting wires. This type of network is combined with remote control information transmission systems by using electromagnetic waves such as radio waves as a carrier of the information signal [8].

This implementation usually takes place at the physical layer of the network. Radio waves are often referred to as radio carriers because they simply perform the function of delivering energy to a remote receiver. The data being transmitted is superimposed on the radio carrier so that it can be accurately extracted at the receiving end. Once data is superimposed (modulated) onto the radio carrier, the radio signal occupies more than a single frequency, since the frequency or bit rate of the modulating information adds to the carrier. Multiple radio carriers can exist in the same space at the same time without interfering with each other if the radio waves are transmitted on different radio frequencies. To extract data, a radio receiver tunes in one radio frequency while rejecting all other frequencies. The modulated signal thus received is then demodulated and the data is extracted from the signal [9].

2.2 Advantages of Wireless Networks (WN)

There are many advantages of wireless networks that make them more widespread and used at the present time, and we will review the most important of these features:

1. Mobility

This mobility increases productivity and service opportunities compared with wired networks.

2. Installation Speed And Simplicity

Installing a wireless system fast and easy and no need to pull cables. The network can be extended to places which can not be wired [9].

3. More Flexibility

Flexibility and adapt easily to changes in the configuration of the network [9].

4. Ownership Cost Reduction

Overall installation expenses and life-cycle costs can be significantly lower in dynamic environments [9].

5. Scalability

Configurations can be changed and range from peer-to-peer networks suitable for a small number of users to large infrastructure networks that enable roaming over a broad area [9].

2.3 Disadvantages of Wireless Networks

there are a number of disadvantages that an individual or organization when using a wireless network such as:

1. Less range

Typically, the mid-range wireless network has a range of about 100 meters. This may be appropriate for a small home or office, but not sufficient for larger buildings.

2. Security issues

Security is a major concern in any form of communication. Wireless networks involve the risk of modification and eavesdropping.

3. Reliability

Since wireless networks work with radio wave communication, the signal is affected by much interference.

4. Less speed

The maximum speed of 802.11n standard network is 600Mbps. This is only almost half the speed of a wired network. The speed further decreases in a busy network.

2.4 Types of Wireless Networks

One way to illustrate types of wireless networks differences are to partition the use cases based on their "geographic range" [8], as can be seen in table 1.

Type	Range	Applications	Standards
Personal area network (PAN)	Within reach of a person	Cable replacement for peripherals	Bluetooth, ZigBee, NFC
Local area network (LAN)	Within a building or campus	Wireless extension of wired network	IEEE 802.11 (WiFi)
Metropolitan area network (MAN)	Within a city	Wireless inter-network connectivity	IEEE 802.15 (WiMAX)
Wide area network (WAN)	Worldwide	Wireless network access	Cellular (UMTS, LTE, etc.)

Table 1 types of wireless networks[10]

2.5 Performance Fundamentals of Wireless Networks

Shannon [9] gave us an exact mathematical model (Channel capacity is the maximum information rate) to determine channel capacity. channel capacity is the maximum information rate.

$$C = BW * \log_2(1 + \frac{S}{N})$$

Where C is the channel capacity (bits/second), BW is the available bandwidth (Hz), S is the signal (Watts) and N is the noise (watts).

The previous formula captures all the details needed to understand the performance of most wireless networks.

2.6 Wireless Network Components

There are some similarities between the equipment used to create a WLAN and the equipment used in a traditional wired LAN, these equipment are:

- Both networks require a network interface card (NIC).

There are two main types of plug-in card available: PCMCIA and PCI, which is inserted into one of the internal slots in a desktop computer. Wireless NICs contain an in-built antenna to connect with the network.

- In a wireless network, an *'access point'* (AP).

A similar function to the switch in wired networks. It broadcasts and receives signals to and from the surrounding computers via their wireless NICs [9].

2.7 Wireless Network Configurations

Wireless networks can be configured in ad hoc mode using two basic things which are Ad-Hoc configuration and access points.

2.7.1 Ad Hoc Configuration

It is the basic wireless network configuration. It is equivalent to a wired peer to peer network. It requires only wireless NICs in each computer with common network name [9].

2.7.2 Infrastructure Configuration Using Access Point(s)

With the installation of an access point, the range over which the network is accessible increases to approximately 150 m indoors and 350 m outdoors (optimum performance within 30 m indoors).

Two other pieces of equipment may be required to support a wireless LAN [10]:-

- Extension points which act as wireless relays extend the range of an access point.
- Directional antennae may be used as a means of connecting two separate buildings so that the network is shared between buildings.

Chapter Three

Mobile Ad-Hoc Network (MANET)

Chapter Three

3 Mobile Ad-Hoc Network (MANET)

3.1 Introduction

MANET is a self- configuring, self-organizing collection of wireless mobile nodes that form a temporary and dynamic wireless network without wires. The MANET technology supports pervasive computing because in many contexts information exchange between mobile units cannot rely on any fixed network infrastructure but on rapid configuration of a temporary wireless network. This is the main motivation behind MANET [1-3].

Ad Hoc is Latin and it means “for this purpose”, each device in a MANET is free to move independently in any direction and will change its links to other devices frequently [11]. The primary challenge in building a MANET is equipping each device to continuously maintain the information required to properly route traffic. Such networks may operate by themselves or may be connected to the larger internet. They may contain one or multiple & different transceivers between nodes. This results in a highly dynamic autonomous topology.

The MANETS are different from internet in two major ways. The first is that the hosts in this network are resource-constraint. They have only limited energy, computing power & memory. The second is that the hosts of the network are mobile & the topology changes rapidly. These two features pose great challenges to the researchers working in the area. MANET nodes are typically distinguished by their limited power, processing & memory resources as well as high degree of mobility. In such networks, the wireless nodes may dynamically enter the network as well as leave the network. Due to the limited transmission range of wireless network nodes, multiple hopes are usually needed for a node to exchange information with any other node in the network [4].

3.2 Characteristics Of MANET

MANET has the following features:

1. Autonomous Terminal:
   In MANET, each mobile terminal is an autonomous node, which may function as both a host and a router [11].
2. Distributed operation:
   There is no background network for the central control of the network operations and so, the control and management of the network is distributed among the terminals [9].
3. Multi-hop routing:
   Basic types of ad hoc routing algorithms can be single-hop and multi-hop, based on different link layer attributes and routing protocols [9].
4. Dynamic network topology:
   Since the node mobile, the network topology may change rapidly and unpredictably and the connectivity among the terminals varies with time [9].
5. Fluctuating link capacity:
   The nature of high bit-error rates of wireless connection are profound in a MANET. One end-to-end path can be shared by several sessions. The channel over which the terminals communicate is subject to noise, fading, and interference.

6. Light-weight terminals:
   In most cases, the MANET nodes are mobile devices with less CPU processing capability, small memory size, and low power storage.

3.3 MANET Architecture

The architecture of MANET is shown in Figure 3-1. The network architecture is grouped into main three categories which are:
• Enabling technologies
• Networking
• Middleware and applications

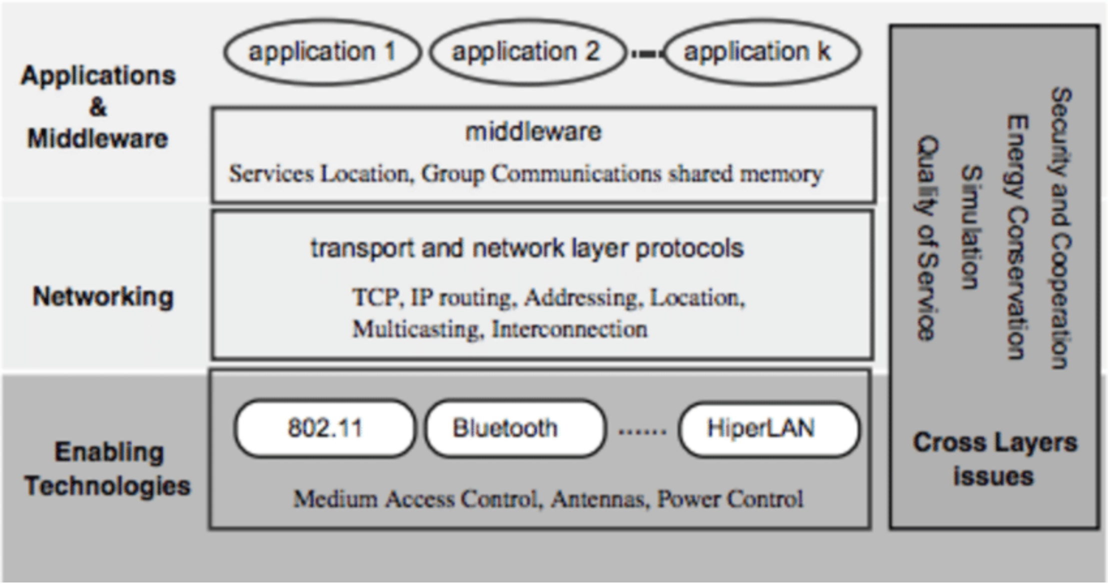

Figure 3-1 Asimple MANET Architecture [11]

3.4 Advantages of MANET

The advantages of the Ad-hoc network include the following [13]:
1. provide access to information and services regardless of geographic position.
2. Independence from central network administration. Self-configuring network, nodes are also act as routers. Less expensive as compared to wired network.
3. Scalable accommodates the addition of more nodes.
4. Improved Flexibility.
5. Robust due to decentralize administration.
6. MANET can be set up at any place and time.

3.5 MANET Deploying Issues

Following are some of the main routing issues to be considered when deploying MANET's:

1. Unpredictability of Environment
Ad hoc networks may be deployed in unknown terrains, hazardous conditions, and even hostile environments here tampering or the actual destruction of a node may be imminent. Depending on the environment, node failures may occur frequently [13].

2. Unreliability of Wireless Medium

Communication through the wireless medium is unreliable and subject to errors. Also, due to varying environmental conditions such as high levels of electro-magnetic interference (EMI) or inclement weather, the quality of the wireless link may be unpredictable [13].

3. Resource-Constrained Nodes

Nodes in a MANET are typically battery powered as well as limited in storage and processing capabilities. Moreover, they may be situated in areas where it is not possible to re- charge and thus have limited lifetimes. Because of these limitations, they must have algorithms which are energy efficient as well as operating with limited processing and memory resources. The available bandwidth of the wireless medium may also be limited because nodes may not be able to sacrifice the energy consumed by operating at full link speed [11].

4. Dynamic Topology

The topology in an Ad hoc network may change constantly due to the mobility of nodes. As nodes move in and out of range of each other, some links break while new links between nodes are created.

As a result of these issues, MANETs are prone to numerous types of faults including the following [13]:

1) Transmission Errors: The unreliability of the wireless medium and the unpredictability of the environment may lead to transmitted packets being garbled and thus received packet errors.

2) Node Failures: Nodes may fail at any time due to different types of hazardous conditions in the environment. They may also drop out of the network either voluntarily or when their energy supply is depleted.

3) Link Failures: Node failures as well as changing environmental conditions may cause links between nodes to break.

4) Route Breakages: When the network topology changes due to node/link failures and/or node/link additions to the network, routes become out-of-date and thus incorrect. Depending upon the network transport protocol, packets forwarded through stale routes may either eventually be dropped or be delayed.

5) Congested Nodes or Links: Due to the topology of the network and the nature of the routing protocol, certain nodes or links may become congested.

Chapter Four

Routing Protocols in MANET

Chapter Four

4 Routing Protocols in MANET

4.1 Introduction

MANETs are ad hoc networks comprised of mobile wireless nodes. Given the mobile nature of the nodes, the network topology can change over time. The nodes create their own network infrastructure, each node also acts as a router, forwarding traffic in the network. MANET routing protocols need to adapt to changes in the network topology and maintain routing information, so that packets can be forwarded to their destinations. Although MANET routing protocols are mainly for mobile networks, they can also be useful for networks of stationary nodes that lack network infrastructure [23].

4.2 Routing in Mobile Ad-hoc Asymmetric Cases

The asymmetric links is a common in many ad-hoc networks, including MANETs and sensor networks. Asymmetry is caused assentialy by node mobility, heterogeneous radio technologies, and irregularities in radio ranges and packet loss patterns. Ad-hoc routing protocols assume fully symmetric networks.
The main problems of routing in asymmetric cases are:

1. Links Dialogue Scenario
Consider a MANET where node B sends a signal to node A, but this does not tell anything about the quality of the connection in the reverse direction. Therefore, lack of connections might occur, in these sort of dialogues of communications [24].
2. Routing Overhead Setup
Some stale routes are generated in the routing table, which leads to unnecessary routing overhead [23]. However, some method of refreshing the routing table are required.
3. Interference Phenomena
This can happen, if any device at transmission, kind of interference might occur, as the case of channel, interference from neighboring channel, while the wireless in mode of operation.
4. Dynamic Topology (free – to – move)
Dynamic topology means, all mobile nodes might change their location as necessary. Problem can occur therefore, the routing protocol, must adapt with these circumstances.

4.3 Classification of Routing Protocols In MANET's

The routing protocols can be categorized as table-driven and source initiated, while depending on the network structure these are classified as flat routing, hierarchical routing. Protocols come under the flat routing. Figure 4-1 shows routing protocol [14], for the purpose of further investigation and comparisons.

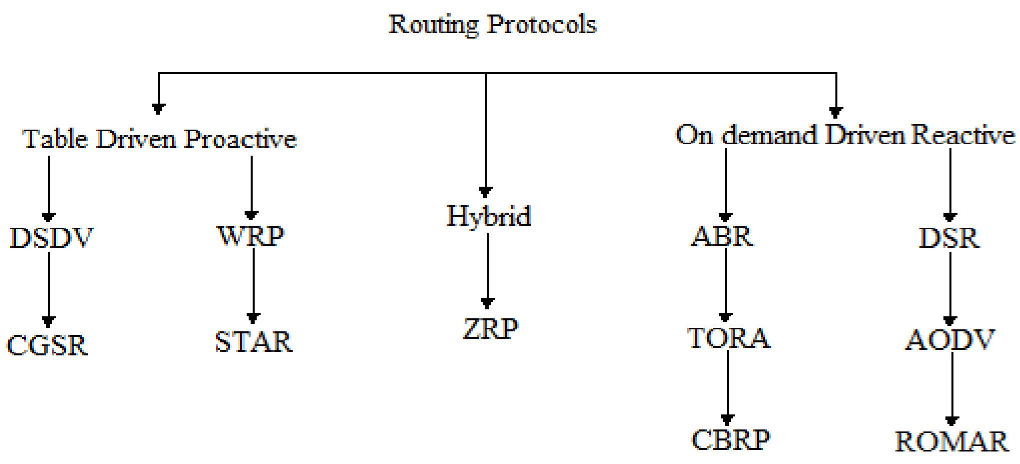

Figure 4-1 Routing Protocol

4.4 Ad-hoc On-Demand Distance Vector (AODV) Protocol

AODV is a very simple, efficient, and effective routing protocol for Mobile Ad-hoc Networks. It borrows most of the advantageous concepts from DSR and DSDV algorithms. The on demand route discovery and route maintenance from DSR and hop-by-hop routing, usage of node sequence numbers from DSDV make the algorithm cope up with topology and routing information.

AODV routing protocol for data delivery algorithm can be classified as:

- Check routing table – entry.
- Check minimal space completely.
- Check bandwidth utilization.
- Check self – starting nodes.
- Check up – data routing information.
- Check loop- free loops.
- Check dynamic topology and links.
- Check scalability.
- Check unicast or multicast.
- Check broadcast medium.
- Check overhead.
- Check route- maintenance.
- Check vulnerability test.

The data delivery flowchart, for the AODV protocol is shown in Figure 4-2.

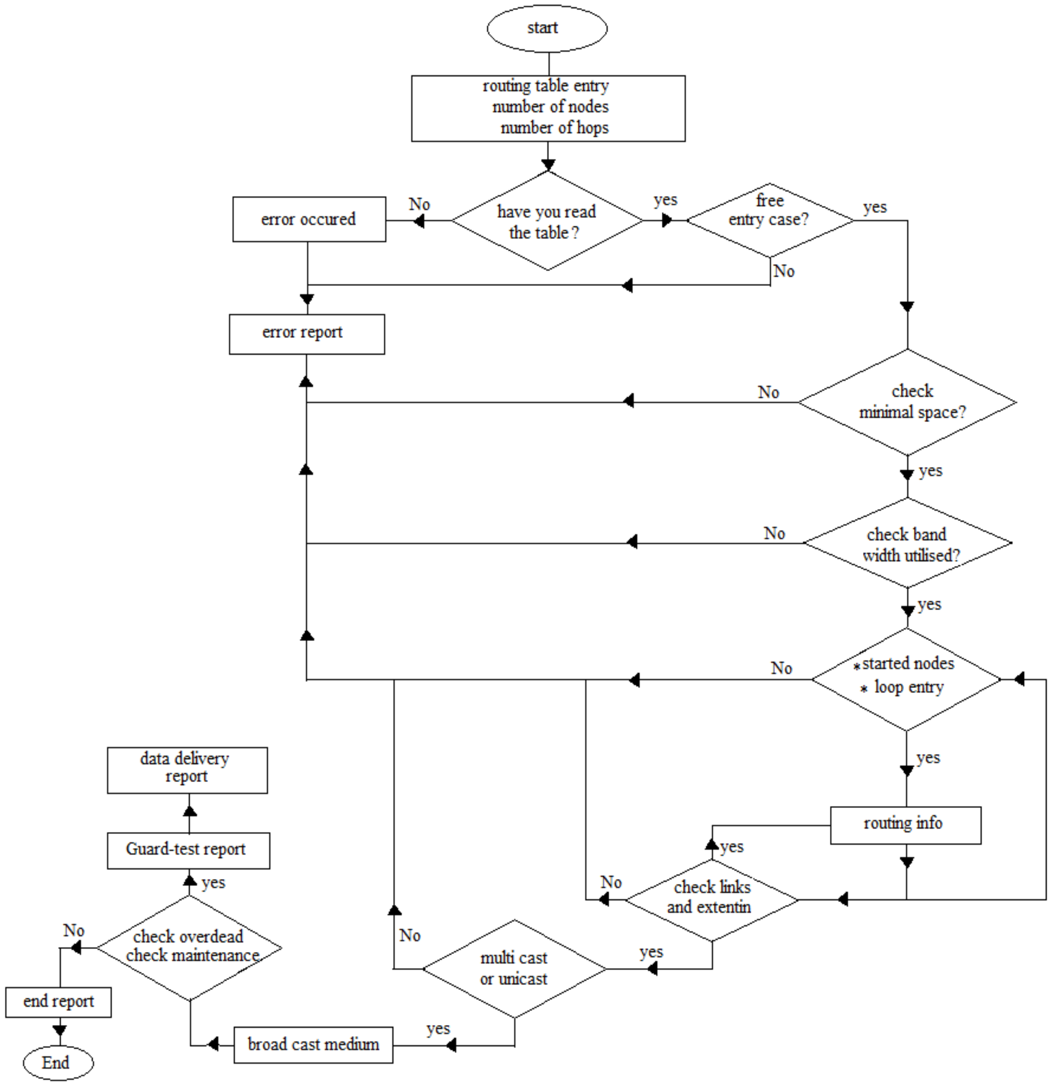

Figure 4-2 Data Delivery Flowchart of AODV

4.4.1 Working Mode Of Operations

Each node in the network maintains a routing table with the routing information entries to it's neighbouring nodes, and two separate counters: a node sequence number and a broadcast-id. When a source node 'S' has to communicate with a destination node 'D', it increments its broadcast-id and initiates path discovery by broadcasting a route request packet RREQ to its neighbors.

The RREQ contains the following fields [12]:

- **source- addr**
- **source-sequence**: to maintain freshness info about the route to the source.
- **destination- addr**
- **destination- sequence**: specifies how fresh a route to the destination must be before it is accepted by the source.
- **hop- count**

The (source-addr, broadcase-id) used to identify the RREQ uniquely. Then the dynamic route table entry establishment begins at all the nodes in the network that are on the path from S to D.

Figure 4-3 is an example, which shows how the route to the destination is found by AODV routing protocol (self explain figure!).

