Routing Traffic Pattern Analysis Using MANET

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Abstract

Goal of the research thesis is to analyze MANET (Mobile Ad hoc Networks) Routing Protocols' performance in order to achieve diverse traffic patterns. Over time, wireless communication has undergone significant advancement. The self-config, infrastructure-less network architecture is the foundation of MANET. The nodes (electronic devices) in the infrastructure-less network architecture lack a fixed base station also called the access points. Network architecture is not stable because network nodes are always migrating from one location to another. As a result, each node can be thought of a router that receives and transmits information and data. These protocols hold the secret to communicate effectively since the propagation distance is constrained by the constant shifting of locations and topology. (AODV) Ad hoc On-Demand Distance Vector and Dynamic Source Routing are two common routing techniques (DSR).

For our research, we have specifically looked into these techniques. Throughput, latency, packet delivery ratio, and packet loss are the parameters chosen for the performance measurement. NS2 simulator and Optimized Network Engineering Tool (OPNET) were used for simulation. Analysis of the NS2 and OPNET findings comes up with the effectiveness of each technique.

Introduction/Literature Review

1.1 Introduction

MANETs are highly quickly deployable protocols with the potential to self-organize and are built on the foundation of being infrastructure-less. It has a wide range of uses, particularly in places where wireless infrastructures are not present. Without the need for any centralized server or authority, mobile nodes create temporary network comprising of different types of wireless electronic devices. The concept of self-configuration and self-organization comes into play when dealing with several hops since the network structure is always changing [6].

The random access wireless access channel is used by a number of network nodes for multi-hop communication. Because of how they operate, nodes are also referred to as routers. The electrical moving parts in the network are constantly shifting, creating new links and, as a result, routing traffic to other routers/nodes that might not be directly related to them. Since there is constant mobility in MANETs, efficient routing methods [7] must be used to provide error-free communications.

Routing is the process of choosing and forwarding network traffic while making informed choices. The routing tables must be maintained in a proper fashion on a logical basis in order to forward packets from the sending nodes to the intended destinations. Therefore, the chosen routing protocols should guarantee control over how the network's nodes forward/transmit information and data. The nodes must determine their topology on their own because the network topology is not fixed. Every new node that is introduced to the network must also synchronize with the existing surrounding nodes in order for connections to be successful.

1.2 The Routing Protocols

We will examine categorization of MANET routing protocols now. Various parameters like routing strategy, communication model and network architecture affect this classification. They are categorized into the following categories based on the routing strategy [8];

(a) Being Proactive
(b) Being Reactive

The proactive ones fall under the category of being "Table Driven". The ones which are reactive are categorized as being "Source Initiated" or sometimes referred to as available on "On Demand". The figure given shows different Routing Protocols for Mobile Ad Hoc Networks.

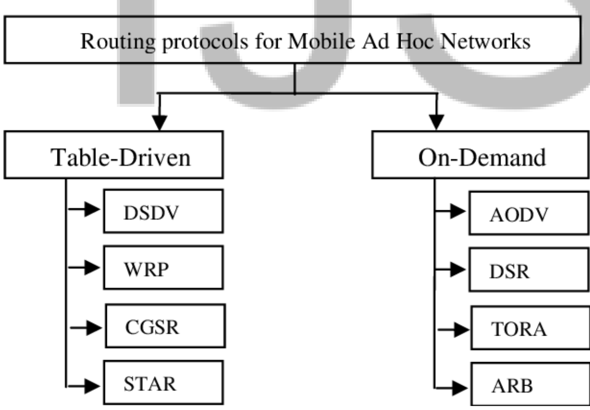


Fig 1.1: Table Driven and On-Demand Routing Protocols

Following are the routing classifications [9];

(a) Flat
(b) Hierarchical
(c) Routing which is called Geographic Position Assisted

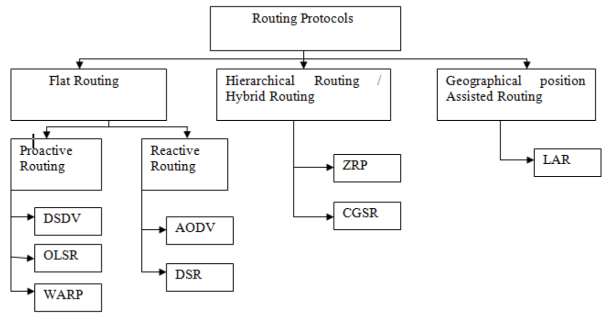


Fig 1.2: Ad-Hoc Routing Protocols

The same will be discussed in the preceding sections.

1.2.0 Table Driven

Pro-activeness is another term used to describe table-driven routing methods. They keep up-to-date records of the information necessary to route traffic from one network node to another. One (or more) routing tables are kept up to date in order to store the routing information. In case of any topological change in the network, the data is kept in them and is continually updated throughout the network. They include some of the following proactive routing protocols [10];

(a) Destination Sequenced Distance - Vector Routing Protocol (DSDV)
(b) The Wireless Routing Protocol (WRP)
(c) Global State Routing (GSR)
(d) Fisheye State Routing (FSR)
(e) Hierarchical State Routing (HSR)
(f) Zone Based Hierarchical Link State Routing protocol (ZHLS)
(g) Clustered Gateway Switch Routing Protocol (CGSR)

1.2.1 On Demand

Reactive routing protocols can go by the name of on demand routing protocols. Because the routes are established as and when they are needed in the network, they are known as reactive routes. A route discovery method is launched when a node i.e. source wants to communicate data to another node i.e. destination, which results in the choice of the route or path. This is accomplished by carefully examining each route and the best passable path's portion. The chosen route is subsequently kept up until any node stops being present.

