Chapter 3

MANET BASED COMPARISON OF NETWORK SIMULATORS: NS2 & QUALNET

3.1 Introduction for NS2 & Qualnet

Choice of a suitable simulation tool is vital for MANET studies. Here NS2 & Qualnet are used for this purpose. They provide various features for preparing, analyzing and evaluating parameters of a network scenario. Simulators are software tools, which simulate the actual working of network in pre-de ined scenarios. A network simulator is used to analyze the features and performance of wired and wireless Networks like packet loss, delay, throughput, Quality of service etc., for various networking scenarios. After executing the scenario on a simulator, the results are analyzed in various dimensions which include customization mechanisms, speed of execution (parallel execution), usability, level of scalability, model diversity. Graphical User Interface helps a lot to understand the Usability feature to start creating a scenario-simulation. There are many network simulators that exist with speci ic features. Some of the network simulators are NS2, NetSim, OMNeT++, REAL and Qualnet. Here we work on the Ns2 and Qualnet simulator with de ined cases.

NS-2 is widely used in academic research. it is popular, widely used freeware, easily available with upgradation. Many enhancements modules (i.e., multi-rate schemes, IEEE 802.11a/g/e and energy consumption models) have been incorporated. Although it's advanced version NS3 has been developed in 2008 but NS2 still continues to be used widely because of its simplicity and usefulness. Qualnet is developed from the GloMoSim simulator. Qualnet incorporates some extra features such as weather factor, complex terrain designer and high speed mobility. Simulator studies have been made with these simulators in an attempt to compare them.

Routing protocols are used to route packets from source to destination. The performance of any routing protocol depends on the duration of interconnection among the nodes in the network for transferring the data. This interconnection results in an average connected path for whole network. The node mobility affects the number of average path as well as the performance of the routing protocols. A mobility model has an impact on the performance of Routing protocols.

This chapter aims to compare characteristic features of these two simulators. MANET simulations have been carried out to observe Good put, Computation run time, memory usage and area impact for NS2 & Qualnet. In this work we have calculated the effect of minimum distance on good put, network size on computation time and memory usage with effect of area. The simulations has been carried out on both NS2 & Qualnet keeping all the parameters same. As well as we made comparison study on other hand with Performance of some of the widely used routing protocols viz. OLSR and AODV under two widely used simulators NS2 and Qualnet, using similar set of parameters. We also wish to observe how the routing protocols perform under different simulators. We have considered two parameters namely throughput and end to end delay.

Organization of the rest of chapter is as follows. In section 3.2, state of the art is discussed followed by a description of the simulation setup and result discussion in section 3.3. Chapter is concluded in section 3.4.

State of the Art

We inspected past few years works on MANET which included simulations done on NS2 and Qualnet. In [55] authors compared nature of traf ic low in simulations with test bed experiments. However, analysis is limited to ixed network and is evaluated on NS-2 only. In the past Kargl and Schoch [56] compared network simulators JiST/SWANS and NS2 for wired networks. Lucio et al. [57] proposed a comparison study for Ns2 and OPNET on the test bed for wired networks. In [58] authors endeavored to map characteristics that MANETs Simulation tools should re lect and support with description of GlomoSim, J-Sim, NS-2, OMNet++, OPNET Modeler. The researchers have chosen random way point mobility model [59] and analysed the general performance characteristics.

Cavin et al. [60] suggested that the learning curve for NS-2 is steep and debugging is dif icult due to the dual C++/OTcl nature of the simulator. An important limitation of NS2 is its large memory footprint and its lack of scalability as soon as simulations of a few hundred to a few thousand of nodes are undertaken.

Imran Khan et al. [61] evaluated the performance of AODV and OLSR. It was observed that OLSR was able to give better PDR and less End-to-End delay than AODV.

Jerome Haerri et al. [62] simulated AODV and OLSR for varying metrics such as node mobility and vehicle density with varying traf ic rates. The goal was to provide a qualitative assessment of the applicability of the protocols in different vehicular scenarios.