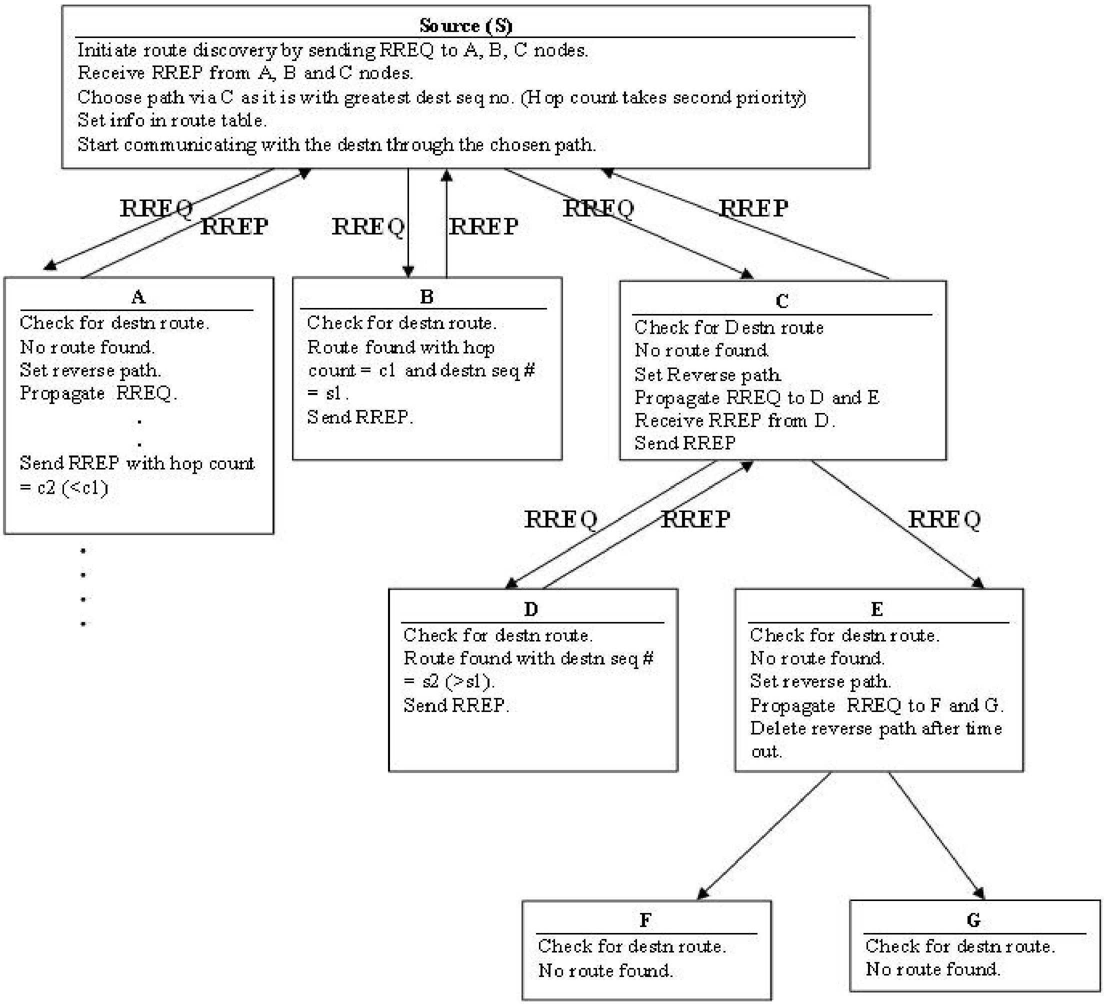

Figure 4-3 Examble to Found Distination by AODV

4.4.2 Route Table Management

Each mobile node in the network maintains a route table entry for each destination of interest in its route table [15]. Each entry contains the following information:

- Destination
- Next hop
- Number of hops
- Destination sequence number
- Active neighbors for this route
- Expiration time for the route table entry

4.4.3 The Concepts of AODV

The concepts of AODV that make it desirable for MANETs with limited bandwidth include the following [13]:

1. Minimal Space Complexity: The algorithm makes sure that the nodes that are not in the active path do not maintain information about this route.

2. Maximum Utilization of The Bandwidth: All the intermediate nodes in an active path updating their routing tables also make sure of maximum utilization of the bandwidth. Since, these routing tables will be used repeatedly if that intermediate node receives any RREQ from another source for same destination. Also, any RREPs that are received by the nodes are compared with the RREP that was propagated last using the destination sequence numbers and are discarded if they are not better than the already propagated RREPs.

3. Simple: Each node behaving as a router, maintaining a simple routing table, and the source node initiating path discovery request, making the network self-starting.

4. Most Effective Routing Info: If a node finds receives an RREP with smaller hop-count, it updates its routing info with this better path and propagates it.

5. Most Current Routing Info: The route info is obtained on demand.

6. Loop-Free Routes: The algorithm maintains loop free routes by using the simple logic of nodes discarding non better packets for same broadcast-id.

7. Coping up With Dynamic Topology And Broken Links: If the active paths are broken, the intermediate node that discovers this link breakage propagates an RERR packet. And the source node re-initializes the path discovery if it still desires the route. This ensures quick response to broken links.

8. Highly Scalable: The minimum space complexity and broadcasts avoided, these lend themselves, to high scalability.

4.4.4 Advanced Uses of AODV

1. AODV can handle highly dynamic behavior of Vehicle Ad-hoc networks, Because of its reactive nature.
2. It's used for both unicasts and multicasts using the 'J' (Join multicast group) flag in the packets [13].

4.4.5 Disadvantages of AODV [25]

There are many things and factors that affect the operation of the protocol, the most important of which are:

1. Requirement on broadcast medium.
2. Overhead on the bandwidth.
3. No reuse of routing info.
4. It is vulnerable to misuse.
5. AODV lacks support for high throughput routing metrics.
6. High route discovery latency.

4.5 The Dynamic Source Routing Protocol (DSR)

DSR is a simple and efficient routing protocol designed specifically for use in multi-hop wireless MANET nodes. DSR, is a reactive routing protocol that uses source routing to send packets. It uses source routing which means that the source must know the complete hop sequence to the destination. Each node maintains a route cache, where all routes it knows are stored. The route discovery process is initiated only if the desired route cannot be found in the route cache [13,33].

DSR routing protocol for data delivery algorithms can be classified as follows;

- Rout discovery.
- Route maintenance.
- Loop free.
- Dropping cashing routing .
- Scalability (routes on demand).
- Limited number of hops.
- Transmission latency.
- Node velocity(mobile case).
- Error detection.
- addressing mode.
- Automatic scaling.
- Data delivery scheme.

The relevant flowchart to this algorithm is shown in Figure 4-4.
The protocol is composed of the two main mechanisms of "Route Discovery" and "Route Maintenance", which work together to allow nodes to discover and maintain routes to arbitrary destinations in the ad hoc network.

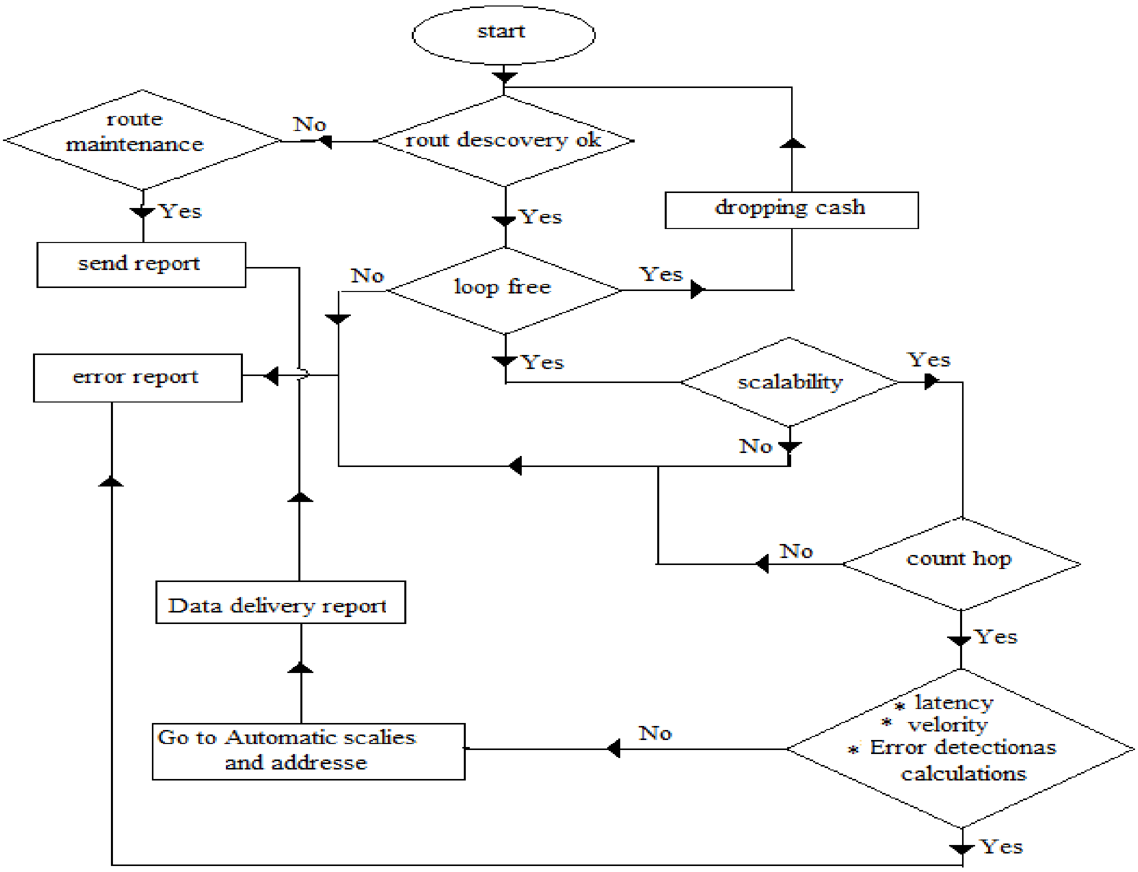

Figure 4-4 Data Delivery Flowchart of DSR

4.5.1 Route Discovery

Route Discovery used whenever a source node desires a route to a destination node. First, the source node looks up its route cache to determine if it already contains a route to the destination. If the source finds a valid route to the destination, it uses this route to send its data packets. If the node does not have a valid route to the destination, it initiates the route discovery process by broadcasting a route request message. Figure 4-5 shows route request mechanisms [15].

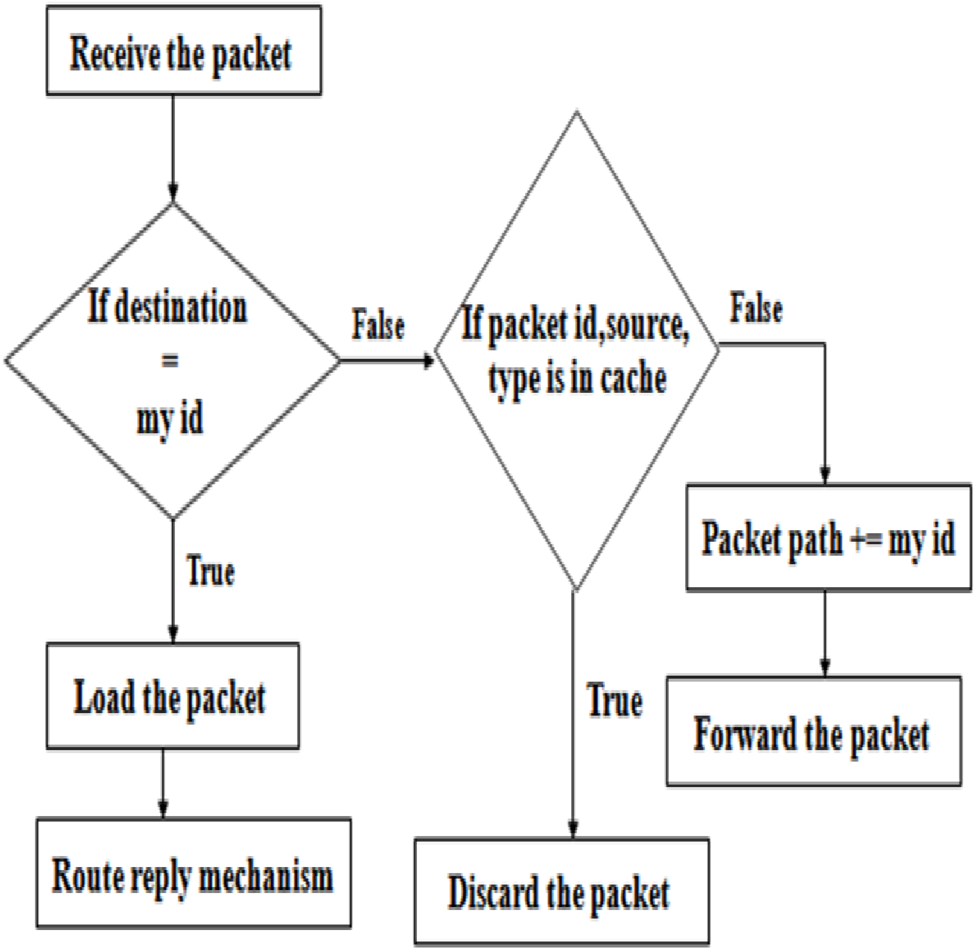

Figure 4-5 Route Request Mechanism [14]

4.5.2 Route Maintenance

Route Maintenance is used to handle route breaks. The route error message is sent to nodes that has sent a packet routed in the broken link. Then a node receives a route error message, it removes the hop in error from its route cache. Figure 4-6 shows that.

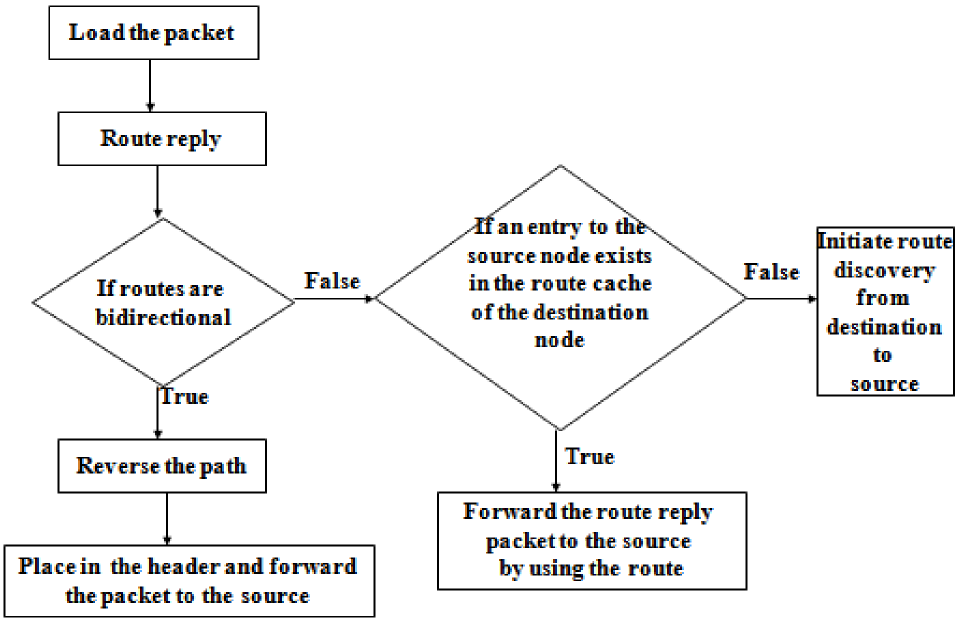

Figure 4-6 Rout Reply Mechanism [14]

4.5.3 Advantages of DSR

The most important features of AODV are:
1. Loop free routing, where nodes can store multiple paths.
2. Allow multiple routes to any direction.
3. Caching routing information from packets forwarded (ease dropping).

4.5.4 Disadvantages of DSR

There are also many disadvantages to the DSR protocol, including the following:
1. Nodes participate fully.
2. Diameter or number of hops is small (5 – 10).
3. Node velocity is small relative to transmission latency.
4. Errors are detectable and discarded.
5. Nodes may enable promiscuous receive mode (hardware layer passes packets & power may be increased).
6. Can operate without promiscuous mode on or in networks where it is unavailable.
7. Only one address is used per node (Home Address).
8. Entirely on-demand, no periodic packets, automatic scaling [18].

Chapter Five
Simulation Setup

Chapter Five

5 Simulation Setup

5.1 Introduction

Majority of routing protocols for wireless network (wn), use hop counting strategy, as essential part of routing scheme, for routing selection policy.
Therefore, packet routing will be achieved taking the mobility in to account, in order to select the minimum requirement to achive roil have low quality links, due to congestion or blocking, henceforth, in this work, dynamic source routing (DSR), and Ad hoc on demand distance vector routing (AODV) as both routing protocols suite to be on demand driven reactive protocols, in order to ensure the performance of both protocols for data delivery scenarios.
This chapter covers an overview of the OPNET, which is used as our tool for simulation. Modeling and performance of both protocols will be followed.

5.2 Overview of OPNET Simulator

OPNET is a well documented and vast modeling high level simulator, for modeling communication nodes and their protocols.

The simulation of network design as well as the configuration can be full filed. In OPNET, the simulation can start from the packet level to the level of the big library, for modules and protocols for realistic networks.

5.2.1 Reasons For Using OPNET

OPNET can be considered as a good modeling tool.
It supports a wide varieties of networks and their protocols, as well as a good formulation of results, and huge library for use.
The following main reasons can be outlined as:

1. The robustness of their modeling will facilitate the simulation environment and data analysis.
2. Troubleshooting, it is easy to follow crashes, and system failure.
3. It has easy environment software steps to follow.
4. Different operating condition, for network protocols applications (Different platforms).

5.3 OPNET Modeling Environment (OME)

The simulation environment of the Opnet can be classified in to the following classes as;

1. The Universal Environment Domain (UED).
2. The Nodal Environment Domain (NED).
3. The Processing Environment Domain (PED).

These domains can be explained as:

- The UED; it concerned with the total space of the system under simulation. It also considers the physical geographical locations around the globe. It is then deemed to be a global Domain System (GDS).

- The NED; it deals with the configuration of the network. These nodes can in routers, switches, workstation, hubs, bridges, gateways, etc.
  Figure 5-1 shows the configuration of mobile nodes.

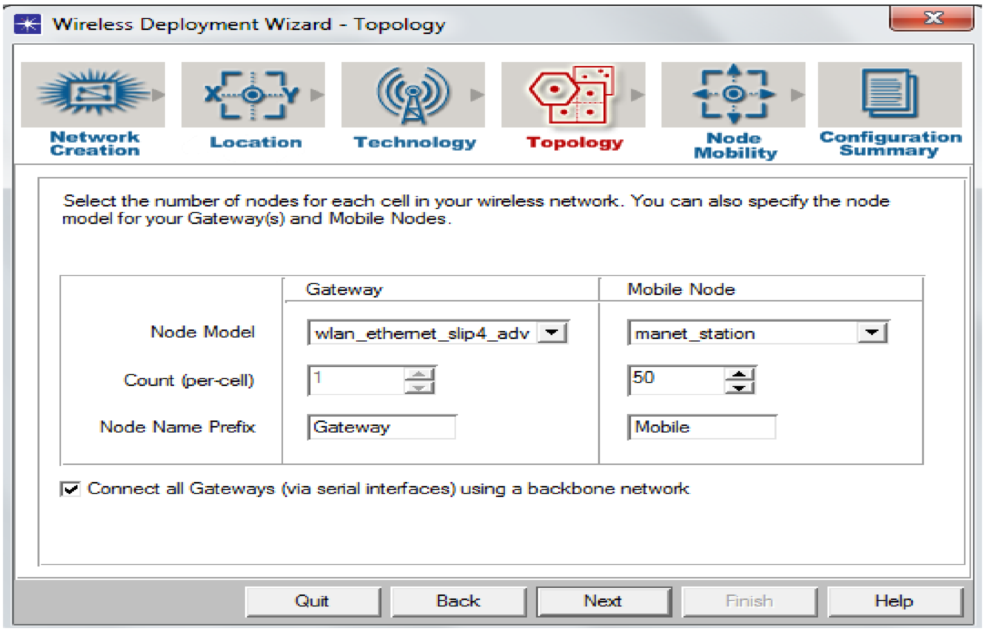

Figure 5-1 The Configuration Topology of Nodes

- The PED; it covers between states of the system. The transition and conditions adopted the inter connection between nodes.

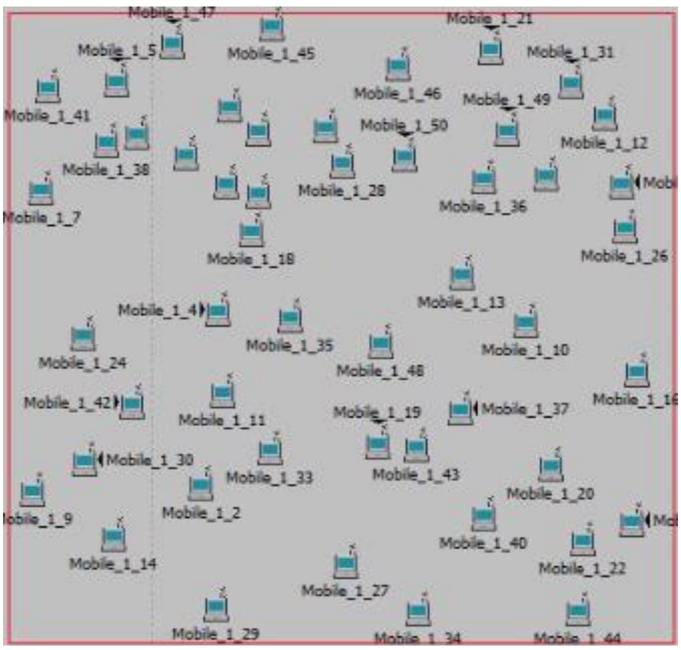

Figure 5-2 The Topology Distribution Process

Figure 5-2 shows the inter relation between mobile nodes, as topological process model.