Some of the protocols used are shown in below Fig;

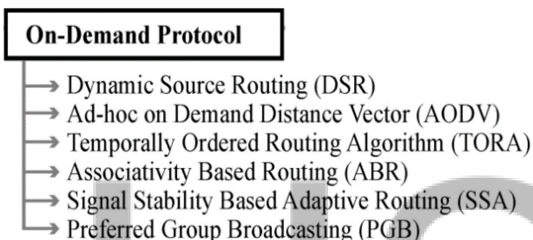


Fig 1.3: On-Demand Protocols

Fig below shows the complete picture of the MANET Routing Protocols.

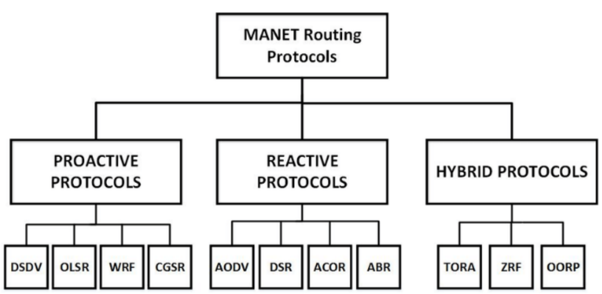


Fig 1.4: Complete Picture of MANET [11]

AODV and DSR protocols are used in this research.

1.3 DSR

A "source" routing protocol is on-demand routing protocol. Routing tables, which hold the source routes caches, must be maintained by the nodes and routers since they are regularly updated when new routes are found. The following two are DSR Protocol's fault;

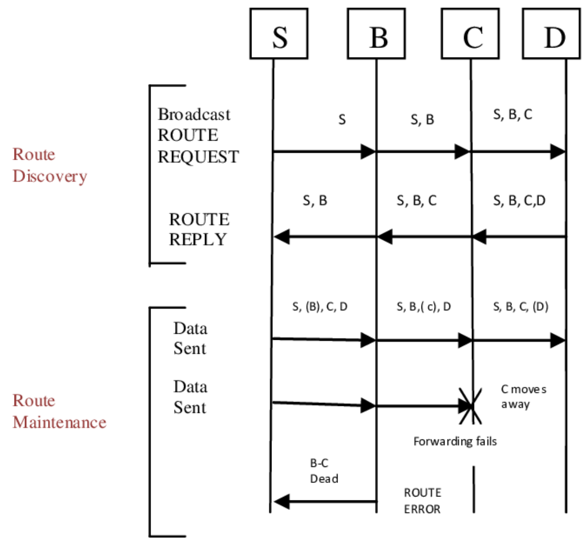


Fig 1.5: Route Discovery and Route Maintenance

Every node keeps "route cache" i.e. information it has gathered about the route in its routing tables. As a result, it checks the route cache, which has all the information regarding number of nodes in between that become part of transmission process. The "packet header" is then used to store and transmit this data to the next hop. The node receiving it looks at the information in packet header before putting the information next to its own node id and forwarding it to the following node. The node which sends data starts the route discovery procedure by buffering the data, albeit, in the event that no route is discovered [12].

In case of transmission of packets, node initially checks the route cache for any routes that are available. If there is a route that is still valid (it can still be used), it is chosen.

However, it is possible for there to have no exiting route, in that case it starts route discovery procedure by broadcasting below mentioned data:

a) Node address of the source
b) Destination Node-Address
c) UIN – Unique Identification Number

Routing tables are changed for the packet's transfer to its destination when this request is seen by the intermediary node or destination that has any route information in its cache.

A "route error packet" combined with acknowledgement protocol is used in the route maintenance method. The DSR utilizes a reactive strategy, as previously mentioned. It should be emphasized that these approaches significantly lower the "control overheads." The lack of a centralized way to fix any damaged links or connections is the drawback of adopting the Dynamic Source Routing protocol, though. The difficulty of this activity increases with movement.

1.4 AODV

An algorithm called Ad-hoc On-Demand Distance Vector uses a dynamic and self-starting technique for handling the environment of mobile nodes with several hops. In AODV, it is not necessary for the nodes or routers to keep track of the routes' specifics and a different approach is used to quickly determine routes. Two stages are used to do this;

a) Route Discovery
b) Route Maintenance

When a route is discovered, the sending node looks for it first. In case route is discovered, communication begins right away; otherwise, a process for route discovery is used. A route request message is sent, same like with DSR [13]. The route reply message is generated using number of hops, source node address, and next hop's address. However, there is a "lifetime" cap in place, meaning that if the route is not discovered in any other way during that time, the cap is abolished.

The "route maintenance" method is started in the following phase. There are two further steps;

a) Source Node initiates a new route discovery
b) Destination node or the Intermediate sends the route error message to the source node

Transmissions between the nodes are effectively carried out by "Route Discovery" and "Route Maintenance" methods.

To summarize, the difference between DSR and AODV is shown in the below comparison.

TERMS	AODV	DSR
Protocol Type	Hop by Hop routing	Source routing
Route maintained in	Routing table	Routing Cache
Route Discovery	On Demand	On Demand
Multiple route discovery	No	Yes
Multicast	Yes	No
Broadcast	Yes	Yes
Reuse of routing information	No	No
Route reconfiguration	Erase route, than source notification or local route repair	Erase route the source information
Limited overhead	No	Concept of route cache
Advantage	Reduced control overhead	Multiple route reduced bandwidth overhead
Disadvantage	Scalability problem, large delay caused by route discovery process	Scalability problem due to source routing and flooding, large delay
Route Storage Space	Low Storage Space	High Storage Space
Routes in routing table	Deletion of valid link	Usage of invalid link
Bandwidth usage	Efficient bandwidth usage	Waste bandwidth
MAC Overhead	AODV has less normalized MAC overhead	DSR have MAC overhead
Performance in AD hoc network	AODV has better performance in high mobility scenario	DSR have poor performance in high mobility scenario
Route discovery frequency	AODV have very frequent route discovery	DSR have less frequent route discovery
Utilization	Route discovery is on demand, which is more efficient in dynamic nature of mobile ad-hoc network.	Route is only created when required and node utilizes the route cache information efficiently to reduce the overhead and collision.
Routing overhead	AODV has complex routing	DSR has less routing overhead

Table 1.1: DSR vs AODV

The literature review included a number of studies [1-3], with the main emphasis being on performance evaluation of the AODV and DSR routing protocols. Additionally, the examination of the MANET protocol while taking mobility and scalability into consideration.