3.2 Simulation Setup & result discussion

This section is divided into two parts, one includes designed case study with reference to simulators and second includes comparison of both simulators on the basis of designed cases which were taken up in irst part. We have taken two simulators Ns2 & Qualnet, with two cases of different scenario to get the comparative result of both the simulator. We also observed how the routing protocols perform under different simulators. We have considered two parameters namely throughput and end to end delay

CASE - 1: For large networks the parallel simulators perform better than others. But for smaller networks most of the features are supported by many simulators. Hence it is dif icult to choose one. The main problem is how to choose the simulator depending upon prevailing conditions. For our simulation, we ixed the minimum distance between a pair of nodes with the simulation area of 500x500m2 and 250x250m2. For performance analysis we worked with minimum ixed distance for a pair of nodes in 10 iterations. Similarly the good put is calculated based on the average result for the simulation study. Good put is de ined as the ratio of total data packets successfully sent and total packets transmitted in the network.

Setup & performance comparison:

The topology consists of seven nodes arranged in an arbitrary fashion with a minimum side length between pair of nodes is 5 meters for irst iteration. Similarly 10 meters for 2nd iteration. In this way its happen similarly for up to 55 meters in 11th iteration. The simulation setup is shown in table 3.1. Nodes are running in 802.11b ad-hoc network at 2.4 GHz. The topology is shown in igure 3.1. Through VBR+ application, data packets send from node1 to node7 over UDP and the good put is measured. Concurrently through another VBR application data send from node4 to node6. Links are used at full capacity.

Packet Size	512 Bytes
Packet Rate	4 packets/sec
Data tra c	VBR+
Dimensions(Area)	500m x 500m & 250m x250m
No. of nodes	10
Min. speed	1m/s
Max. speed	15m/s
Routing algorithm	AODV
radio transmission range	60m
Posi on Granularity (meters)	1.0
pause mes	5s
Simula on me	200s
Antenna Model	Omni-direc on
Mobility Model	Random way point
propaga on model	Two ray

Table-3.1: Parameters for simula on setup case1

In Qualnet the good put luctuates at larger distances and also at all distances. Although the luctuation is quite more, it is considered more reasonable. The simulated good put is slightly over 10 MB/s for distances smaller than 25 meters. The results are shown in igure 3.2 for 500x500 area and igure 3.3 for 250x250 area. After the initial alignment of the nodes they tend to move towards each other with the passage of time. This process continues repeatedly and if the area is larger it is less frequent else it is more frequent. This is due to the fact that in a bigger area the probability of best orientation is lesser as compared to smaller area. This improves the throughput. Movement has a positive effect on throughput.

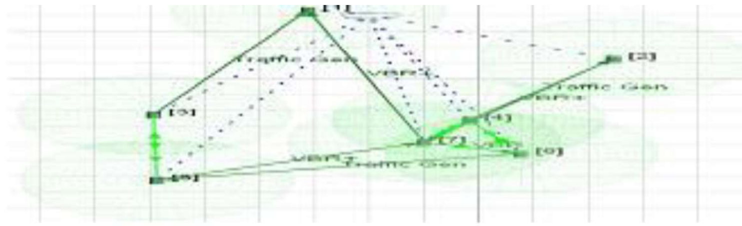


Figure 3.1: Topology run shot of the simulation in Qualnet for case 1.

CASE - 2: For any application the running time and hardware (memory) usage are crucial factor to decide simulation tool. Here for comparing simulation tools we have taken simple network structure, without aiming the simulation of a real network, because its performance is mostly dependent on the code of the network models and their computational complexity.

Setup & performance comparison: We have taken a basic network structure, where the nodes are arranged in a square fashion connected with the CBR links in Figure 3.4. Here we made two nodes that must have communication between each other. In igure 3.4 those nodes are labeled with the name of sender and receiver. The receiver node “11” is located at the below corner and sender node “1” is located at the top left corner; instead of it we have chosen different pair in each iteration for the same wireless environment.

Packet Size	**512 Bytes**
Packet Rate	**4 packets/sec**
Data tra c	**CBR**
Dimensions(Area)	**250m x250m & 500m x 500m**
No. of nodes	**50,100,150,200 and 250**
Min. speed	**1m/s**
Max. speed	**15m/s**
Rou ng algorithm	**AODV**
radio transmission range	**60m**
Posi on Granularity (meters)	1.0
pause mes	**5s**
Simula on me	**200s max**
Antenna Model	**Omni-direc on**
Mobility Model	**Random way point**
propaga on model	**Two ray**

Table-3.2: Parameters for simulation setup case2

We have taken this scenario for its simplicity. Same nodes setup pattern has been used for 50,100,150,200 and 250 nodes. All simulation runs were conducted on a processor dual core-2.6Ghz with 2GB of RAM, running Ubuntu Linux 9.0 desktop edition. Our measurements were taken using ns-2 version 2.33 and Qualnet version 5.0.