5.4 The DSR Model Using OPNET

5.4.1 Node Configuration Model

The DSR model and configuration parameters are shown and displayed in Figure 5-3.

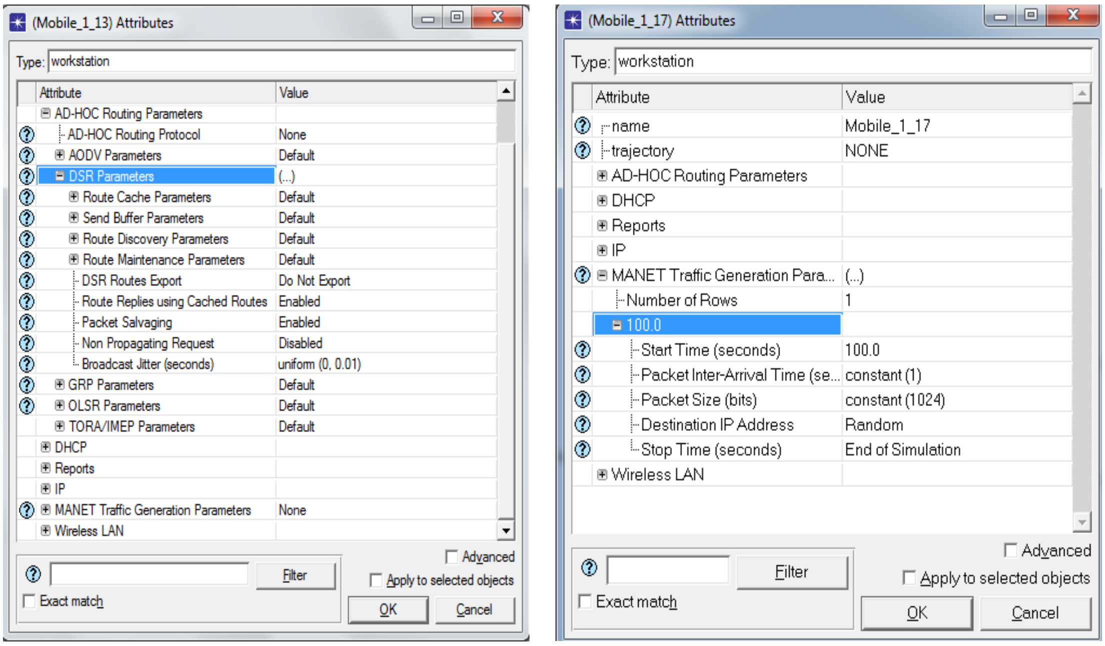

Figure 5-3 Node Configuration Model For DSR

5.4.2 The Process Environmental Model

The process model is described for DSR protocol.

- The initialization state (prior-setup). The pre-state initialization is to initialize the DSR process (program) model, by motivating the current address of the DSR node. Hens the validity of the address will be checked with the network configurations.
- The initialization stage makes sure that user parameters are satisfied by the user.
- The Idel condition, in this case if the process is awaiting for commands (events).
- Packet arrival treatment, this state of process can handle the packets to destination. This also governs the states of packets (data, reply, lost, etc).
- Reply state, it handles the send and no reply states.
  However, send reply will be established. On the other hand if time out occurred with requested packet by node is expired, then no reply message will be send.
- Ack state, an acknowledgment message will be send if correct packets are received. Hence forth other data will be send.
- The state of error, if the error detected, then the link declared broken. Therefore, the route table is initiated.
- Route discovery state, it handles the route discovery of DSR protocol. Therefore the route request, route reply, and route cache data structures will be used respectively, in order to select the proper route.

5.5 The AODV Model Using OPNET

5.5.1 Node Configuration Model

The parameters of AODV protocol model is shown in Figure 5-4.

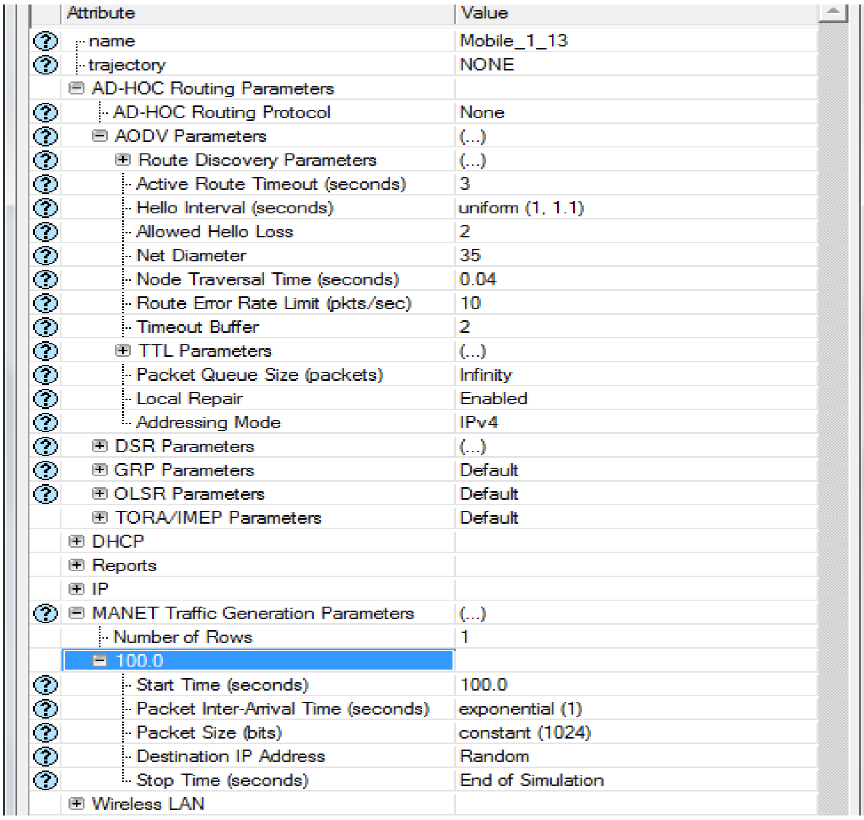

Figure 5-4 The AODV Configurations

5.5.2 The Process Environmental Model

The model is concerned with the AODV protocol.
The following stage are related to this AODV model.

- Priori initialization model; it is used to initialize the AODV process, this can be done by establishing the AODV node address, and it is validity state.
- The initialization state; it handles user parameters.
- Idle condition; this is used if a process is waiting for command.
- Packet arrival treatment; this process handles the packet arrival to destination. It also classifies the packet types.
- Reply state; it treats the send reply and no reply state, interchangeably as required.
- Ack state; acknowledgment message will be send, for correct or un correct reception of packets, as positive or negative acknowledgments.
- The state of error; it is activated, if an error occurred and the route table will be re-initiated.
- Route discovery state; will be classified in to
  a. Route request.
  b. Route reply.
  c. Route cache data structure.

For more information about the MANET used scenarios, please refer to appendix I, where also the simulation steps environment, can be found.

Chapter Six

Simulation Results

Chapter Six

6 Simulation Results

6.1 DSR Routing Protocol vs. Network Capacity

In the last scenarios the number of nodes was varied from 25,50,75 in order to assess the MANET performance when using DSR routing protocol. The following graphs show the obtained simulation results of the increase of network capacity by increasing the number of active loads on the amount of traffic being send and received and hence finding the Packet Delivery Ratio (PDR).

6.1.1 DSR Traffic Sent With Varying Capacity

Figure 6-1 shows the amount of the traffic sent in bits per second as the number of nodes is increased in the test MANET configuration. As it can be seen from the figure, trafficking in the network starts at about 100s, which is set in the simulation and then traffic start increasing linearly with time up to nearly the 150 s mark, and then start to drop exponentially, and this is due to the fact that at the start the nodes start source destination path setup and trafficking starts in the network ,and due to the dynamic nature of the networks, the packet dropping rate starts to increase and hence the total data being sent starts declining in a negatively exponential manner i.e.as time passes the amount of traffic being sent drops until it reaches to a steady state rate. Also it is clear as the number of nodes increases the amount of transmitted traffic increases. The size of data being sent as per the obtained results from Figure 6-1. It's around 9 kbps for 25 nodes, 18 kbps for 50 nodes and 48 kbps for 75 nodes. It is quite clear that the amount of data being sent is proportional to the number of nodes.

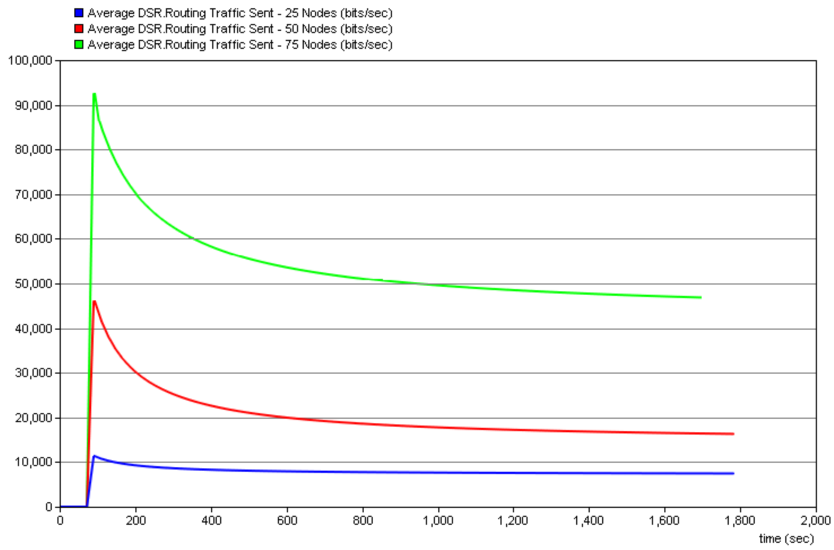

Figure 6-1 Average DSR Routing Traffic Sent

6.1.2 DSR Traffic Received With Varying Capacity

In a similar manner the amount of data being received by destination nodes will be affected by the number of active nodes in the MANET and this due to the same reason being explained in the case of sending traffic. From Figure 6-2, the size of total received data is about 7 kbps,14 kbps and 15 kbps for 25, 50 and 75 nodes respectively. This result indicates that as the number of nodes increases the packet drop rate increase and this is expected due to the dynamic nature of the MANET. Also DSR protocol is reactive type protocol and as network gets larger the packet overhead size gets bigger which increase latency in the network and consequently the packet loss ratio increase.

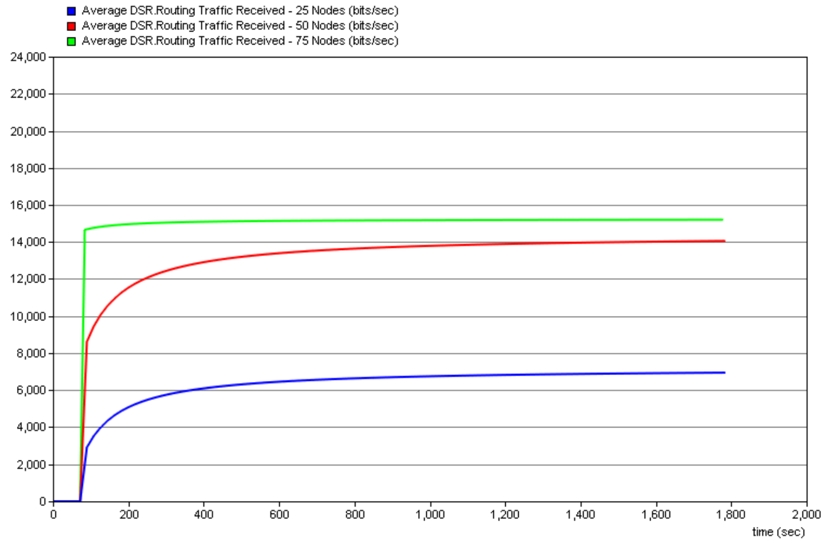

Figure 6-2 Average DSR Routing Traffic Received

6.1.3 Packet Delivery Ratio of DSR with varying capacity

PDR is the ratio between the number of packets transmitted by a source node and the number of packets received by a destination node. It measures the loss rate as seen by transport protocols and as such, it characterizes both the correctness and efficiency of ad hoc routing protocols. A high packet delivery ratio is desired in any network. A data delivery graph is shown in Figure 6-3 data behavior looks reasonable using DSR, the efficiency of this protocol fells sharply when number of nodes is 75.

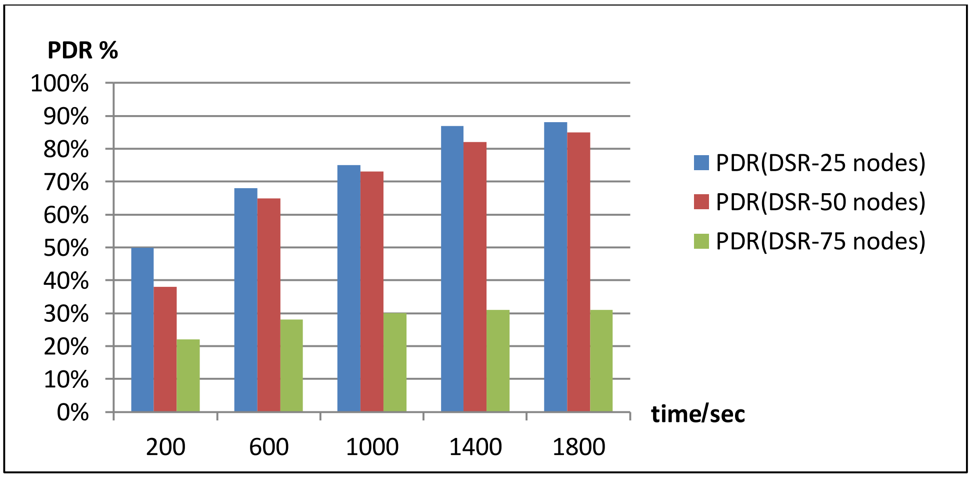

Figure 6-3 Data Delivery Ratio

As can be seen from Figure 6-3, as the number of nodes increase in the network the PDR decrease, which an indication of degradation in performance. For example, at the time 1800 sec, it is clear from the figure that the PDR for 25 nodes case is 89%, 50 nodes case is 85% and for the 75 nodes case is 30%. This means that 89% of the transmitted packet are delivered when the number of nodes in the network was 25, but this rate is reduced to 85% and 30% when the number of nodes increased to 50 and 75 respectively.
This gives a clear indication that DSR routing protocol is efficient when the network size is small but its performance will degrade as the number of nodes increases.

6.2 AODV Routing Protocol vs. Network Capacity

In the following scenario the number of nodes was varied from 25, 50 to 75 in order to test the performance when using AODV protocol. The AODV routing works in similar manner to DSR since it is also a reactive type protocol but it should be faster since it maintains routing table at each node in order to minimize packet overhead. The following Figures 6-4, 6-5, 6-6 show the obtained simulation results of the effect to increase network capacity by increasing the number of active loads on the amount of traffic being send and received and hence the Packet Delivery Ratio (PDR).

6.2.1 AODV Traffic Sent With Varying Capacity

Figure 6-4 shows the total data being delivered by source nodes using the AODV routing protocol when the number of nodes of this MANET was increased from 25 to 75. Once again as the case with DSR protocol as the number of nodes is increased the number of packets being transmitted is increased. From the graph it is clear that the data delivery is increased from about 23 kbps when the number of nodes is 25, to 47 kbps for 50 nodes case and 73 kbps when number of nodes increased to 75.

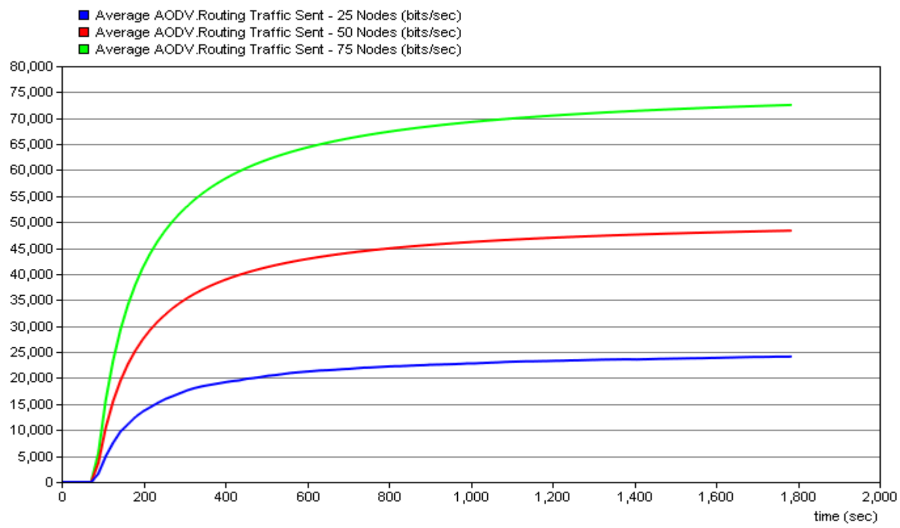

Figure 6-4 Average AODV Routing Traffic Sent

6.2.2 AODV Traffic Received With Varying Capacity

As shown in Figure 6-5, the size of data receiving in bps in the 25 nodes case was about 23kbps, 45kbps for the 50 nodes case and around 30kbps for 75 nodes case. From the graph it is very clear that there is large drop of the number of received packets when the nodes in the MANET increased to 75. This sharp drop indicate that this protocol cannot handle large number of nodes and hence the network is congested the packet drop rate increased sharply.

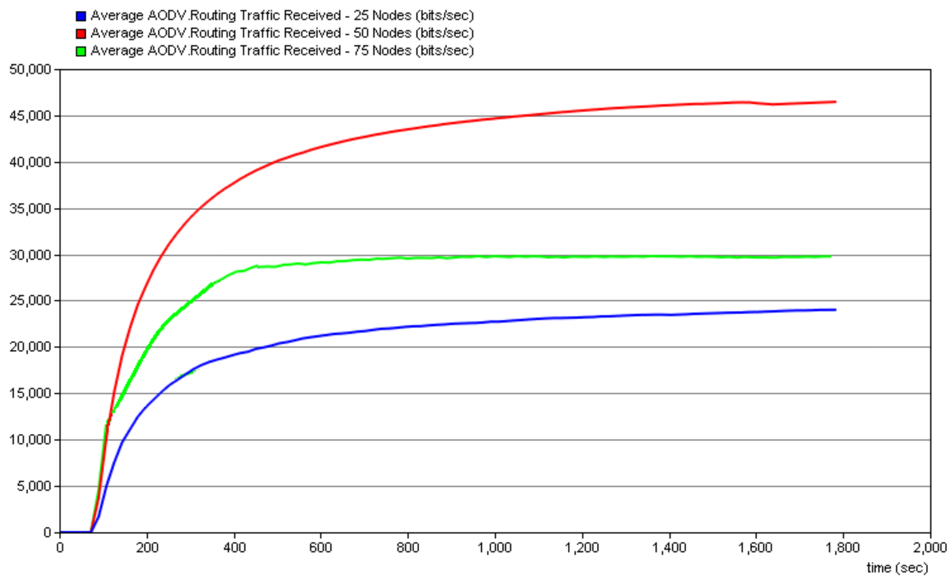

Figure 6-5 Average AODV Routing Traffic Received

6.2.3 Packet Delivery Ratio to AODV With Varying Capacity

Data delivery graph is shown in Figure 6-6 data behavior looks reasonable using AODV.

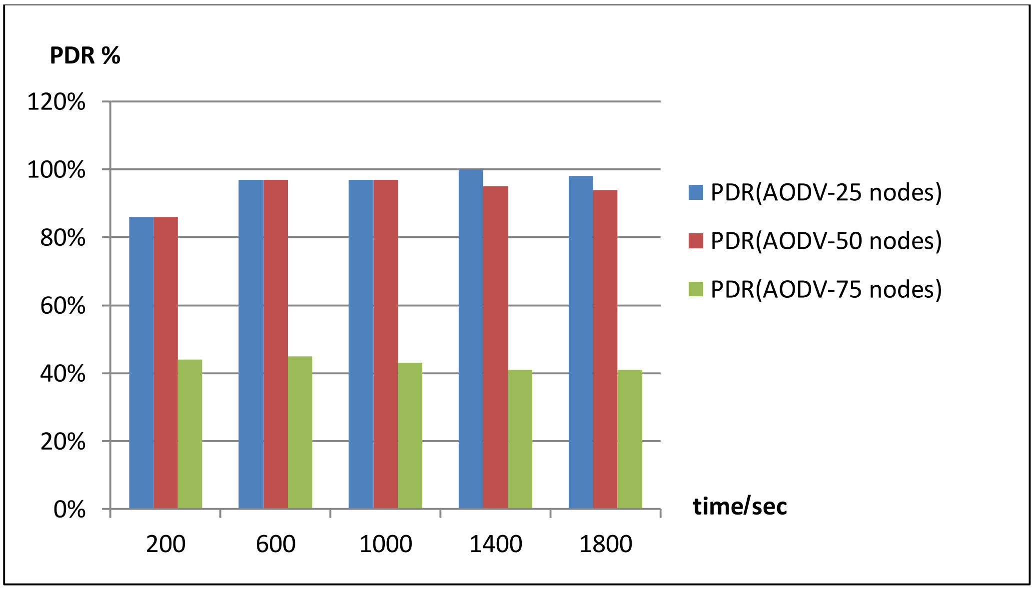

Figure 6-6 Data Delivery Ratio to AODV

In Figure 6-6 the similar trend of the results can be obtained using AODV protocol as the performance is declined as the number of nodes is increased to 75. However, the number of nodes vary from 25 to 50, the performance swing from 80 to 100%.