Research Concept

2.1 Research Problem

Requirement to comprehend MANET protocol performance increased with the development of wireless technologies. Both the military and the civilian world can benefit from MANET. There is a need to examine their behavior using the best simulators because older protocols were not built for mobility when the node's location changes. Studies comparing effectiveness of the MANET protocol under various traffic patterns are scarce. Furthermore, no research is conducted in order to confirm the outcomes of these different performance criteria by using various network analysis methods to identify the gaps.

2.2 Objectives

Results of simulations using MANET Routing Protocols vary depending on different simulated traffic patterns. Even when different simulators are utilised for the analysis, there is a disparity in the way that they generate patterns. After assessing the traffic patterns, it will be possible to establish how to most effectively use the simulator to produce more accurate results by minimising these gaps.

The results of simulations using different traffic patterns for MANET Routing Protocols will advance the body of scholarly knowledge. It will incorporate outcomes from many simulators (Commercial & Open Source).

By identifying discrepancies or variations in findings and selecting the most precise and effective simulator, practical contribution will be made.

Following are research objectives:

- Simulating the MANET Routing Protocols for different traffic patterns.
- Simulation results analysis by the use of different Simulators available commercially and the Open Source ones.
- Determining the variation of results and recommending the most effective simulator with utmost accuracy.

2.3 Research Methodology

- The Review of the Literature
- Using OPNET Simulator
- Using NS2 Open Source Simulator
- Simulation Results Analysis

The process flow chart is shown below:

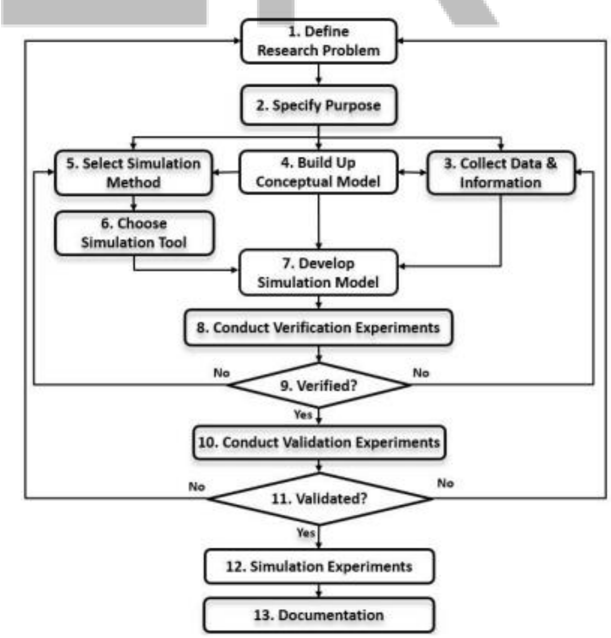


Fig 2.1: Modelling and Simulation Process

Simulation Tools

3.1 Simulators

We require strong tools to develop performance measurements in order to analyze ad hoc routing methods. A simulator is, by definition, a piece of software used to replicate the behavior of a real network on a computer for the purposes of research and development. In order to create, verify, analyze, and simulate network protocols for obtaining performance aspects, academic researchers employ these tools. Different network topologies and network kinds can be created with the aid of the simulators [14].

Network simulators come in a variety of forms and are widely utilized. Shown below are commercially available and open source simulators.

	OPNET	NS2
License	Needed	free
open source	No	Yes
documentation	A lot	Less
pre-implemented algorithms & protocols	Many	Less
Preferable	Network operators	Network researchers

Fig 3.1: Network Simulators Classifications

Simulators from both the commercial and open source were chosen for analysis.

3.1.1 Network Simulator - NS2

Investigation was conducted using the NS2 Simulator. The NS simulator is in its second iteration. NS2 has been chosen to assess MANET since the findings obtained using the simple simulator were less accurate. For wireless and wired networks, it is used to simulate the routing, Transmission Control Protocol (TCP), and multicast protocols. It is considered as discrete event simulator which is built on the UNIX platform [15].

The interface of NS2 simulator snapshot is given below.

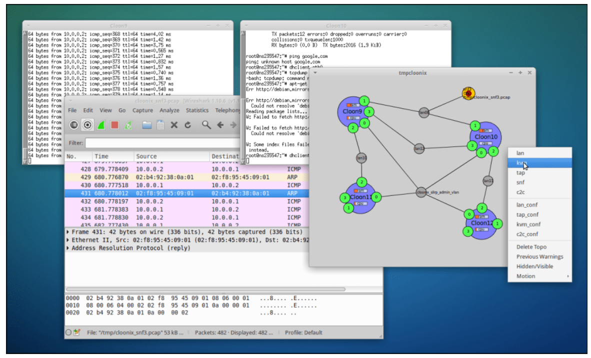
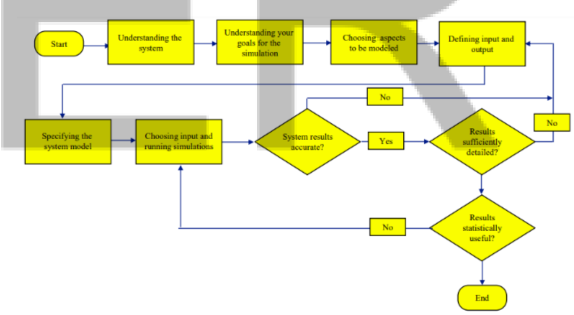


Fig 3.2: Generic view of NS2 Simulator

3.1.2 Simulator OPNET

Due to its lengthy history and high degree of maturity, extensive use of the commercial simulator OPNET is done by the researchers. In Fig below, the fundamental simulation process is displayed.