Computation-runtime: For bigger area movements can be longer and frequent, and this result in higher computation runtime. Figure 3.5, 3.6 shows the measured simulations runtime at different network sizes for the compared network simulators. It is not applicable to large-scale network simulations: For a network size of 250 nodes, it needs 30 seconds on an average to complete the simulation run, actually it is a very small network and system is so much powerful and so it computes very quickly. Ns2 takes more computation time by network sizes 200 &250 nodes in compare to Qualnet.

Memory usage: As similar setup of simulation for computation run-time, we measured the maximum memory usage of the individual simulators .The outcome shows in igure 3.7, 3.8. Ns2 and Qualnet for area 500x500 setup takes up more memory than the Ns2 and Qualnet for area 250x250 setup scenario .The difference in memory usage between Qualnet and the Ns2 tools increases with larger network sizes.
The memory usage performances of ns-2 and Qualnet share a dissimilar linear growth of memory usage but Qualnet is the better simulation tool out of the two. It is because of the fact that with increasing network size and area-size node moment will get large number of coordinates, analyzing all movement would be possible with relatively high degree of space & time complexity. Also in NS2 as the topology grows, more trace iles are generated and it consumes memory.

Area impact: For same setup environment, we measured computation-runtime of the individual simulator with change in simulation Area for ixed network size 200 nodes. Figure 3.9 shows impact of area on computation time with ixed network size. It depicts that Ns2 is taking more computation time than Qualnet for the area A3 & A4. This happens in Ns2 because with increase in area the trace iles increase exponentially and it leads to more memory consumption, hence computation time is more as compare to Qualnet.

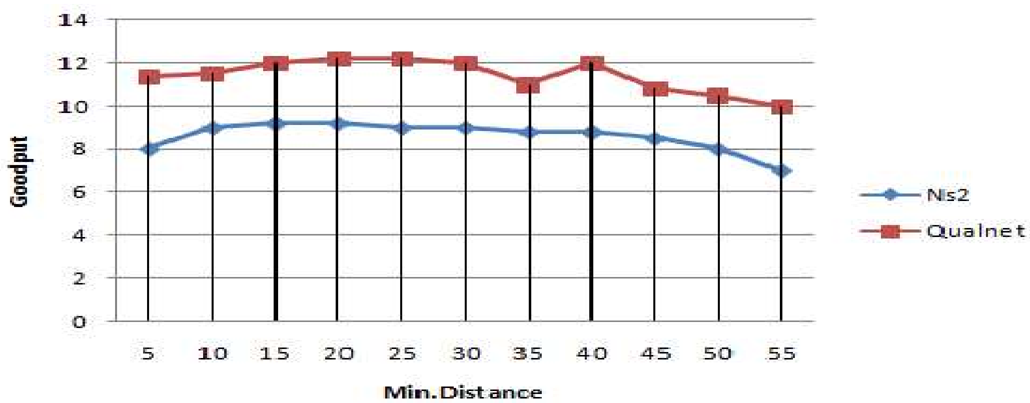


Figure 3.2: Good put performance with minimum side length between pair of nodes & ixed simulation area 500x500.

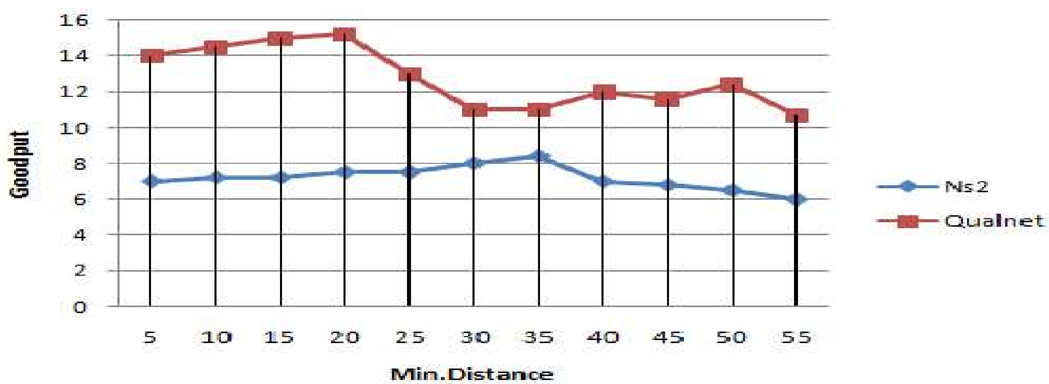


Figure 3.3: Good put performance with minimum side length between pair of nodes & ixed simulation area 250x250.