6.3 DSR vs AODV for Varying Capacity

6.3.1 Routing Traffic Sent For 25 Nodes Scenario

Amount of Traffic sent by AODV exceeds that is sent by DSR shown in Figure 6-7.

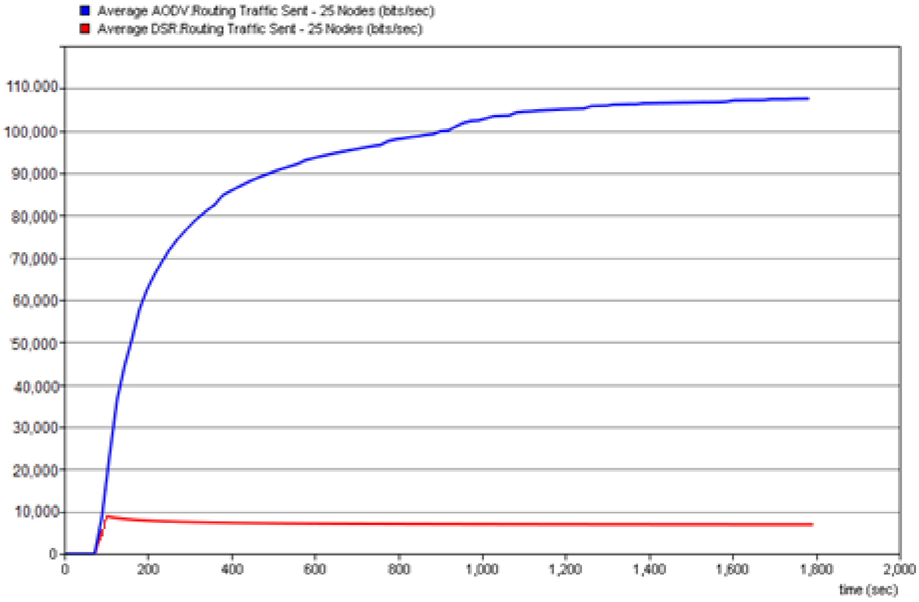

Figure 6-7 DSR vs AODV for 25 Nodes

6.3.2 Routing Traffic Received for 25 Nodes

Amount of traffic received by AODV exceeds that is received by DSR, shown in Figure 6-8, indicating the large number of broadcasts that AODV performs.

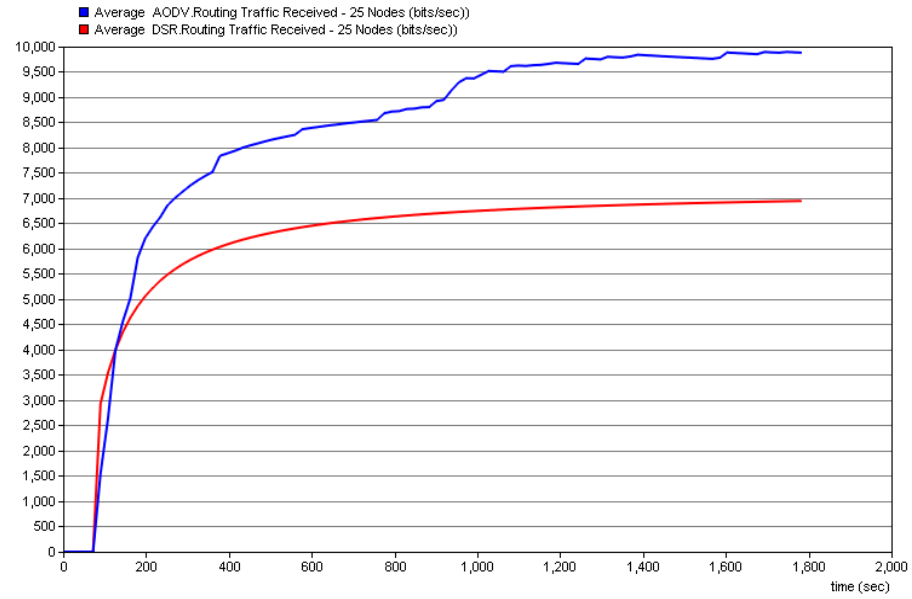

Figure 6-8 DSR vs AODV for 25 Nodes

6.3.3 Packet Delivery Ratio to DSR &AODV

Data delivery graph to AODV and DSR for 25 nodes is shown in Figure 6-9 .

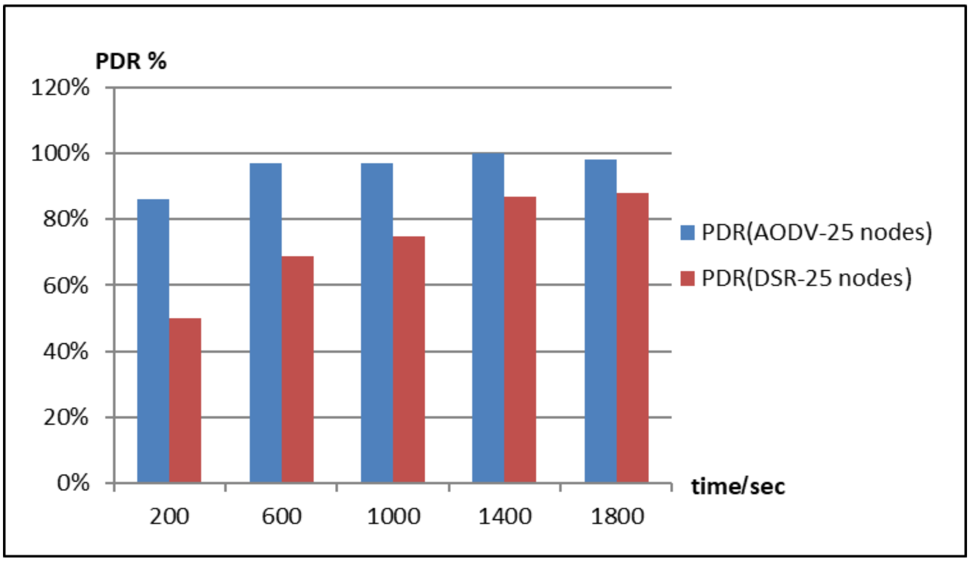

Figure 6-9 Comparison of AODV and DSR(25 nodes)

As depicted from Figure 6-9, A direct comparison between AODV and DSR protocols, in terms of their PDR%, performance which shows, the superiority of AODV protocol as the number of nodes were fixed to 25 nodes only.

6.3.4 Average Delay Between AODV and DSR in 25 Nodes

The packet end-to-end delay is the time of generation of a packet by the source to the destination. So this is the time that a packet takes to go across the network. And expressed in sec.

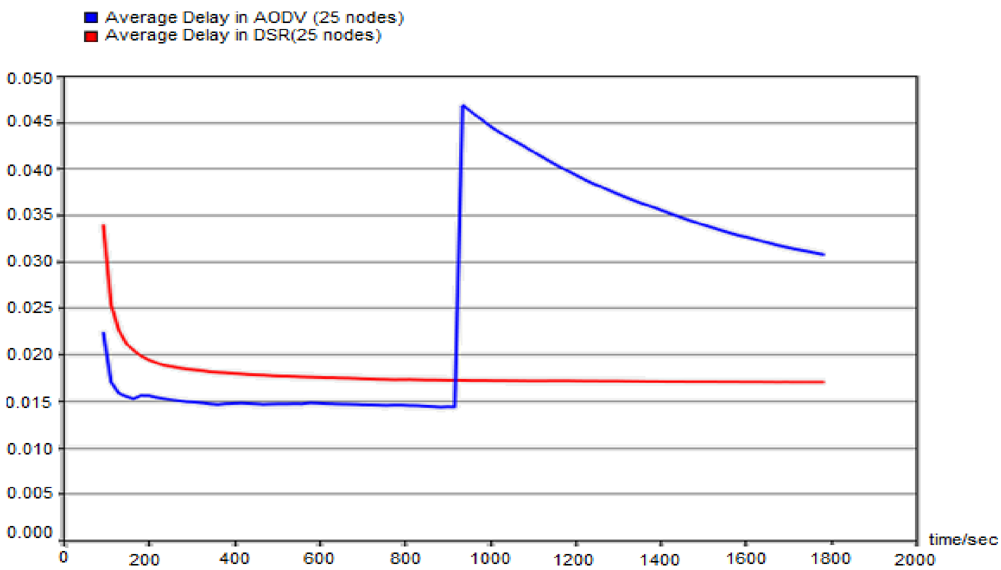

Figure 6-10 Average Delay to AODV and DSR in 25 Nodes

As shown in Figure 6-10, delay in ADOV is higher because it takes longer time to setup routes i.e. longer route discovery time as well as the packet drop rate is high and this of course results in higher route error rate. This is why in the above graph there is a prompt increase in delay. The same concept is reached for other scenarios of 50 & 75 nodes.

6.3.5 Routing Traffic Sent For 50 Nodes Scenario

As shown in Figure 6-11 traffic sent by AODV exceeds that is sent by DSR and increases as number of nodes increases.

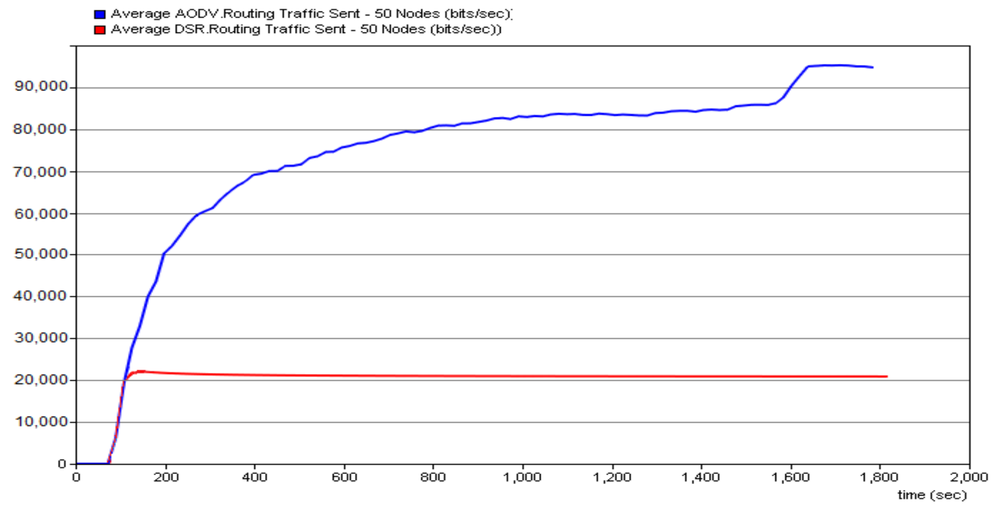

Figure 6-11 AODV and DSR traffic sent by 50 Nodes

6.3.6 Routing Traffic Received For 50 Nodes Scenario

Amount of traffic received by AODV much exceeds that is received by DSR and increases as number of nodes increases of as shown in Figure 6-12. And traffic received less than traffic sent.

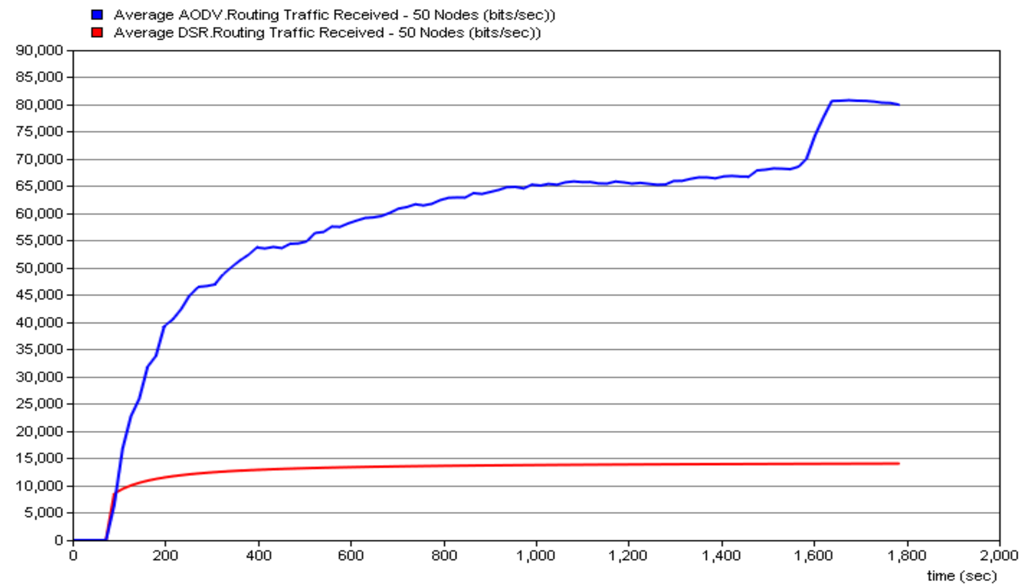

Figure 6-12 AODV and DSR traffic received by 50 Nodes

6.3.7 Packet Delivery Ratio to AODV & DSR for 50 nodes

Data delivery graph to AODV and DSR for 50 nodes is shown in Figure 6-13.
The percentage of data delivery in the event of increasing the number of nodes to 50 nodes is less than in the case of the number of nodes 25.

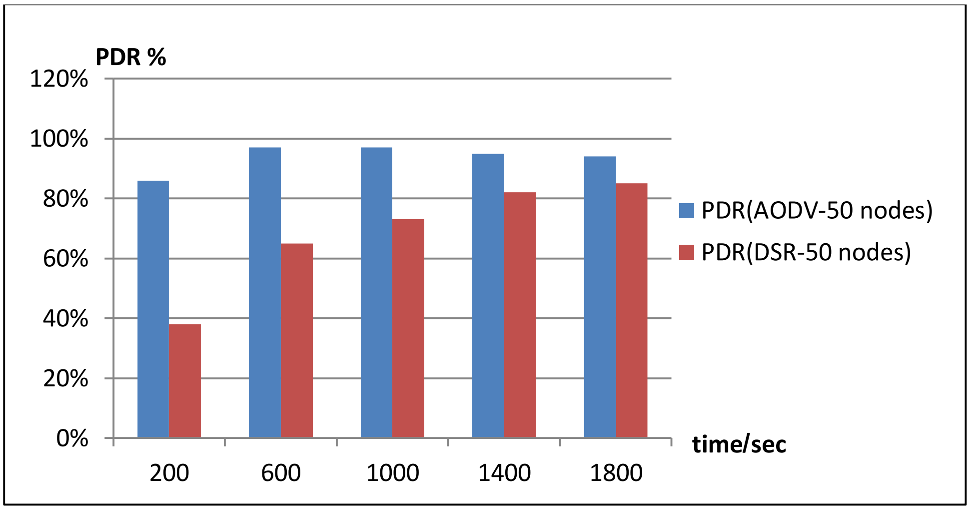

Figure 6-13 Comparasion of the Performance AODV and DSR (50 nodes)

6.3.8 Average Delay Between AODV and DSR with 50 Nodes

The delay increases, as shown in Figure 6-14, with increasing number of nodes, and we notice that DSR delay is less than AODV.

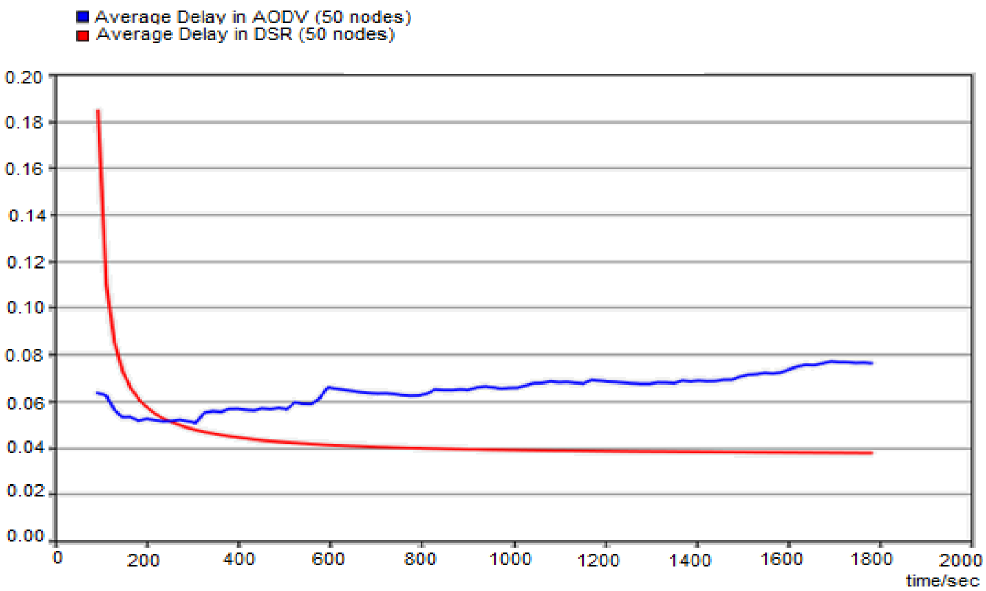

Figure 6-14 Average Delay AODV & DSR for 50 Nodes

6.3.9 Routing Traffic Sent For 75 Node Senario

The amount of traffic sent in the network increases as the number of nodes in the network increases, and it is clear that the amount of traffic sent with AODV is more than DSR. Figure 6-15 shown that.

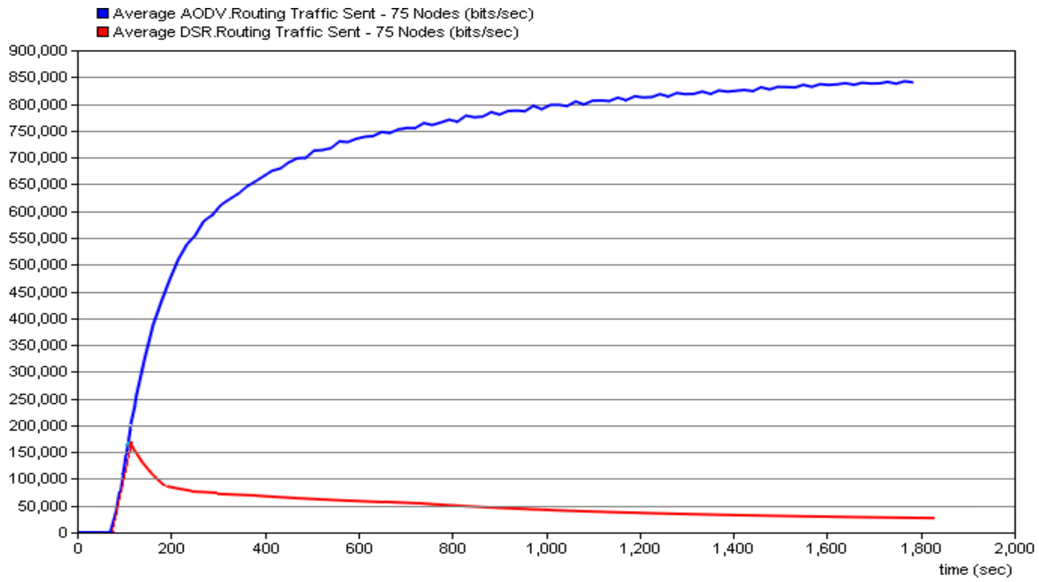

Figure 6-15 AODV and DSR Traffic Sent by 75 Nodes

6.3.10 Routing Traffic Received For 75 Node Senario

Amount of Traffic received by AODV exceeds that is received by DSR and increases as number of nodes increases, as shown in Figure 6-16.