(Source: http://www.sce.carleton.ca/faculty/lambadaris/courses/5001/opnet_tutorial.pdf)

Fig 3.3: Simulation Process

3.2 Simulators Environment

Fedora, a Linux-based operating system, was utilized to conduct the performance investigation. Installed was Network Simulator NS2 (Version: 2.35). Over the Windows XP operating system, OPNED Modeler (ver 14.5). The full simulation setup is described in Table 2.

Seed	1.0
Simulation Tools	- NS-2.35 - OPNET Modeler 14.5
Simulation Time	100 Seconds
Simulation Area	1000 * 1000
Rate	5.5 Mbps
Traffic Type	Transmission Control Protocol (TCP)
Number of Nodes	100
Routing Protocols	- DSR - AODV
Mobility	Random Way Point

Table 3.1: Simulation Setup

3.3 Performance Metrics

Fedora, a Linux-based operating system, was utilized to conduct the performance investigation. Installed was Network Simulator NS2 (Version: 2.35). Version 14.5 of OPNET Modeler was additionally installed on the windows XP. Full simulation setup is described in Table 2 above. Performance measures required four variables as shown below.

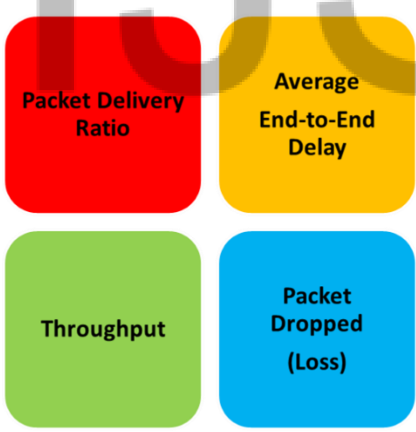


Fig 3.4: Performance Metrics

3.3.1 PDR

It is the ratio of total no of packets successfully delivered to the destination node or point divided by the total no of packets sent by nodes throughout simulation session.

Packet delivery Ratio (PDR) = No of Packets received ÷ No of Packets Sent

3.3.2 Average End-to-End Delay

The network requires certain amount of time for packets to get from source to destination. This time interval is defined as the Average End-to-End Delay. Following circumstances can cause several delays to happen:

Route Discovery

- Queuing Delay
  - How Many packets in the queue?
  - How long a packet takes to go through?

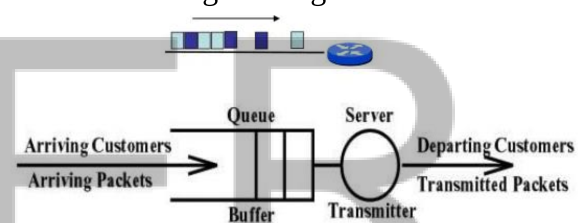


Fig 3.5: Queuing Delay

- Propagation Delay
- Transfer Time Delay

All can be summarized in the below Fig:

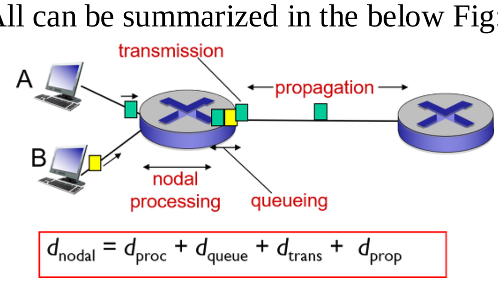


Fig 3.6: Packet Transmission Delays

Average End to End Delay = (Time Received – Time Sent) ÷ Total Received Data Packets

3.3.3 Throughput

Describes typical rate of data packets that reach their destination successfully [16].

Fig 3.7: Throughput

*Throughput = (No of delivered Packets * Packet Size * 8) ÷ Total duration of Simulation*

3.3.4 Packets Dropped

Dropping of the packets can be calculated using the below formula.

Packet Dropped (Loss) = Total Packets Sent – Total Packets Received

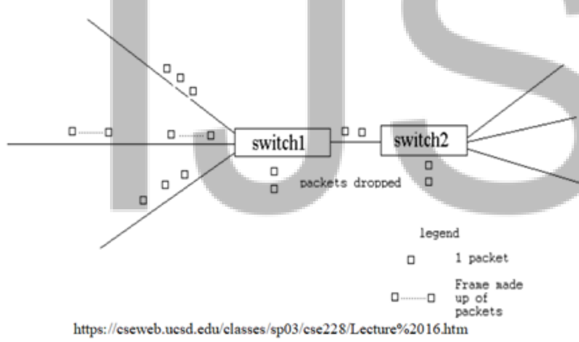


Fig 3.8: Packet Drop

Simulation Analysis

4.0 Analysis

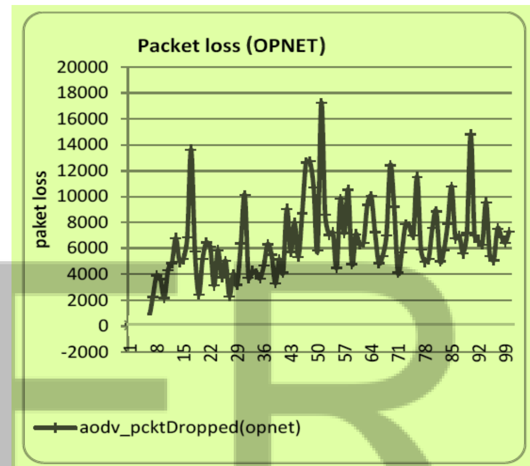
Researcher will analyse how the findings from the OPNET and NS2 simulators compare in terms of performance. The plots will show different AODV and DSR protocol suit parameters. Plots of the subsequent variables would be used for simulators comparisons:

- PL- Packet Loss
- PDF- Packet Delivery Ratio
- TH- Throughput
- AETED- Average End-to-end Delay

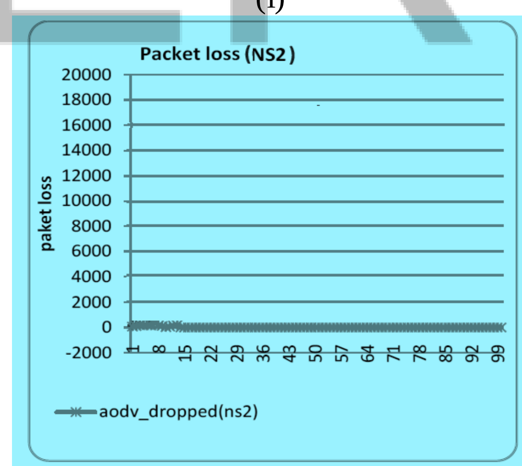
For a big audience of researchers, the graphical depiction will be much simpler to analyse and comprehend.

4.1 PL - Packet loss

Packet loss of AODV (using OPNET) and AODV (using NS2) is shown below:



(i)



(ii)

Fig4.1: (i) Packet Loss (AODV using OPNET) (ii) Packet Loss (AODV using NS2)

Figs show the routing protocols' packet loss rates for AODV & DSR using different simulators. When calculated on NS2 as opposed to the OPNET, the packet loss (AODV protocol) is quite less as shown below.

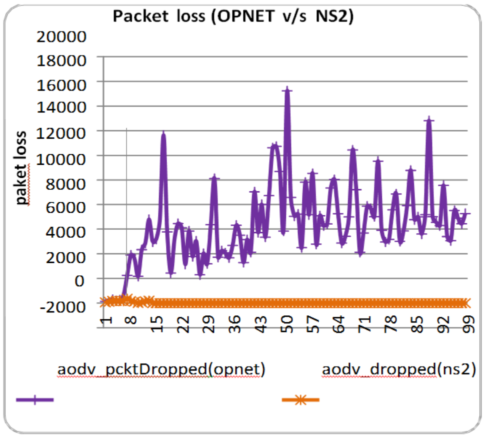
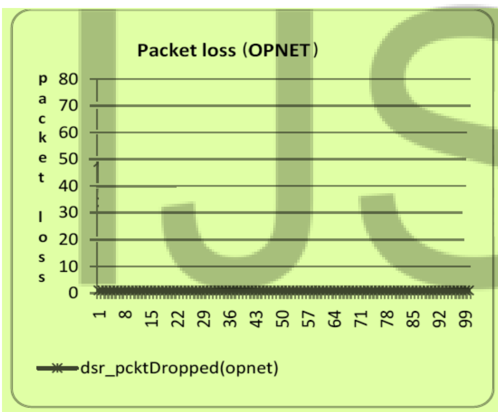
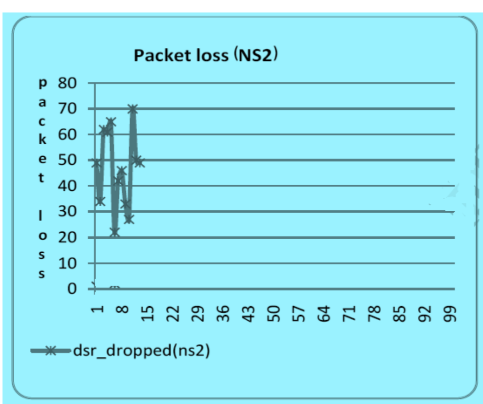


Fig 4.2: PL(AODV)



(i)



(ii)

Fig 4.3: (i) PL (DSR using OPNET) (ii) PL (DSR using NS2)

However, NS2 data reveals increase in packet loss. We notice high level of packet loss (for OPNET) when using the AODV protocol, demonstrating the inaccuracy in terms of missing packets.

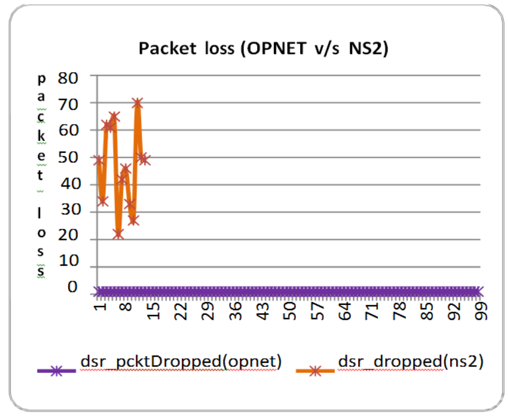
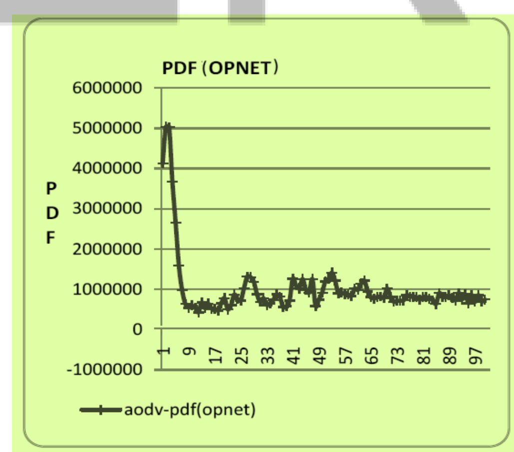


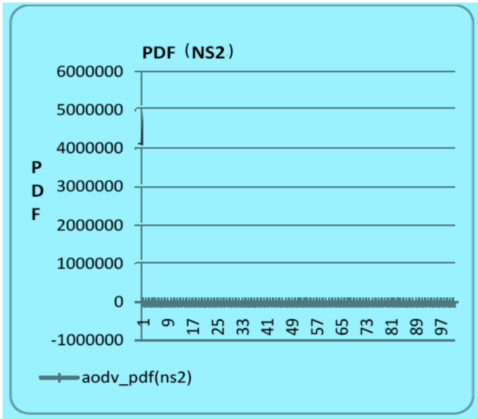
Fig 4.4: PL (DSR)