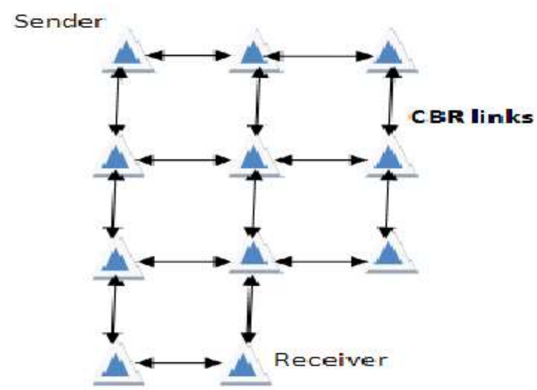


Figure 3.4: shows the topology of the simulation in Qualnet for case 2.

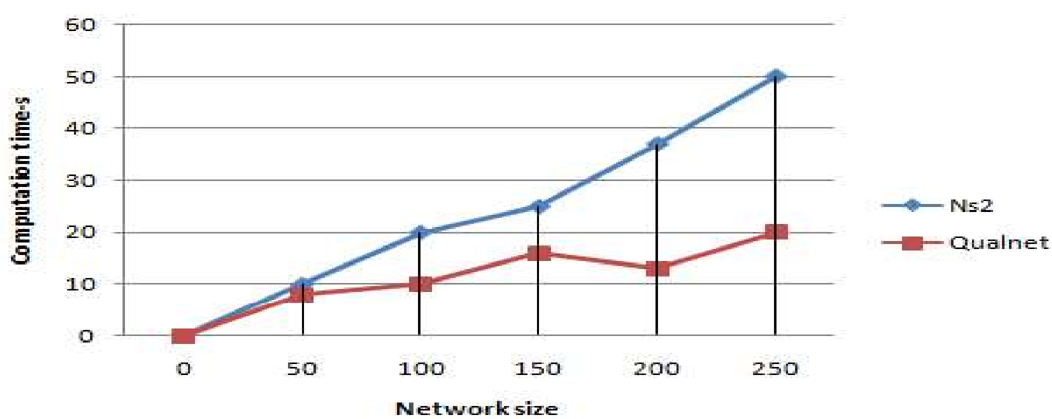


Figure 3.5: computation time performance with network-size & simulation area 500x500.

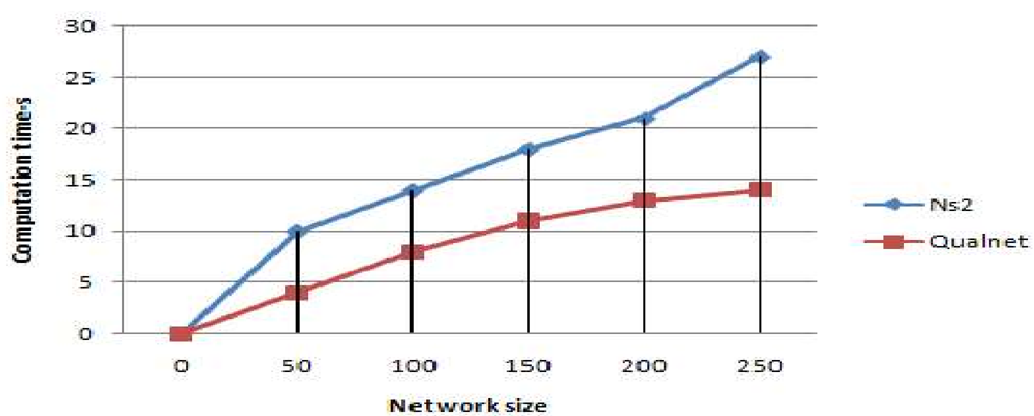


Figure 3.6: computation time performance with network-size & simulation area 250x250