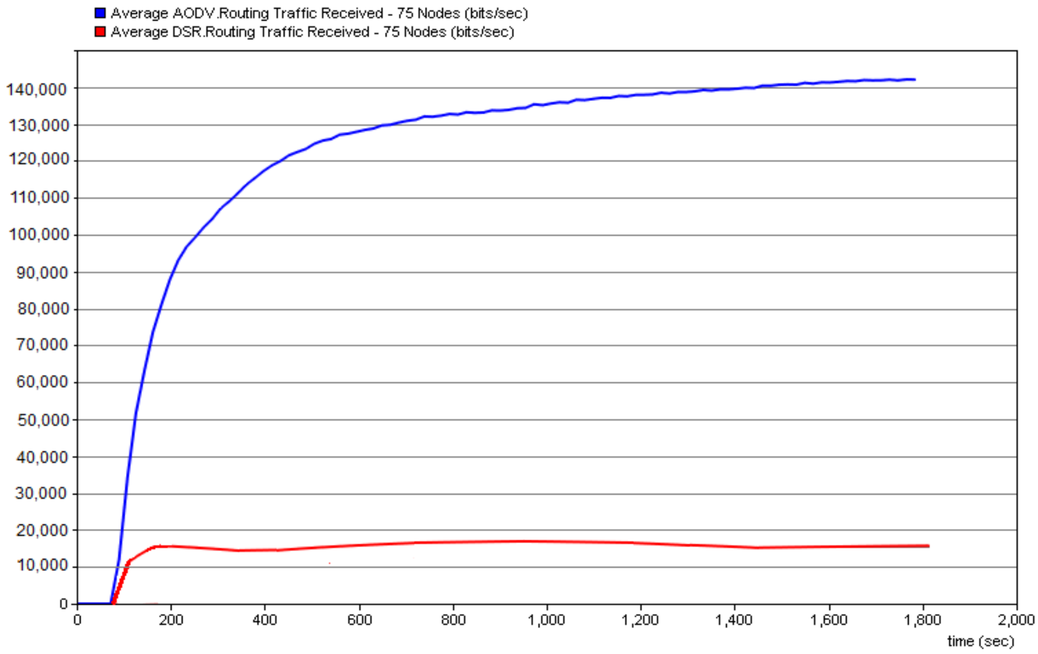

Figure 6-16 AODV and DSR Traffic Received by 75 Nodes

6.3.11 Packet Delivery Ratio to AODV & DSR for 75 Nodes

Data delivery graph to AODV and DSR for75 nodes is shown in Figure 6-17. Data delivery rate does not exceed 45% in AODV protocol. And about DSR protocol, it does not exceed 31%, this is due to the increase in the number of nodes in the network.

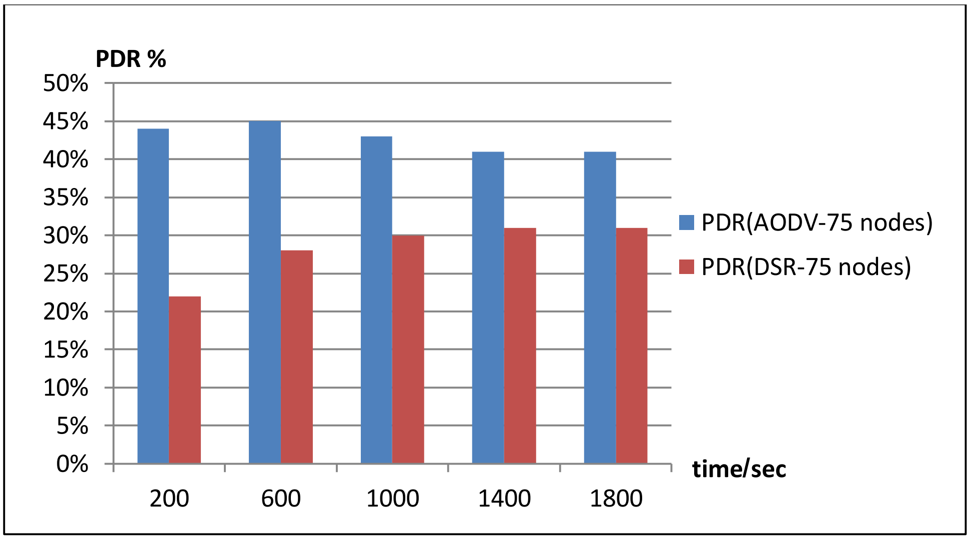

Figure 6-17 Comparison the Performance of AODV and DSR (75nodess)

6.3.12 Average Delay Between AODV and DSR with 75 nodes

In the Figure 6-18, as explained the delay will increase as the number of nodes increases. This means that AODV protocol cannot be implemented efficiently in MANETS with large number of nodes especially if this network uses sensitive traffic such as voice and video.

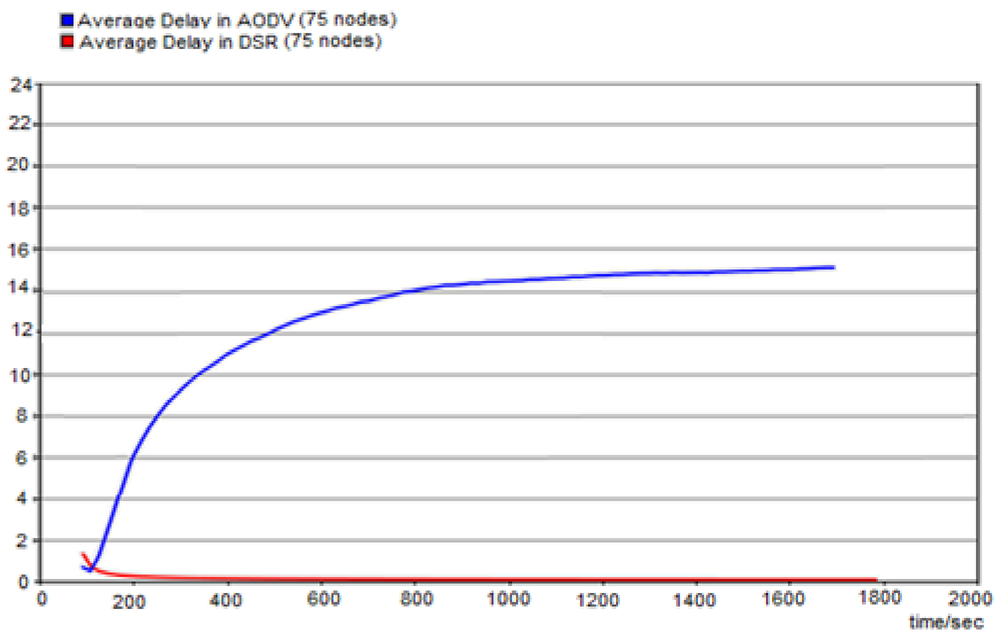

Figure 6-18 Average Delay(AODV and DSR) with 75 Nodes

6.3.13 Number Of Hops Between DSR and AODV

Figure 6.19 and 6.20 shown the DSR routing protocol produces from 1 to 1.3 hops per route. AODV fluctuates between 1.8 and 2.1. This is due to the method of DSR offering one main route and AODV offering multiple routes to the destination.

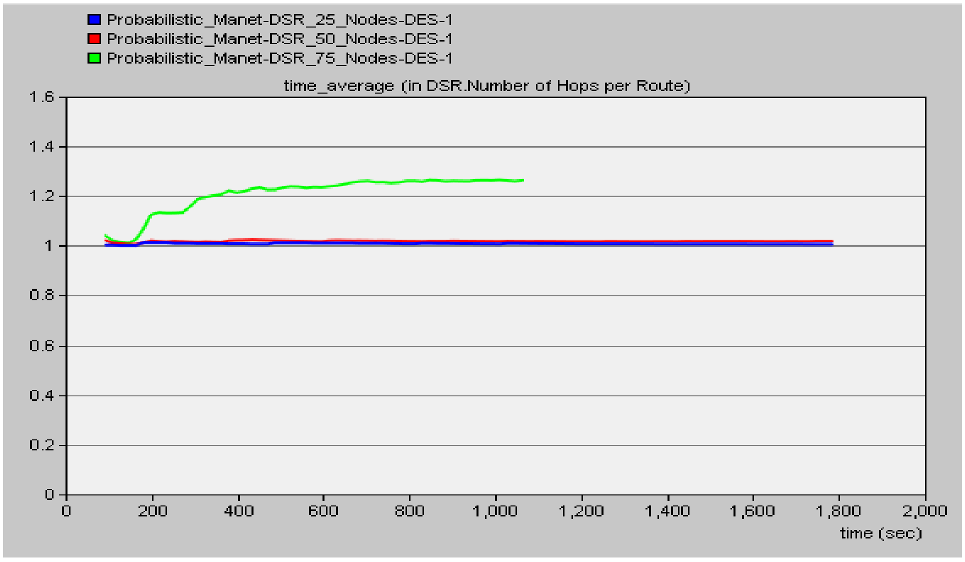

Figure 6-19 DSR Number of Hops

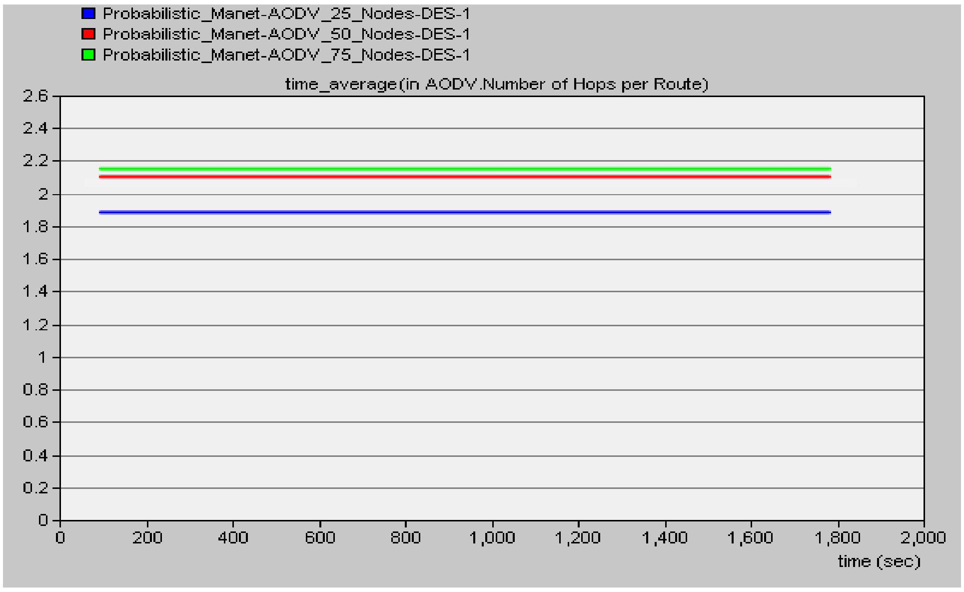

Figure 6-20 AODV Number of Hops

From the previous results and Figure 6-21 find that the number of hops with DSR less than AODV , and this reinforces the previous results to delay. Increasing the number of hops is associated with increasing delay.

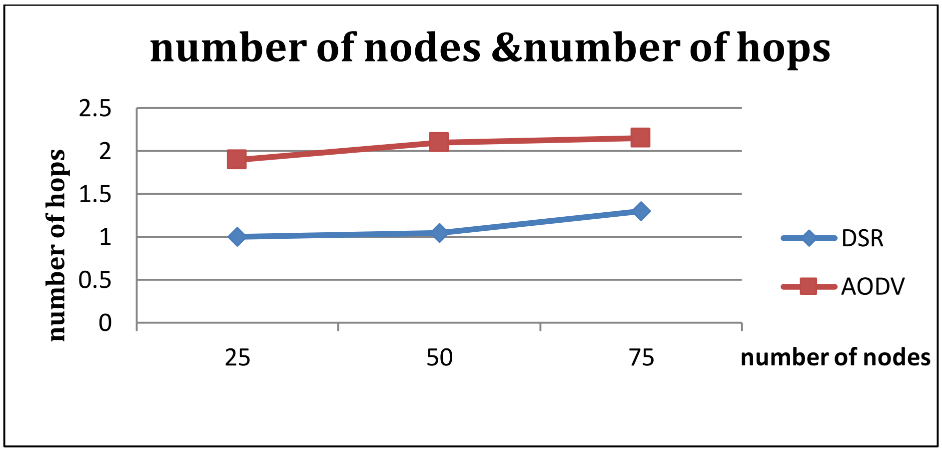

Figure 6-21 Number of Hops to AODV&DSR

6.4 DSR and AODV for Varying Loads

In these Scenarios both DSR and AODV has been investigated as the amount of traffic sent from MANET nodes increases (Traffic Loads). The traffic sent and received will increase from 10 KB to 50KB to 100 KB.

6.4.1 Traffic Sent Using DSR by 75 Nodes with Varying Load

The amount of traffic sent using DSR increases from 50k to 765k by increasing the load from 10 to 100 k(bits/sec) as shown in the Figure 6-22

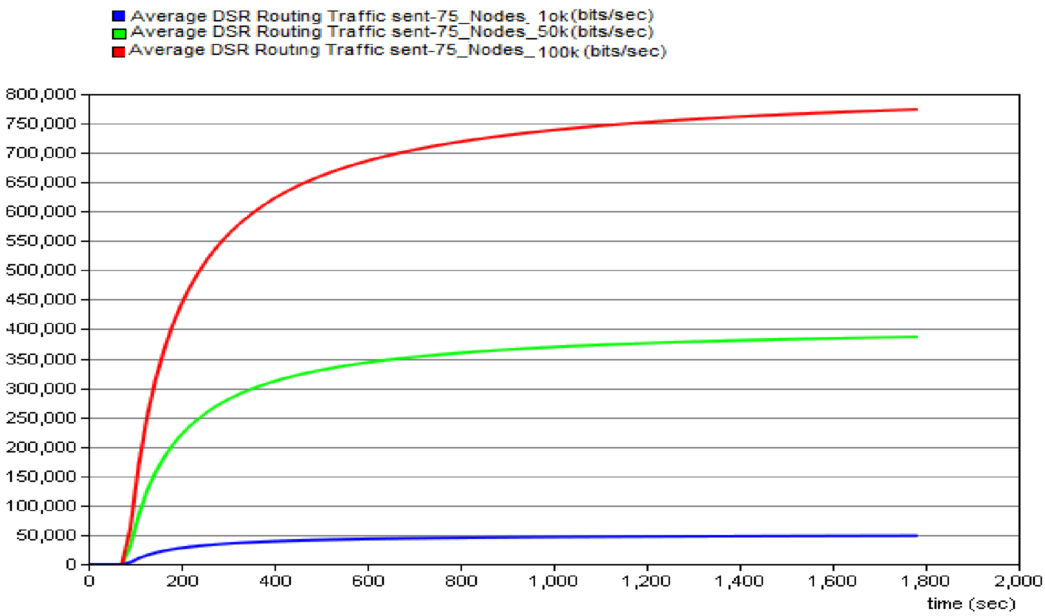

Figure 6-22 Traffic Sent Using DSR with Varying Loads

6.4.2 Traffic Reseived Using DSR and 75 Nodes With Varying Load

The amount of traffic reseived using DSR increases from 50k to 450k by increasing the load from 10 to 100 k(bits/sec) as shown in the Figure 6-23.

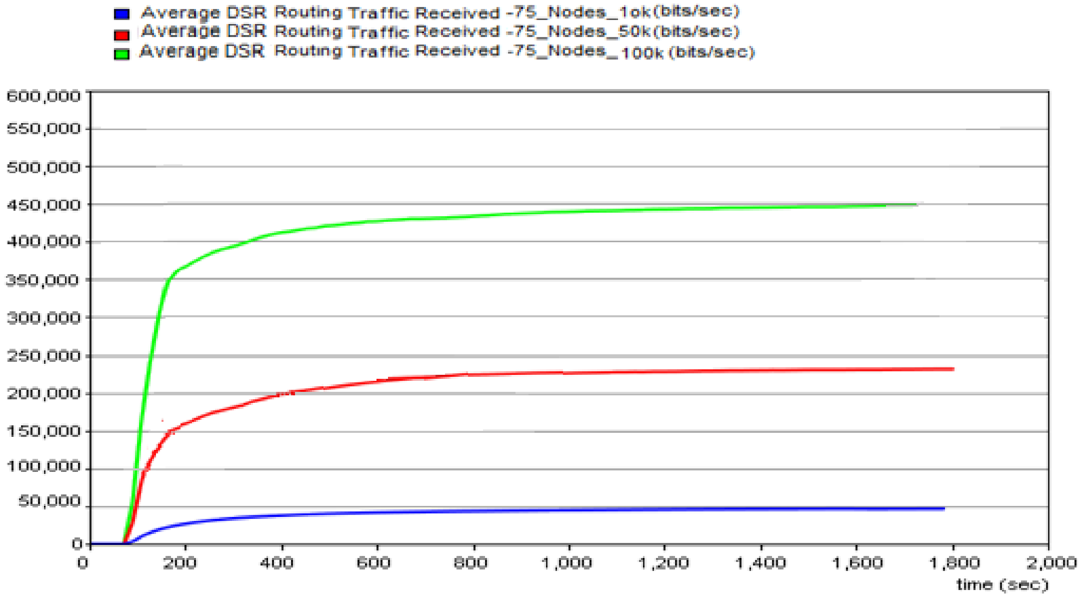

Figure 6-23 Traffic Received Using DSR with Varying Loades

6.4.3 Packet Delivery Ratio of DSR Nodes with Varying Load

Data delivery graph using DSR for 75 nodes with varying load, is shown in figure 6-24. In this figure, if the number of nodes at 75 nodes, using same DSR, but varying the loads from 10k, 50k, 100k bytes, this protocol performs around the same, if the number of bits fixed at load 10k, 50k or 100k, respectively.

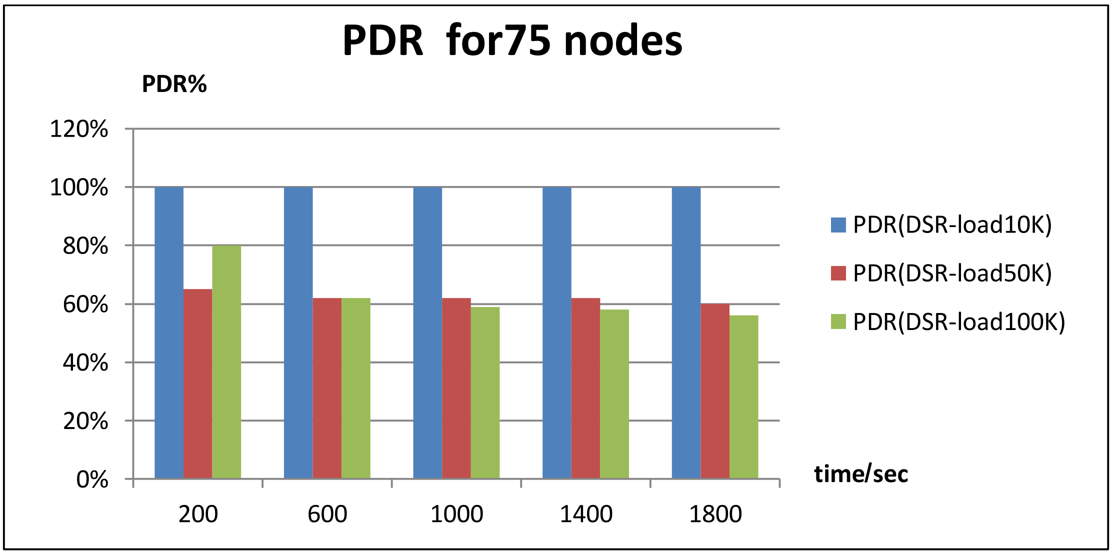

Figure 6-24 Data Delivery Ratio of DSR for Varying Load

6.4.4 Traffic Sent Using AODV by 75 Nodes with Varying Load

The amount of traffic sent with AODV increases by increasing the load from 10, 50 and 100 k (bits/sec) as shown in the Figure 6-25

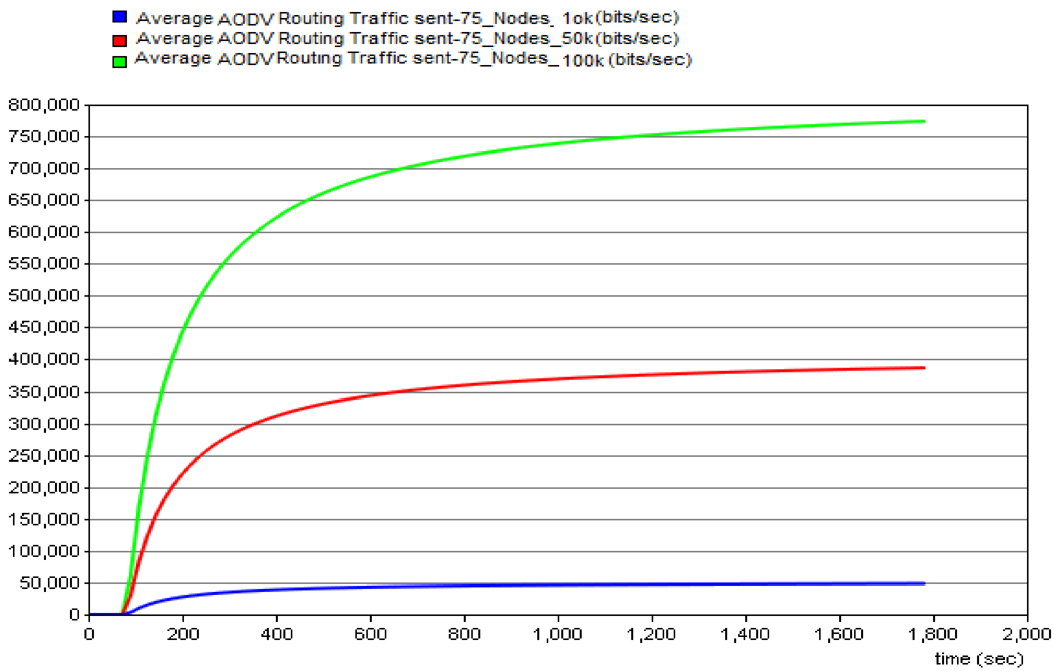

Figure 6-25 Traffic Sent Using AODV with Varying Load

6.4.5 Traffic Received Using AODV by 75 Nodes With Varying Load

The amount of traffic received in relation to changing the load in the network increases as the load increases as shown in Figure 6-26.