4.2 PDF - Packet Delivery Ratio

PDF on NS2 and OPNET are plotted separately against the number of nodes. As shown below in two different figures



(i)



(ii)

Fig4.5: (i) PDF (AODV using OPNET) (ii) PDF (AODV using NS2)

Figs illustrate that packet delivery ratios (for NS2 and OPNET). The packet delivery ratio, as determined by the NS2 simulator, is found to be low (nearly constant) for both protocols (AODV & DSR). Similarly, even while the packet delivery ratio for the OPNET simulation is not great, it's better than NS2 simulation as can been seen in fig4.6

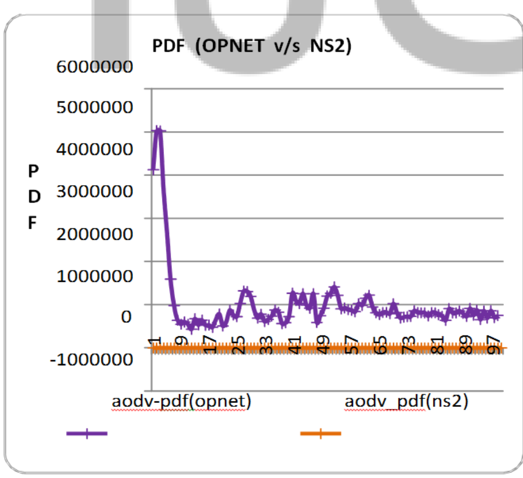
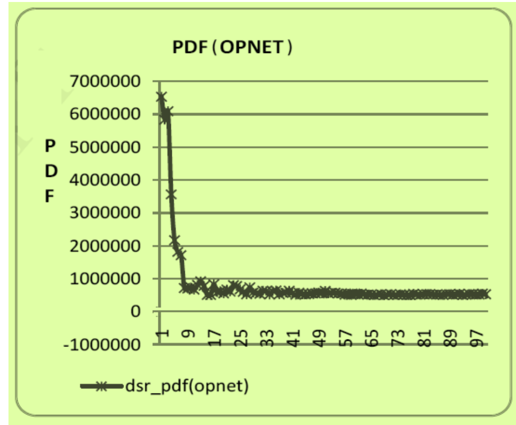
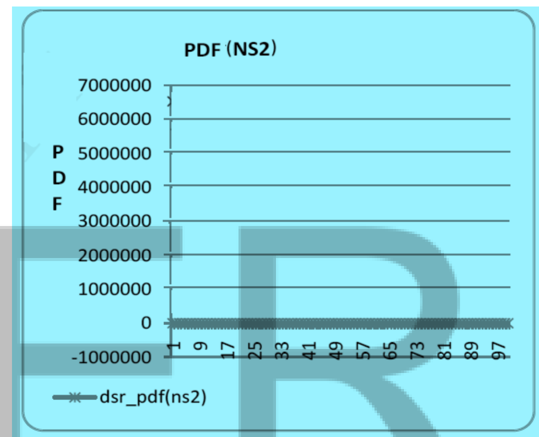


Fig 4.6: Packet Delivery Ratio (AODV)

Noted that AODV has a significantly higher packet delivery ratio than DSR. It is important to note that we selected 100 nodes for our research at this point.



(i)



(ii)

Fig4.7: (i) PDF (DSR using OPNET) (ii) PDF (DSR using NS2)

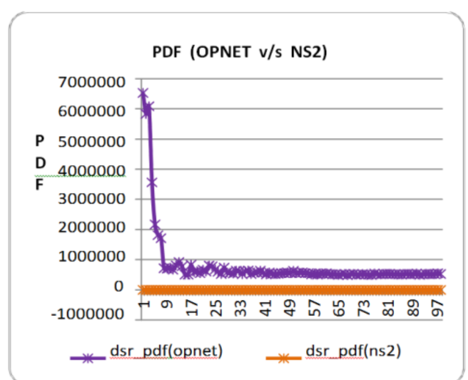
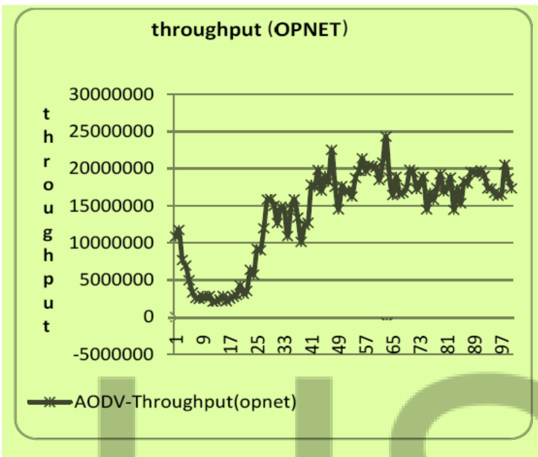


Fig 4.8: Packet Delivery Ratio (DSR)

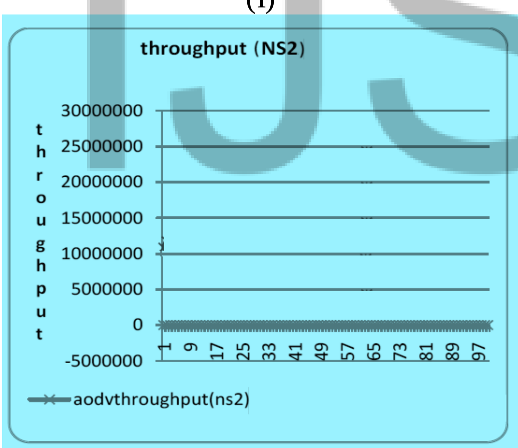
The quantity of nodes is another intriguing finding. The packet delivery ratio for DSR displays favourable patterns of results when there are fewer nodes overall in the network (NS2).

4.3 TH - Throughput

Now let's examine throughput graphs-given below, for the AODV using OPNET and NS2 and the DSR suit for both of simulators.



(i)



(ii)

Fig 4.9: (i) TH (AODV using OPNET) (ii) TH (AODV using NS2)

Now think about the throughput metric. The throughput levels measured using the OPNET simulator are found to be highly encouraging. When AODV protocol (OPNET) is used, throughput is increased in comparison to NS2.

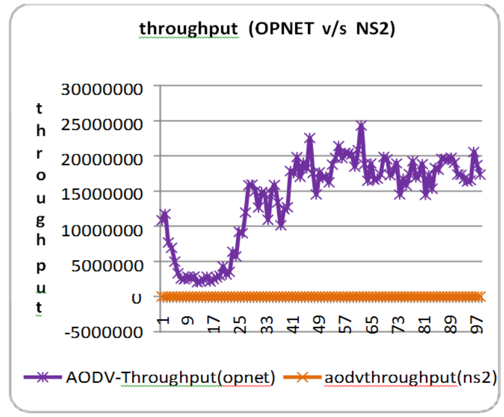
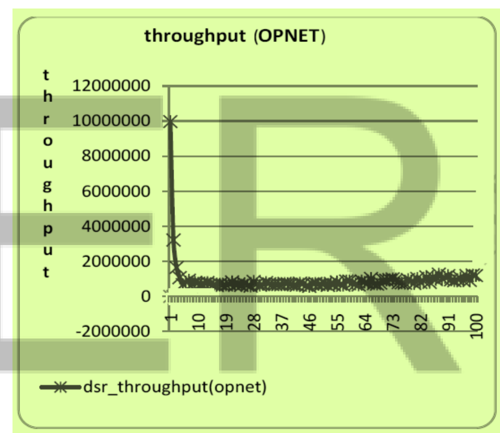
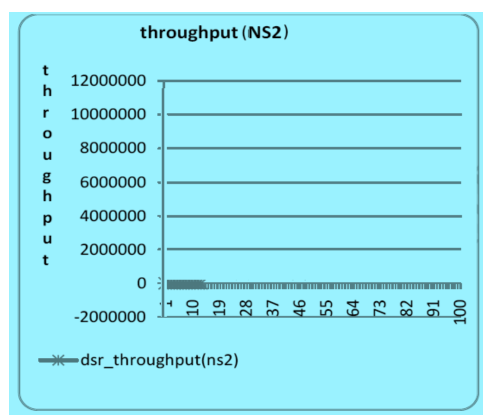


Fig 4.10: TH (AODV)

The throughput decreases when we use the DSR protocol (OPNET). Even so, it still outperforms the outcomes of the NS2.



(i)



(ii)

Fig 4.11: (i) Throughput (DSR using OPNET) (ii) Throughput (DSR using NS2)

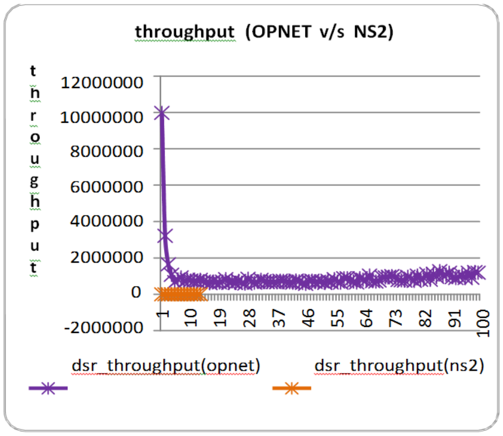
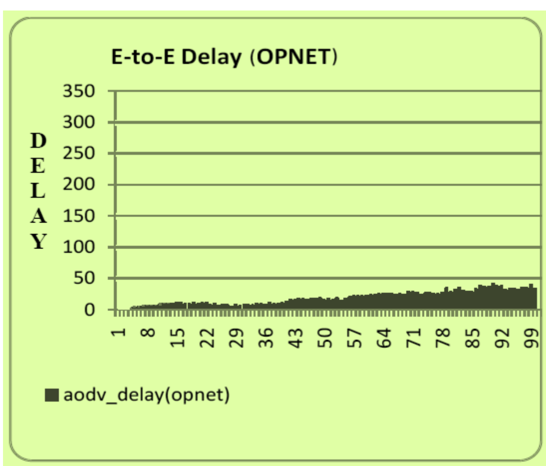


Fig 4.12: Throughput (DSR)

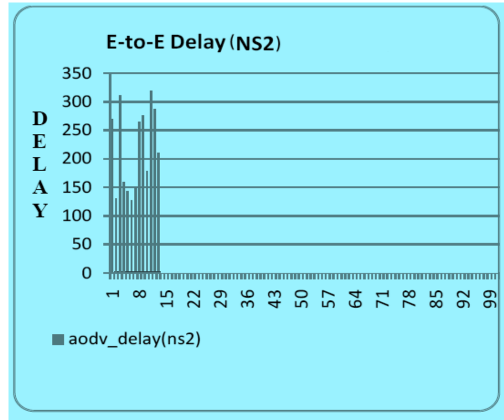
Whenever we measure TH, AODV protocol gives results comparatively better than that of DSR.

4.4 AETED - Average End-To-End Delay

In case of both of the protocols implementations, it has been noted that performance results of OPNET simulator are superior to those of NS2 simulator regardless of the protocol, depicted in the figures (i) and (ii).