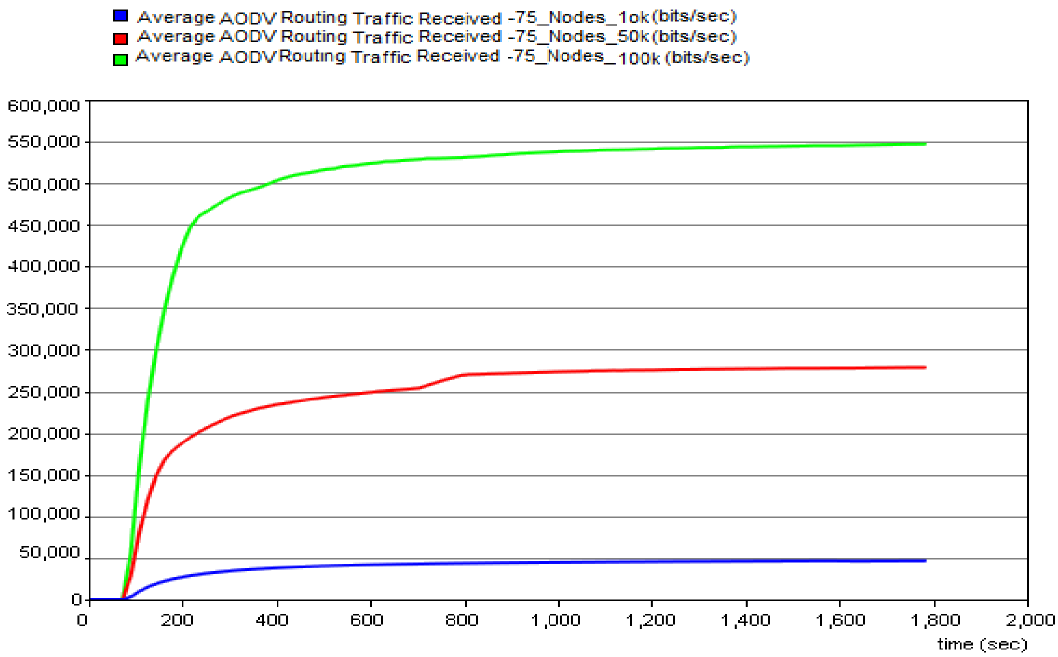

Figure 6-26 Traffic Received Using AODV with Varying Load

6.4.6 Packet Delivery Ratio to AODV with varying load

Data Delivery graph to AODV for75 nodes with varying load, is shown in Figure 6-27.

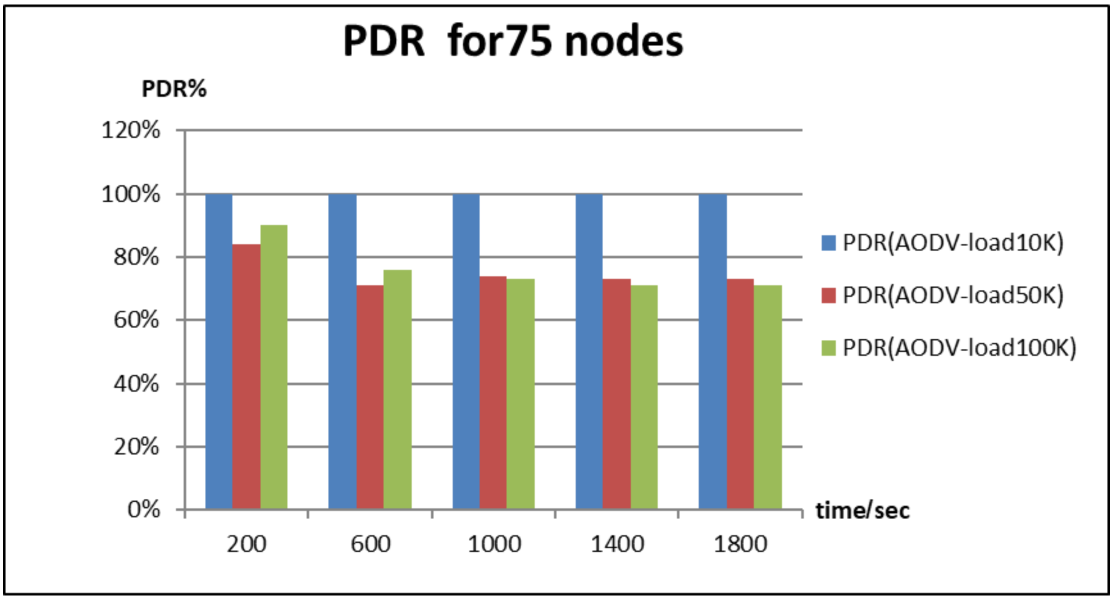

Figure 6-27 Data Delivery Ratio of AODV for Varying Load

Figure 6-27 shown the performance measure of AODV at different traffic loads, 10k, 50k and 100k bytes of loads. The efficiency of PDR% is around 80%, at fixed 75 nodes, the results shown the reliability of this protocol.

6.4.7 AODV and DSR Traffic Sent with Varying Load

The Figure 6-28 more illustrated the comparison between the two protocols when changing loads from (10, 50, 100 k bytes).

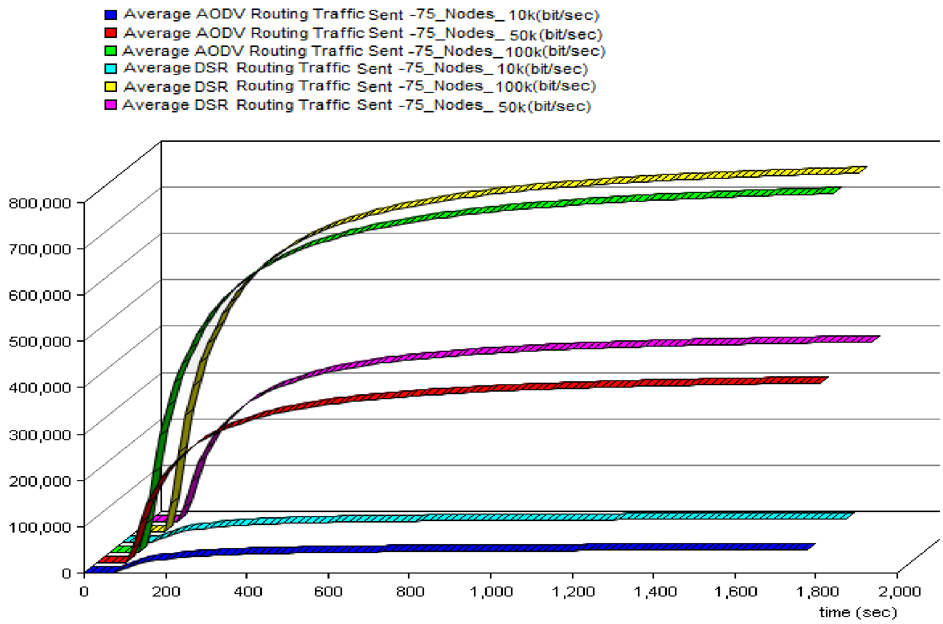

Figure 6-28 DSR and AODV Traffic Sent for Varying Load

6.4.8 AODV and DSR Traffic Received with Varying Load

As shown in Figure 6-29 the comparison between traffic received about AODV and DSR protocols when changing loads from (10, 50, 100 k bytes).

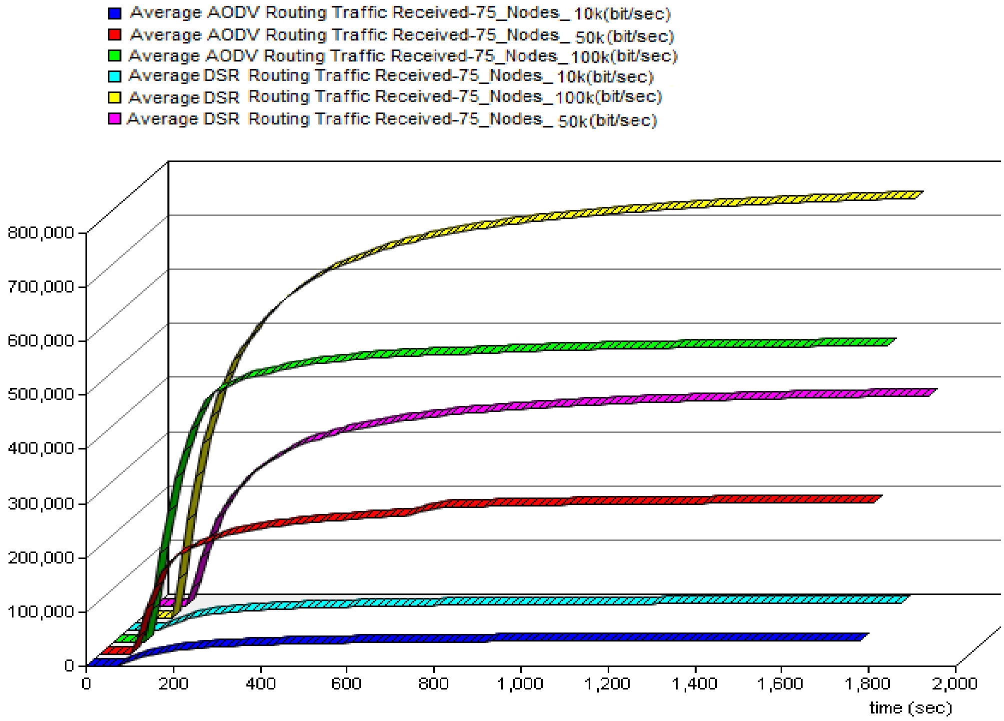

Figure 6-29 DSR and AODV Traffic Received for Varying Load

6.4.9 Average Delay AODV and DSR with 75 Nodes -10k Load

Figure 6-30 shown the delay about two protocols when changing the load.

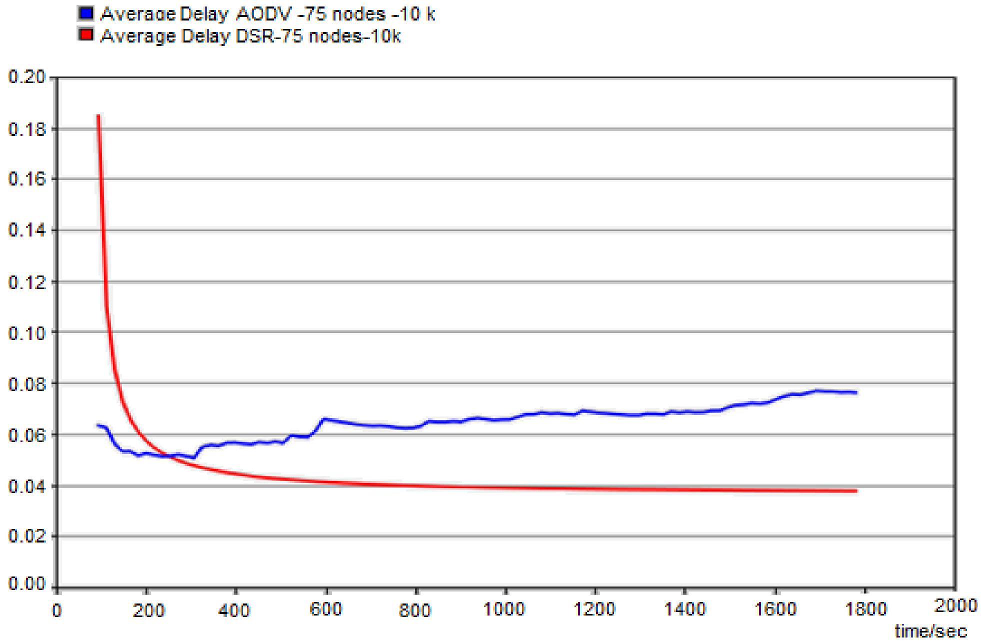

Figure 6-30 AVerage Delay AODV and DSR with 10 k Load

6.4.10 Average Delay AODV and DSR with 75 Nodes -50k Load

The delay in the following figure 6-31 increases as the load on the network increases.

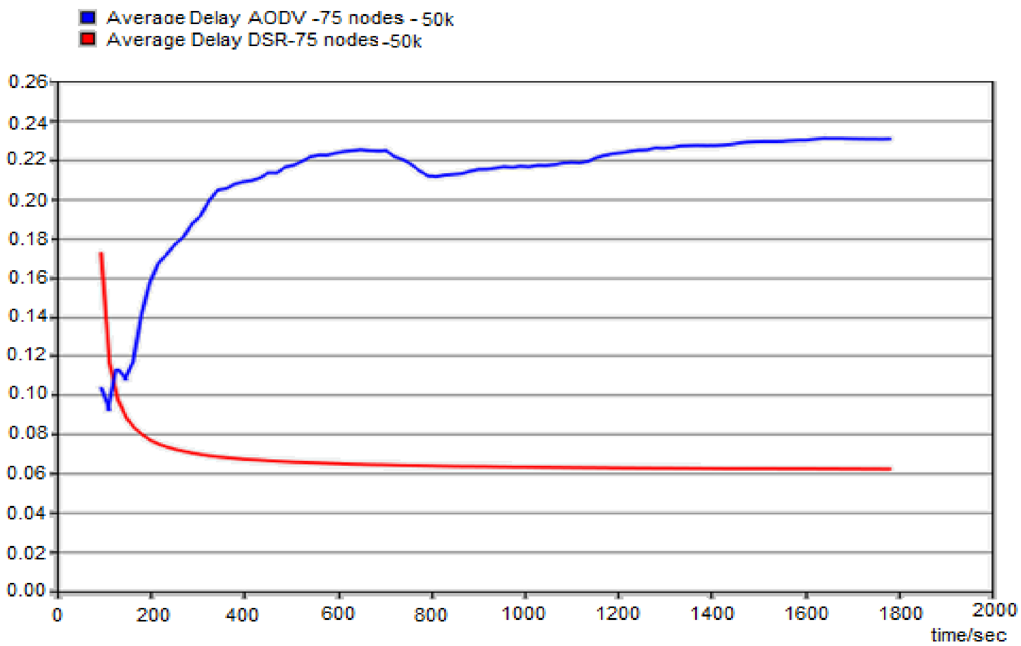

Figure 6-31 Average Delay AODV and DSR with 50k Load

6.4.11 Average Delay AODV and DSR with 75 Nodes -100k Load

The delay in the following figure 6-32 increases as the load on the network increases. Note that it is less in DSR protocol than AODV protocol.

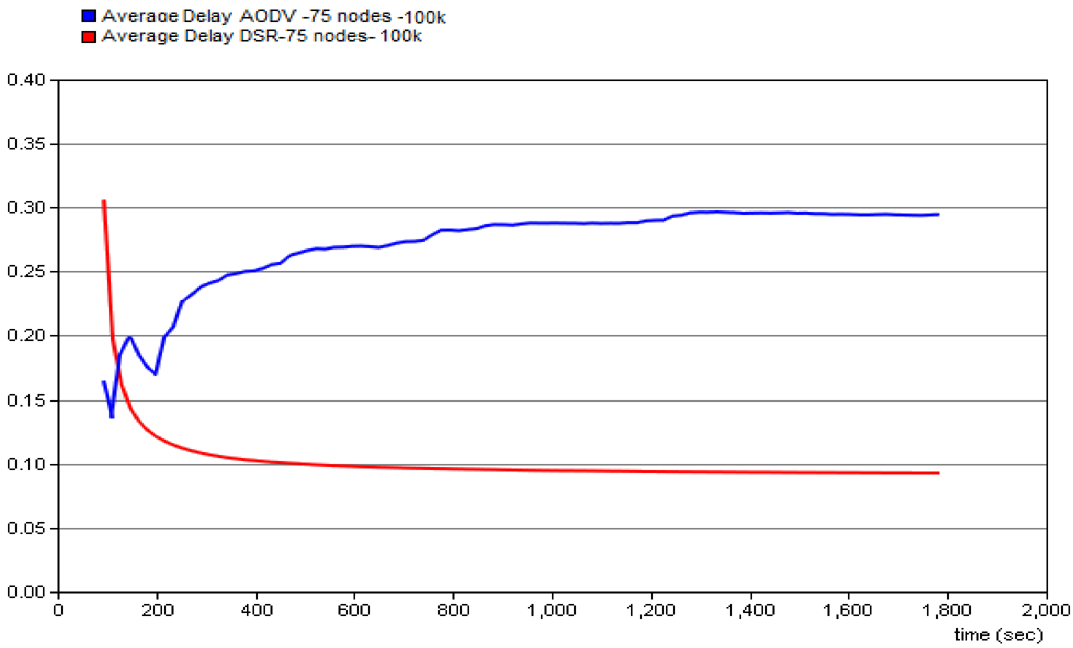

Figure 6-32 Average Delay AODV and DSR with 100k Load

The delay increases with the load and this is normal since it takes longer time to setup the routs to destination and as it can be seen from the above Figures 6-30, 6-31 and 6-32, due to the same reasoning that was explained previously the DSR has lower overall delay.

6.5 AODV and DSR vs Different Speeds

As nodes faster, their position changes and more routing is required to reach destination.

6.5.1 Traffic Sent Using DSR with Different Speed (1, 5 and10mps)

Traffic Sent using DSR for 75 nodes sending 1 KB of Traffic for nodes moving with different speeds (1 mps, 5 mps and 10 mps).
The amount of traffic sent is the same for the different speeds as shown in Figure 6-33.

6.5.2 Traffic Received Using DSR with Different Speed (1, 5 and10mps)

Traffic Received using DSR for 75 nodes sending 1 KB of Traffic for nodes moving with different speeds (1 mps, 5 mps and 10 mps).
The amount of traffic Received is the same for the different speeds as shown in Figure 6-33.

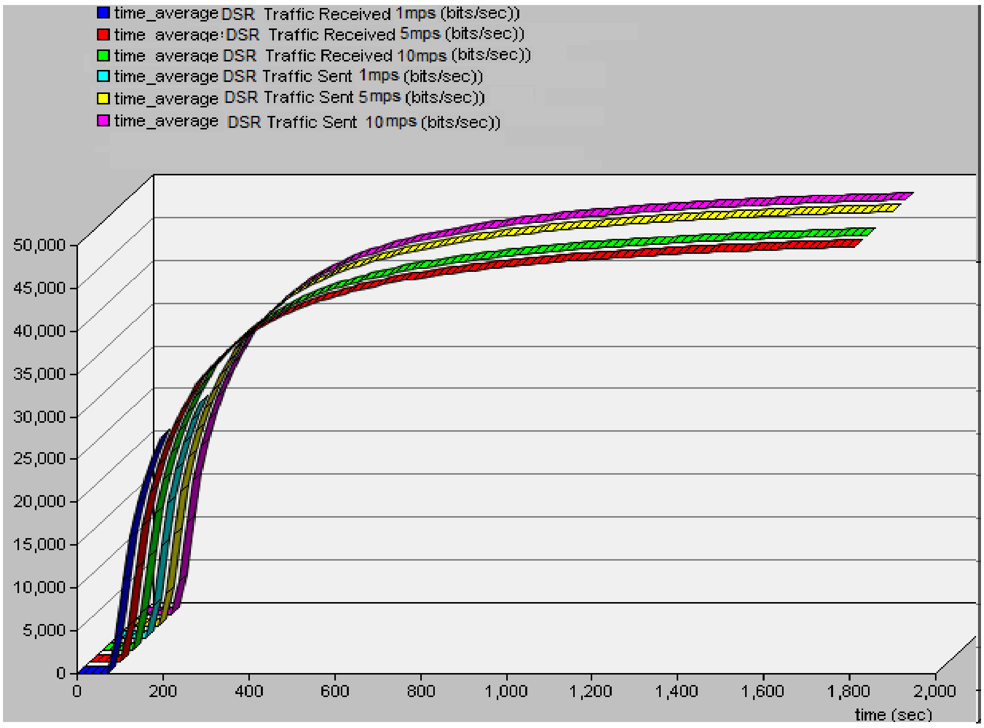

Figure 6-33 DSR Traffic Sent and Received vs Different Speed

6.5.3 Packet Delivery Ratio Using DSR with Different Speed

Data delivery graph to DSR for 75 nodes with sending 1 KB of Traffic for nodes moving with different speeds (1 mps, 5 mps and 10 mps), is shown in Figure 6-34.