(i)



(ii)

Fig 4.13: (i) AETED (AODV using OPNET) (ii) AETED (AODV using NS2)

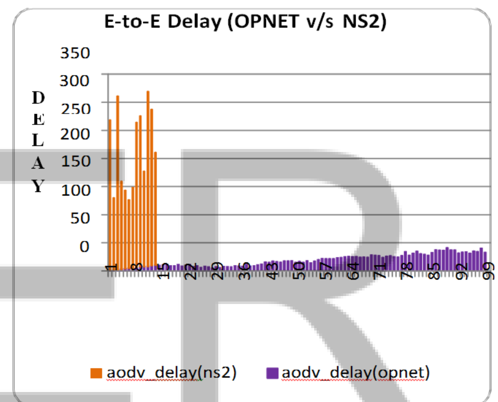
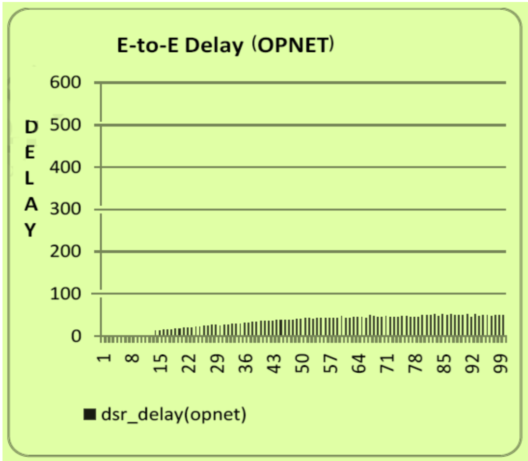
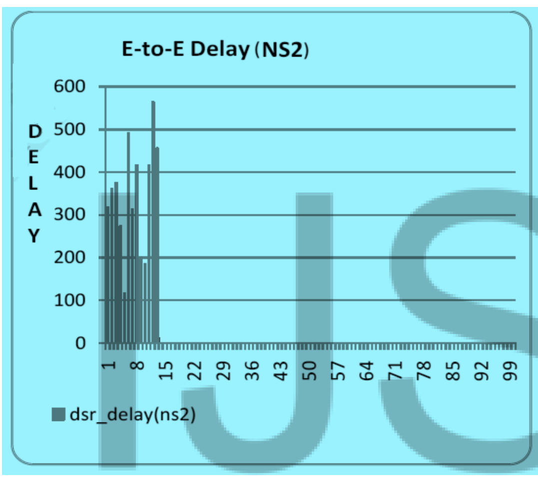


Fig 4.14: AETED (AODV)

Observed is less variability in OPNET and lower levels of latency. When examining the NS2 results over time, more variances with significant delays are seen.



(i)



(ii)

Fig4.15: (i) AETED (DSR using OPNET)
(ii) AETED (DSR using NS2)

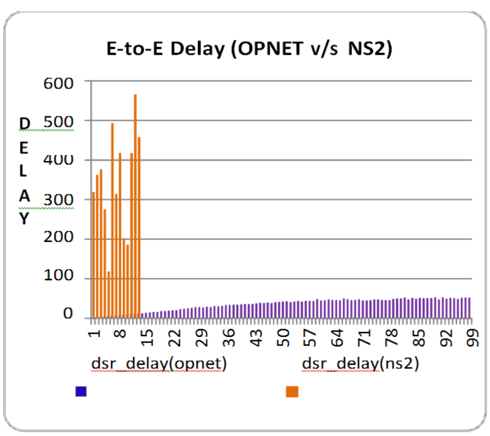


Fig4.16: AETED (DSR)

As seen that end-to-end delay should always be minimal when considering good data transmissions. Accuracy of data transfer is a big concern when there is excessive End-To-End latency (as is the case of NS2).

In short;

- Simulation results using OPNET are better than that using NS2.
- Graphical interface of OPNET is easier to comprehend.
- In case of OPNET more time is consumed.

Table below provides a full comparison of both features. NS2 is widely accessible because it is an open source product. Similar to that, it supports a variety of systems like Windows and UNIX. However, OPNET is a for-profit simulator, and the kernel code is not based on open source. But only the Windows platform is supported.

NS2	OPNET
Open source (easily available)	Commercial level simulator
Kernal code is open source.	OPNET modeler kernel code is not open source.
Command based	GUI and drag and drop function based
Supported by both platform : Windows (CygWin) and UNIX	Supported by only Windows version
No extra requirement are needed for NS2	Visual studio and C++ library are must for OPNET

Table 4.1: Features Comparison (Simulators)

Table 4.2 provides more information on the comparison of both parameters. It shows that when NS2 is used instead of OPNET, the end-to-end delay is significantly worse. The throughput is the same. The Packet Data Ratio in OPNET is frequently changing.

	NS2	OPNET
E-to-E Delay	Worst	Very Good
PDR	Constant (bad)	Frequently change
Packet Loss	Less in AODV, but very much for DSR	More data loss in AODV, but in DSR negligible
Throughput	Worst	good

Table 4.2: Parameters Comparison (Simulators)

Conclusions

5.0 Conclusion

The study's methodology involved the analysis of numerous metrics falling under the AODV and DSR protocol suites. We chose two popular network simulation tools. A number of metrics factors were tested against NS2 and OPNET. Due to the fact that the identical parameters were examined and compared using two distinct, reliable tools, the results have produced some extremely intriguing views.

Based on the results and data analysis for the various MANET alternatives, it was determined that, overall, the trends were constant, even when the numbers (absolute) occasionally achieved were quite different. Additionally, we got to the conclusion that the MANET routing protocol performs better on the OPNET simulator. Furthermore, OPNET is very user-friendly, so there is no need to memories numerous commands. However, because NS is so easily accessible, it is utilized more frequently.

The following conclusions were arrived at in brief;

- OPNET simulator produces simulation results that are unquestionably superior to those of NS2.
- OPNET graphical user interface is significantly simpler to understand.
- OPNET requires extra time because to the update of files and functionality.

It should be mentioned that this study was done for a limited number of parameters, therefore future efforts may encompass additional parameters.

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