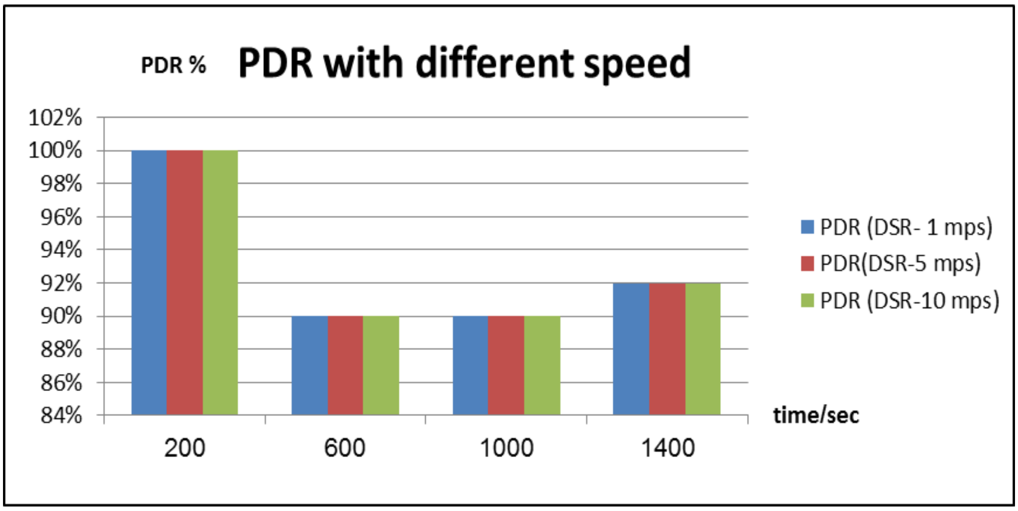

Figure 6-34 Performance of DSR at Different Speed

6.5.4 Traffic Sent Using AODV with Different Speed (1,5 and 10 mps)

Traffic Sent using, AODV for 75 nodes sending 1 KB of Traffic, for nodes moving with different speeds (1 mps, 5 mps and 10 mps).
The amount of traffic sent is the same for the different speeds as shown in Figure 6-35.

6.5.5 Traffic Received Using AODV with Different Speed (1,5 and 10 mps)

Traffic Received using, AODV protocol for 75 nodes sending 1 KB of Traffic, for nodes moving with different speeds (1 mps, 5 mps and 10 mps).
The amount of traffic Received is the same for the different speeds as shown in Figure 6-35.

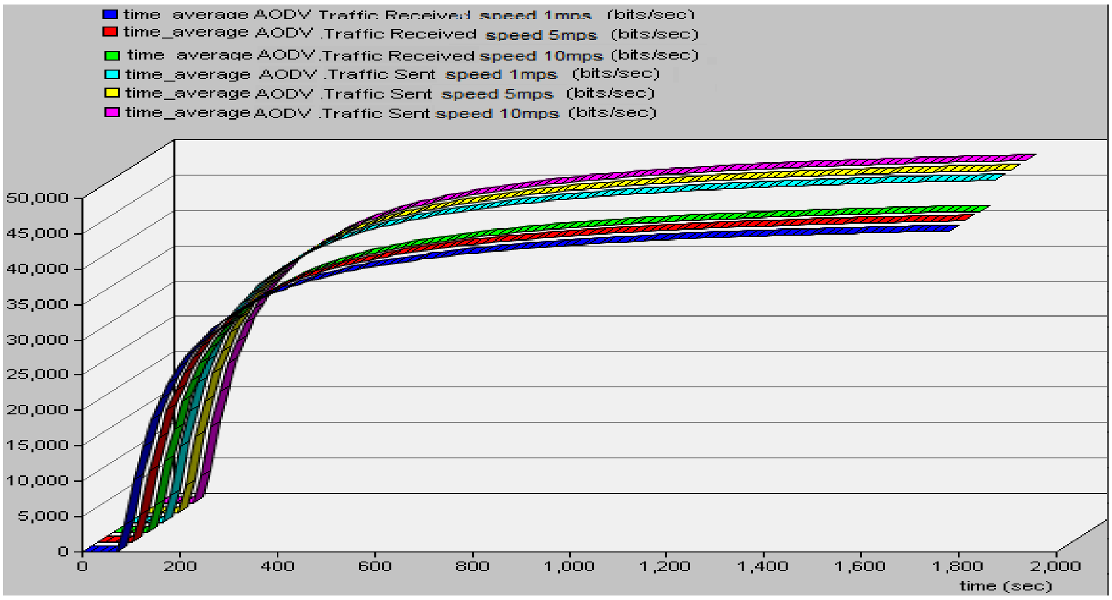

Figure 6-35 AODV Traffic Sent And Received vs Different Speed

6.5.6 Packet Delivery Ratio of AODV at Different Speed

Data Delivery graph to AODV for75 nodes with sending 1 KB of Traffic for nodes moving with different speeds (1 mps, 5 mps and 10 mps), is shown in Figure 6-36 .

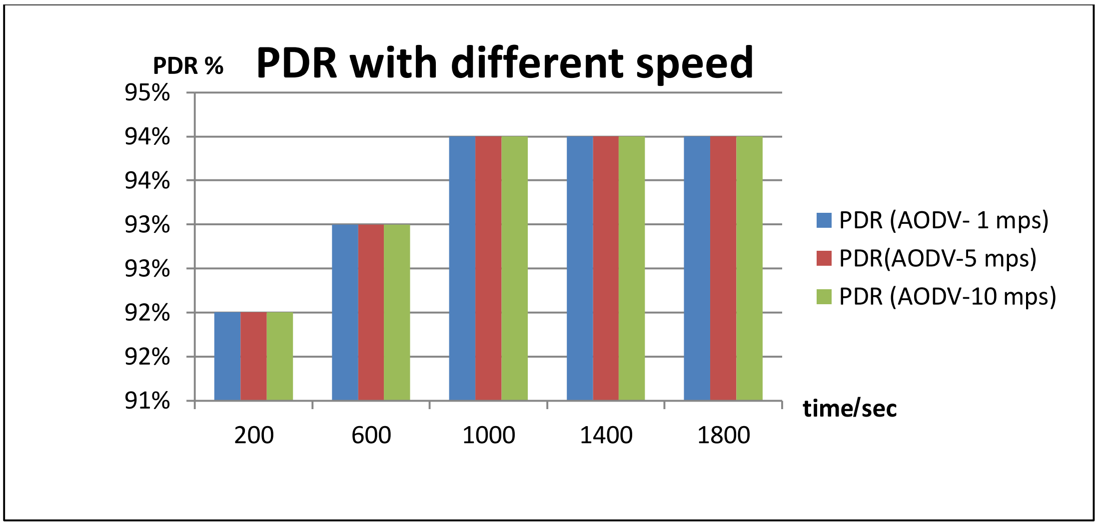

Figure 6-36 Performance of AODV at Different Speed

6.6 Discussion

These results as can be seen in Figure 6-1, and Figure 6-2, for DSR routing protocol, at different size of data and different number of nodes, for sent and received data scenario. However Figure 6-3 show the data delivery in percentages for DSR protocol in which, the good and degradation of performance was occurred, due to the size of nodes used. However from this Figure, if the number of nodes equals 25 nodes, the ratio of data delivery was reached to 89%, but if the number of nodes are increased to 75 nodes, the pdr will be 30%. This situation indicate that DSR protocol performs well at smaller network scenarios.

On the other hand, another investigations carried out if AODV, routing protocol to be applied. Figures 6-4 and 6-5 shows the data sent and received, respectively, for AODV protocol, with different modes.

The performance criteria, by using pdr in percentages shows as in Figure 6-6, the superiority of AODV performance, as the number of nodes increased. As can be seen, if at number of nodes were 25 nodes the pdr was 100%, but at 75 nodes used, the pdr was 40%. This shows the capability of AODV protocol over DSR.

Figure 6-9, show direct comparison between DSR and AODV protocols, in terms of pdr, from this figure, a declaration of the superiority of AODV over DSR, was evident from the results, at the number of nodes were 25.

Figure 6-10 shows the effect of average delay on DSR and AODV, from which, the average delay for AODV seemed to be higher in it is values, and this due to longer route discovery time, and packet drop rate is higher than the DSR protocol.

Figure 6-11 and 6-12 illustrates a direct comparison between AODV and DSR, for sent and received data, at 50 nodes, from which more traffic received at AODV.

Figure 6-13 illustrates, the pdr for both protocols AODV and DSR, where AODV's pdr is much higher than DSR, for data delivery is concerned.

The average delay is shown in Figure 6-14 for both AODV and DSR at 50 nodes.

Figure 6-15 and 6-16 illustrate the sent and received data for 75 nodes, for both AODV and DSR protocols.

Figure 6-17 the data delivery ratio for both AODV, and DSR, at 75 nodes, from which the pdr for AODV is much better than DSR.
Figure 6-18, shows the average delay for AODV and DSR, and this delay was higher for AODV, if we increase, the number of nodes to 75 node, this will have same impact on data.
Figure 6-19 and 6-20 shows, the number of hops for AODV and DSR, where the number of hops are less for DSR than the AODV.
Figure 6-21 shows, the relationship between the number of nodes and the number of hops, from which, the AODV, will have higher number of hops, if number of nodes increased.
The traffic loads, were increased from 10kb, 50kb, and 100kb, sequentially for DSR at 75 nodes. The throughput as indicated in Figure 6-22, will decrease as the traffic load increase.
Figure 6-23 illustrate the effect of increasing traffic load from 10kb, 50kb, to 100kb, on throughput the higher traffic load, the lower throughput, at 75 nodes, for the DSR protocol.
Figure 6-24, shows different capability of DSR, if the traffic loads were from 10, 50, 100kb, respectively. The DSR capability in using pdr, quize noticeable at 10kb load, but if traffic load increased from 50 to 100kb, the performance, in terms of pdr are almost slightly the same effect.
Figure 6-25 and 6-26, illustrate the throughput for AODV protocols, at different loads, this protocol performs well at different loads and same number of nodes (75).
Figure 6-27 shows, the data delivery pdr, for AODV, with same number of nodes (75) and different traffic loads. High percentage of pdr at 10kb load, but same pdr for 50, and 100kb.
Figure 6-28 and 6-29, show the throughput at different traffic loads, and same number of nodes (75), for AODV and DSR.
Figure 6-30, shows the average delay for AODV and DSR protocols. The average delay for both protocols at 75 nodes, at 50kb and 100kb, respectively, as depicted from Figures 6-31 and 6-32. They show the slight effect of delay.
Figure 6-33 shows the sent and received data throughput of DSR at different speeds. The data delivery (pdr), was shown at Figure 6-34, for same number of nodes (75), at different speeds, for DSR protocol. High pdr at 10mps, but lower pdr at 5mps and 10mps.
Figure 6-35 shows the throughput of both protocols, at different speeds. The pdr or data delivery, shown in Figure 6-36 for AODV, at different speeds, shown high performance for same protocol.

Chapter Seven

Conclusion and Future Work

Chapter Seven

7 Conclusion and Future Work

7.1 Summary of Concluding Remarks

In this research topic, a method endevours with a unique metric has been undertaken. This metric was the data delivery ratio has been applied to two major, on demand driven reactive protocols, to seek performance, classification (speed, load, number of nodes, etc), and application domain. In order to follow, these establishments, two routing protocols namely, AODV and DSR have been selected, to carryout the simulations and investigations, and variety of pilot results have been obtained.

In the early stage of this work, a through study has been under taken. Therefore, a direct comparison has been made, in terms of their performance measures. Simulation results show that the AODV protocol performs better than DSR protocol, in terms of load, speed, throughput and data delivery.

However the average delay has been evaluated, at both protocols under study, small amount of delay has been obtained for both protocols, as indicated in Figures.

The current results showed a promising findings, in terms of throughput, for both protocols, with superiority of AODV over DSR, and other metric measurements.

7.2 The Main Contributions

The thesis presented a unique metric, investigations, classifications, and applications of two protocols(AODV&DSR). Henceforth, the major contributions can be catogrised in to the following;

1. The performance evaluaions, for routing protocols.
2. Improving the performance of the AODV and DSR, in terms of data delivery metric.
3. Evaluations and analysis of the results, in order to classify and apply the two protocols.
4. Scenario documentations of the two protocols.
5. The applications domain, and the cost effectiveness.

7.3 The Findings of The Current Work

The work criteria, of these investigations, can represent the following findings;

1. The AODV protocol has higher metric evaluations, in terms of performance, classification and application domain.
2. The average delay of both protocols has slight change, this might, but it has not yet been proven, to have a direct effect on audio, image, data.
3. Data delivery metric measurement, will find it is way to performance criteria.
4. The results analysis showed that, another measurable quantities, like reliability, durability, and cost effectiveness, will be a hand held tools to improve data, towards proper knowledge decision making strategies.

7.4 Future Work

Ad hoc networking is a hot topic in the research community. And there are many areas that needs to be explored further such as:

1- In this thesis, a comparison of two routing protocols, AODV and DSR, has been carried out. It is proposed to compare all other routing protocols considering the same simulation parameters so that an exhaustive comparison of various routing protocols can be made.
2- Data Delivery for arbitrary data can be documented for performance, from other table driven proactive protocols (ph.D, proposed!).
3- Mobile IP nodes, and data delivery can be investigated, in terms of home agent foreign care of address, network edge data delivery for ad hoc and access point infrastructure networks (ph.D, proposals.
4- More research in the field of probabilistic route maintenance is required.

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Appendix (I)

I.1 Simulation Setup

The main method of evaluating the performance of MANETs is simulation of AODV and DSR routing protocol. The simulation is done in OPNET 14.5. The network is taken as 1000X1000 square meters. The performance is recorded taking different

number of nodes, loads and varying speed. The nodes are placed randomly in the network.

The parameters that will be considered in this study are packet delivery ratio, end-to-end delay, number of hop. The network topology that was used to setup the scenarios consists mobile nodes and base station,. Each scenario will have number of parameters set for the base station. In total 18 scenarios were set up that used varying capacity, loads and mobility.

Methodology of this study is:

- Create a MANET cell network with different capacities.
- Deploy MANET Traffic to be transferred between nodes with different loads.
- Examine the performance of ad-hoc Routing protocols in static conditions.
- Configure MANET nodes to move with different speeds.

I.2 Standard Scenarios

Following is a description of the 18 scenarios that have been implemented for this study:

Scenario 1

This scenario is setup for a 25 nodes that are randomly distributed using DSR protocol in order to test the performance of the setup MANET under this protocol in terms of end to end delay, packet delivery ratio. The setup parameters for this scenario are shown in Figure I-1.

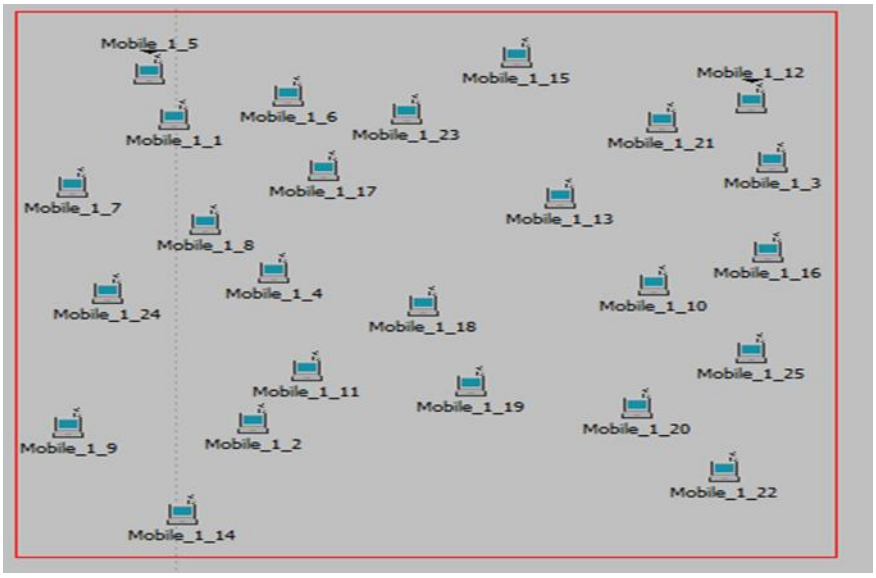

Figure I- 1 MANET 25 Nodes Topology

Then the ad-hoc routing protocol parameters are defined and configure the ad-hoc routing protocol to be DSR. In the MANET traffic generation parameters, add a row to specify the traffic transmitted between nodes, with packet size 1kB, and put the destination IP random, as shown in Figure I-2.

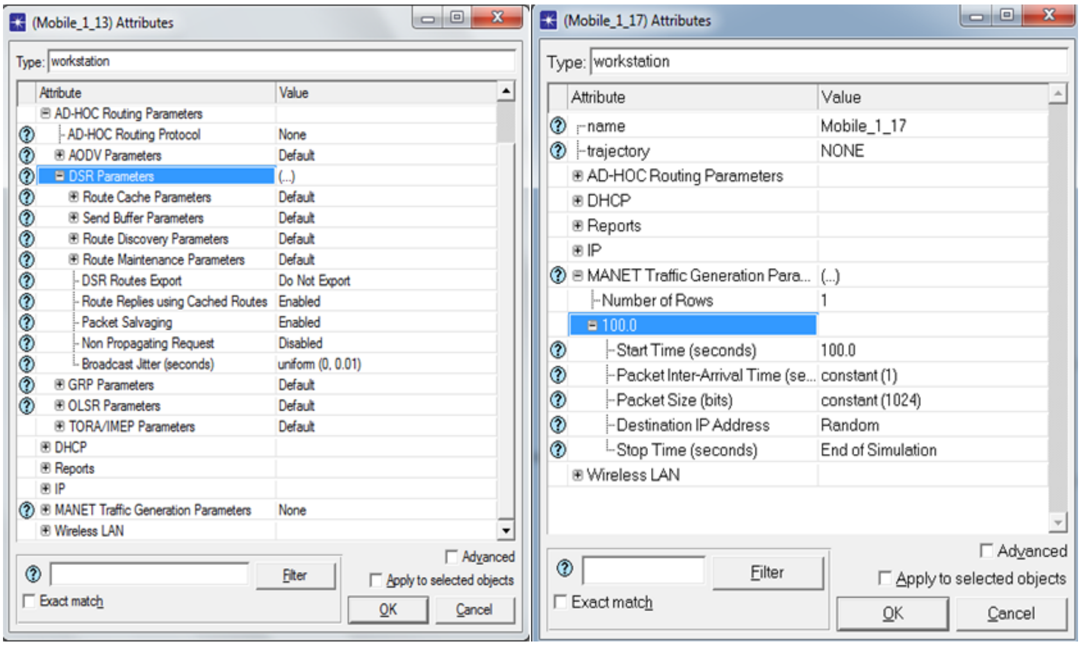

Figure I- 2 MANET Traffic Generation

Scenario 2

In this scenario the same steps are repeated as in scenario 1 with an increase in the number of nodes to 50 nodes that are randomly distributed using DSR protocol with no mobility in order to test the performance of the setup MANET under this protocol in terms of end to end delay, packet delivery ratio. The setup parameters for this scenario are shown in Figure I-3.

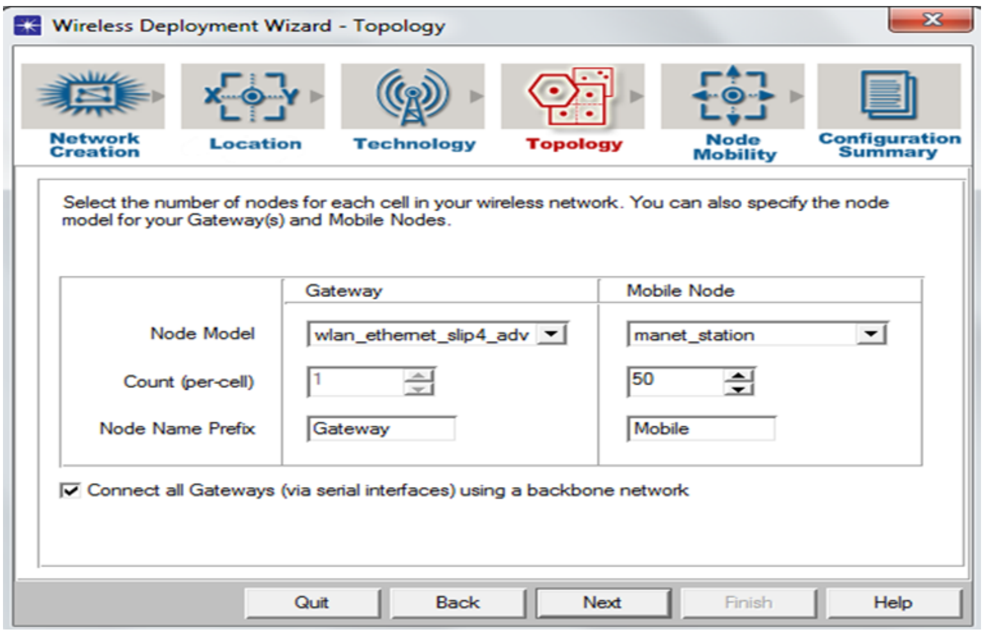

Figure I- 3 MANET 50 Nodes Topology Configuration

The Topology now appears like as Figure I-4.

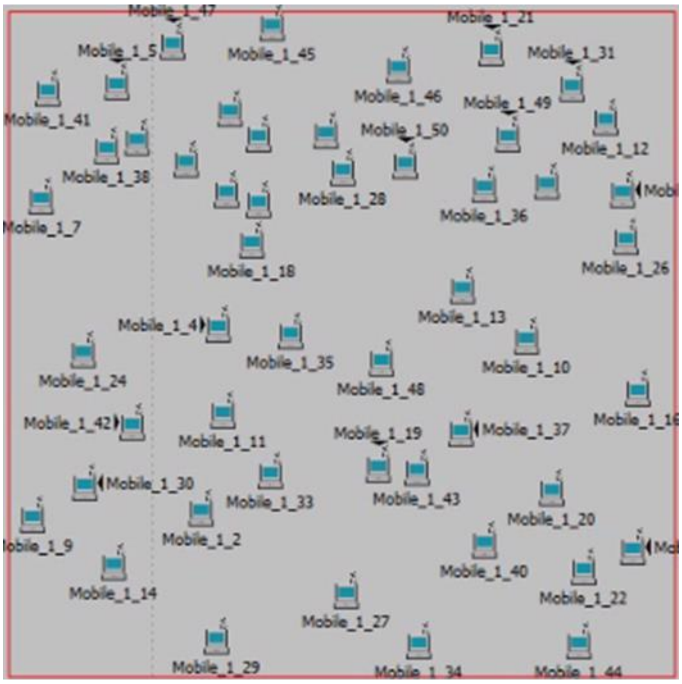

Figure I- 4 MANET 50 Nodes Topology

Scenario 3

In this scenario the same steps were repeated as the case for scenarios 1 and 2 with a change in the number of nodes to 75 nodes that are randomly distributed using DSR protocol with no mobility in order to test the performance of the setup MANET under this protocol in terms of end to end delay, packet delivery ratio. The setup parameters for this scenario are shown in Figure I-5. The scenario was run for 1800 seconds.

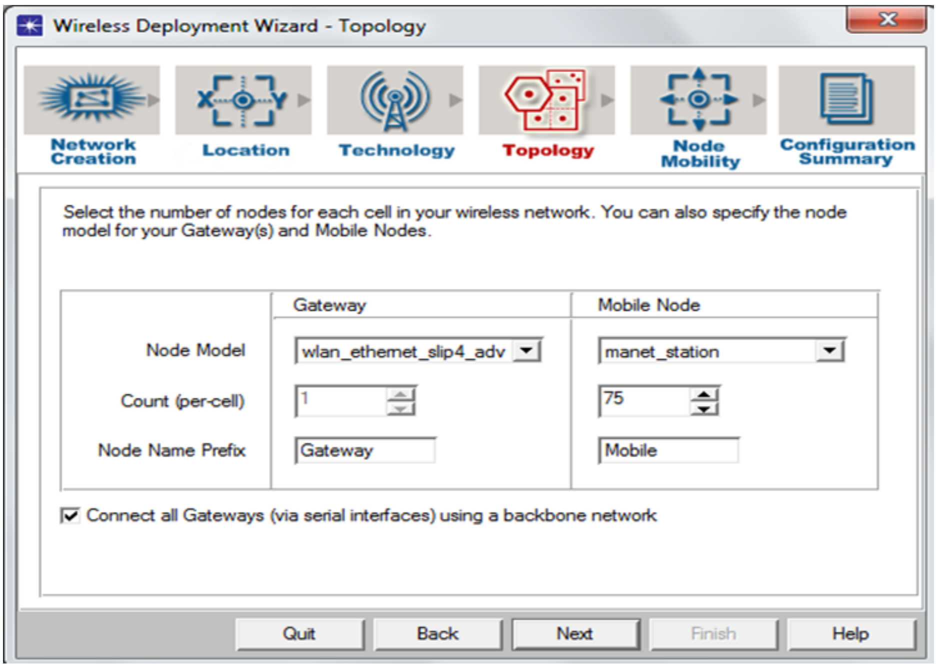

Figure I- 5 MANET 75 Nodes Topology Configuration

The Topology now appears like as Figure I-6 .

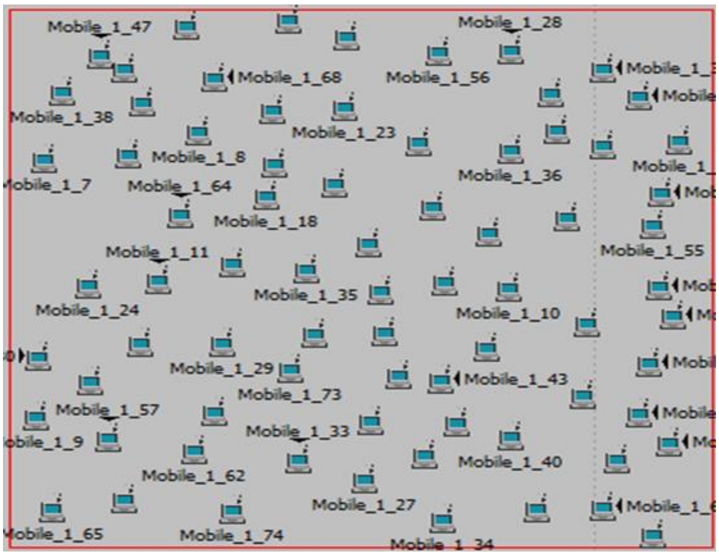

Figure I- 6 MANET 75 Nodes Topology

Scenario 4

This scenario is setup for a 25 nodes that are randomly distributed using AODV protocol with no mobility in order to test the performance of the setup MANET under this protocol in terms of end to end delay, packet delivery ratio. The setup parameters for this scenario are shown in Figure I-7.

Attribute	Value
name	Mobile_1_13
trajectory	NONE
AD-HOC Routing Parameters	
AD-HOC Routing Protocol	None
AODV Parameters	(...)
Route Discovery Parameters	(...)
Active Route Timeout (seconds)	3
Hello Interval (seconds)	uniform (1, 1.1)
Allowed Hello Loss	2
Net Diameter	35
Node Traversal Time (seconds)	0.04
Route Error Rate Limit (pkts/sec)	10
Timeout Buffer	2
TTL Parameters	(...)
Packet Queue Size (packets)	Infinity
Local Repair	Enabled
Addressing Mode	IPv4
DSR Parameters	(...)
GRP Parameters	Default
OLSR Parameters	Default
TORA/IMEP Parameters	Default
DHCP	
Reports	
IP	
MANET Traffic Generation Parameters	(...)
Number of Rows	1
100.0	
Start Time (seconds)	100.0
Packet Inter-Arrival Time (seconds)	exponential (1)
Packet Size (bits)	constant (1024)
Destination IP Address	Random
Stop Time (seconds)	End of Simulation
Wireless LAN	

Figure I- 7 AODV Protocol Parameters Configuration

Scenario 5

This scenario is the same as scenario 4, except the number of nodes was increased to 50 nodes that are randomly distributed using AODV protocol with no mobility in order to test the performance of the setup MANET under this protocol in terms of end to end delay, packet delivery ratio.

Scenario 6

This scenario is the same as scenarios 4 and 5, except that the number of nodes was increased to 75 nodes that are randomly distributed using AODV protocol with no mobility in order to test the performance of the setup MANET under this protocol in terms of end to end delay, packet delivery ratio.

Scenario 7

In this scenario, the number of nodes is set to 75 nodes that are randomly distributed using DSR protocol with no mobility with a traffic load of 10kb (10240 bits) in order to test the performance of the setup MANET under this protocol in terms of end to end delay, packet delivery ratio. The setup parameters for this scenario are shown in Figure I-8.

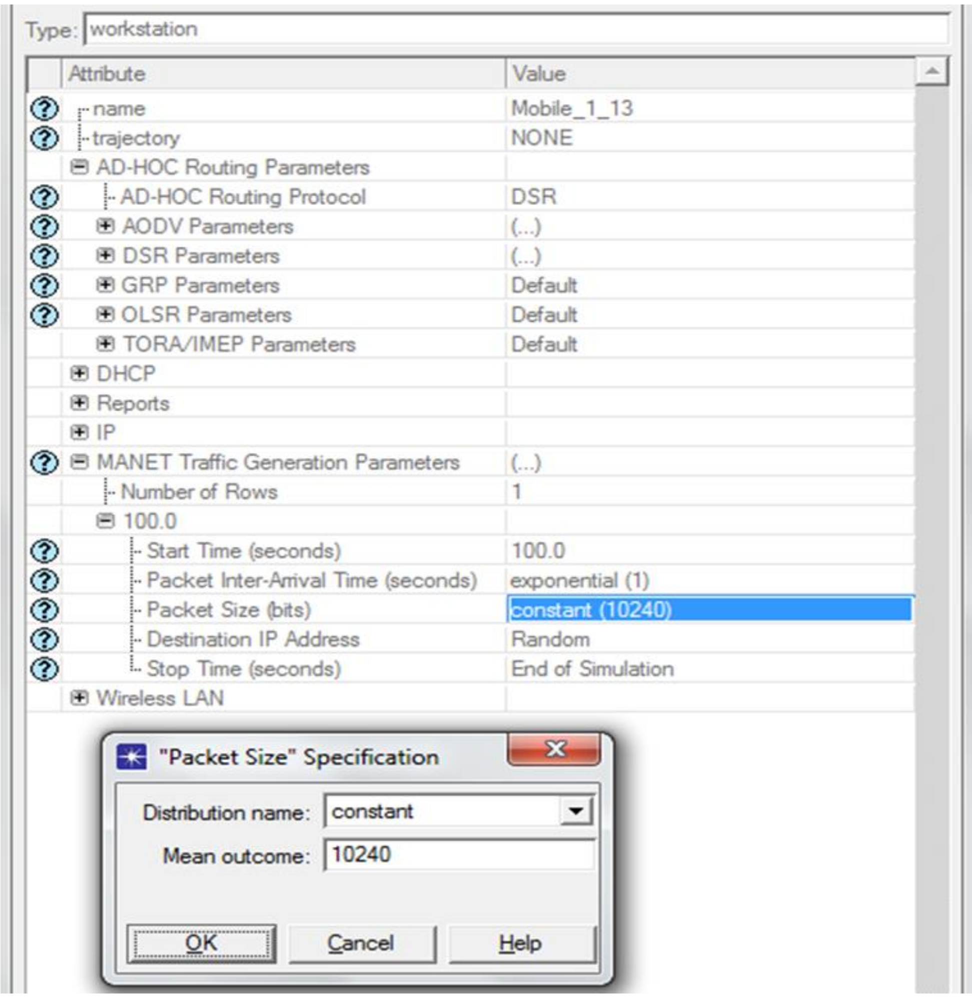

Figure I- 8 (10kb) Load Setup DSR Protocol

Scenario 8

This scenario is setup for a 75 nodes that are randomly distributed using DSR protocol with no mobility with a traffic load to be 50kb (51200 bits) to test the performance of the setup MANET under this protocol in terms of end to end delay, packet delivery ratio.

Scenario 9

This scenario is the same setup for scenarios 7 and 8 with varying traffic load 100kb (102400 bits) and 75 nodes using DSR protocol with no mobility.

Scenario 10

In this scenario, the numbers of nodes were set to be 75 nodes that are randomly distributed using AODV protocol with no mobility with setting the traffic load to be 10kb (10240 bits) to test the performance of the setup MANET under this protocol in terms of end to end delay, packet delivery ratio. The setup parameters for this scenario are shown in Figure I-9.

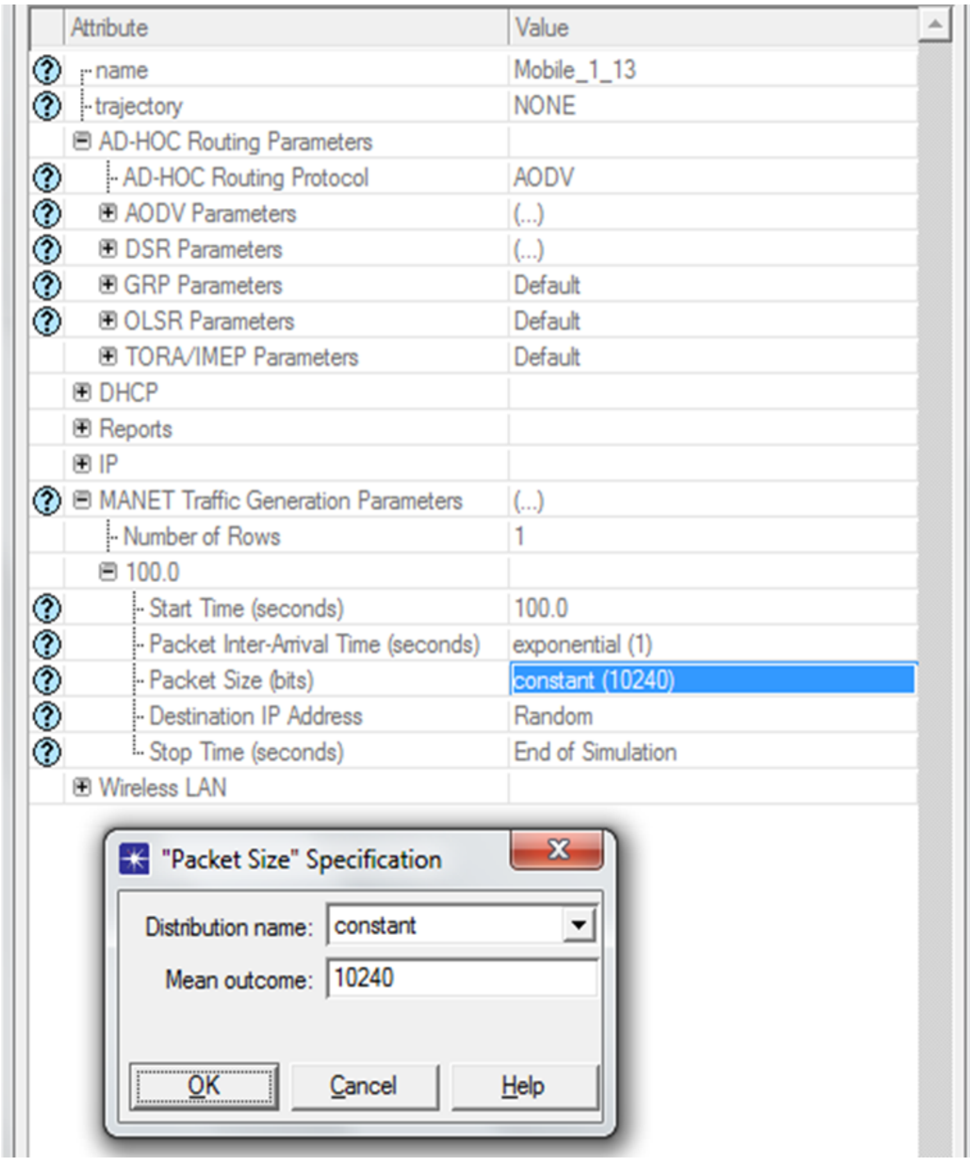

Figure I- 9 (10kb) Load Setup AODV Protocol

Scenario 11

This scenario is the same setup for scenario 10 with varying traffic load 50kb (51200 bits) and 75 nodes using AODV protocol with no mobility.

Scenario 12

This scenario is the same setup as for scenarios 10 and11 with varying traffic load 100kb (102400 bits) and 75 nodes using AODV protocol with no mobility.

Scenario 13

In this scenario the mobility configuration is applied to the mobile MANET nodes by DSR protocol for 75 nodes sending 1 KB of traffic for nodes moving with speed (1 mps), as shown in Figure I-10, and test the performance of the setup MANET under this protocol in terms of end to end delay, packet delivery ratio.

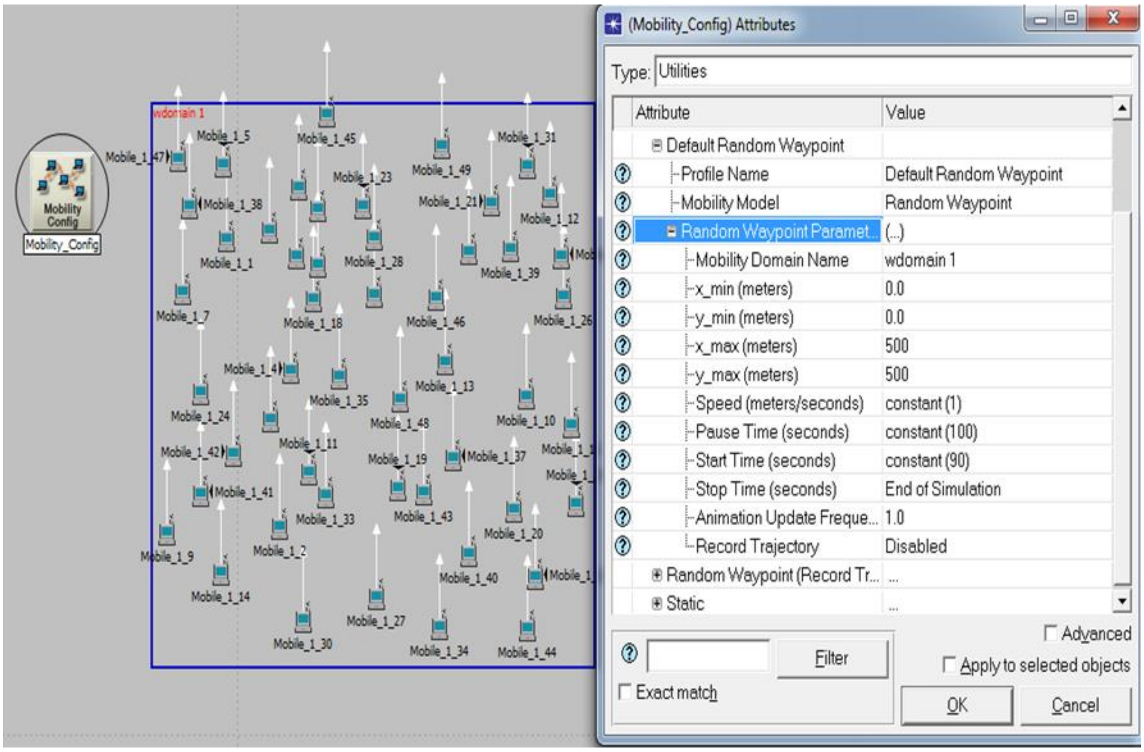

Figure I- 10 MANET Mobility Configuration With DSR for 1mps Speed

Scenario 14 and 15

In these scenarios the same steps were repeated as in scenario 13 with varying speed to

(5 ,10 mps) by DSR protocol, as shown in Figure I-11.

Scenario 16,17,18

In these scenarios the mobility configuration was applied to the mobile MANET nodes by AODV protocol for 75 nodes sending 1 KB of Traffic for nodes moving with speed (1,5 and 10 mps), and test the performance of the setup MANET under this protocol in terms of end to end delay, packet delivery ratio, the same last steps will repeat with varying the protocol to AODV.

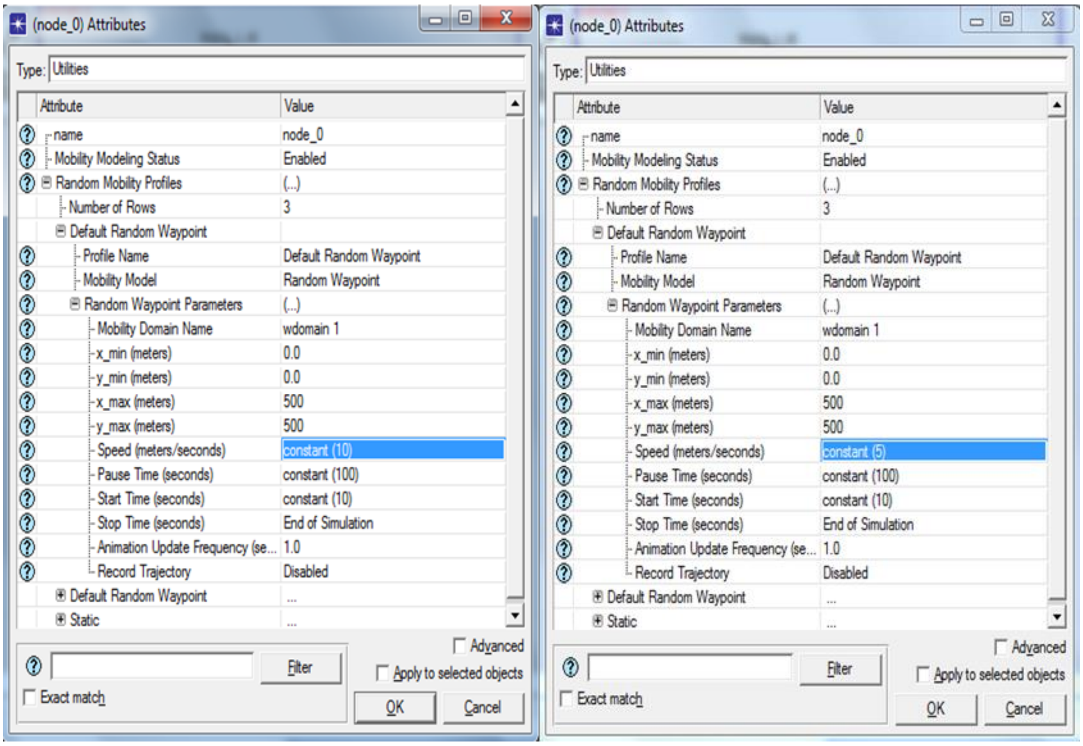

Figure I- 11 MANET Mobility Configuration With DSR Protocol (5&10 mps)