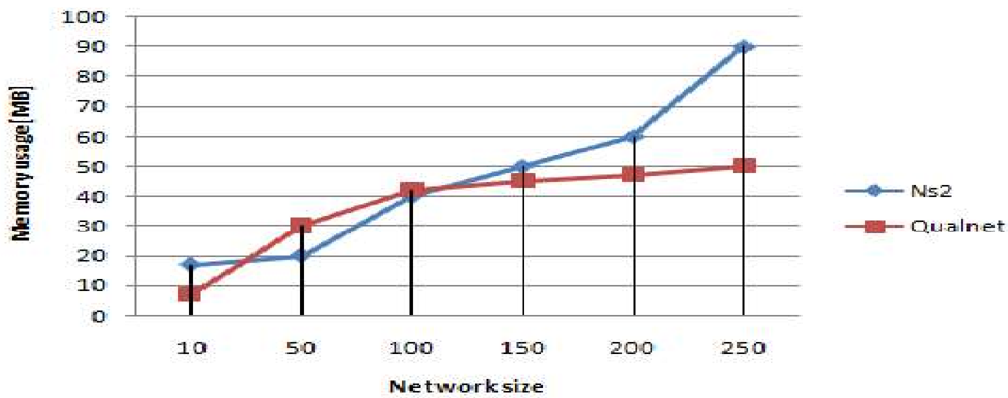


Figure 3.7: Memory usage performance with nodes increment & simulation area 500x500

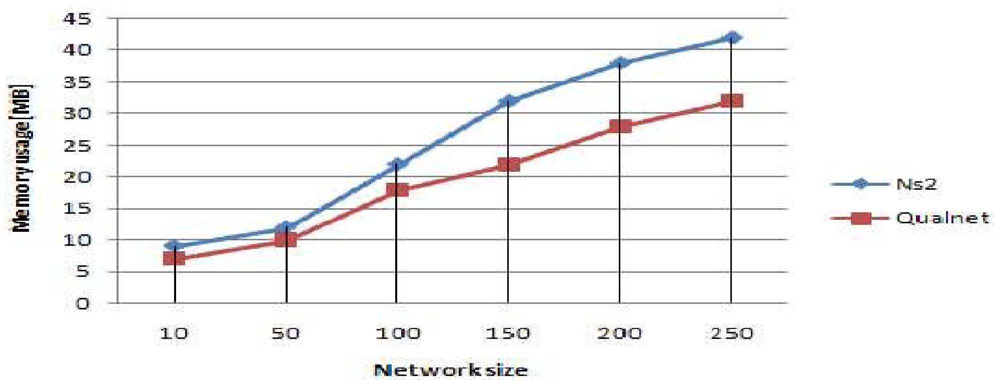


Figure 3.8: Memory usage performance with nodes increment & simulation area 250x250

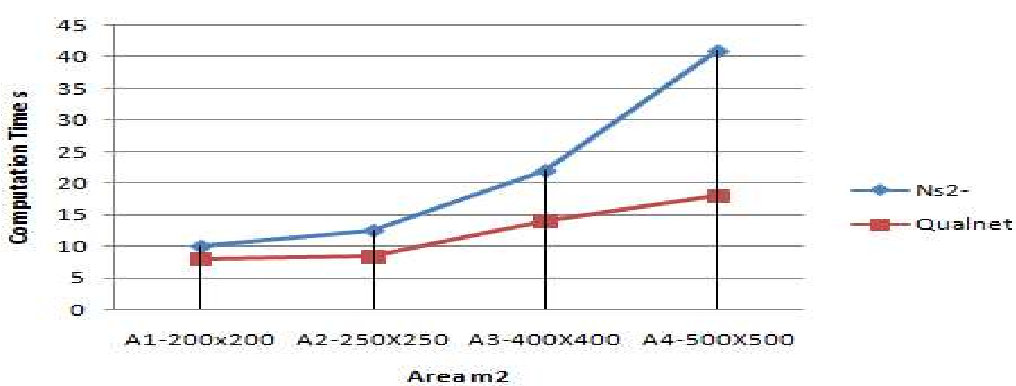


Figure 3.9: computation time performance with change in simulation Area for ixed network size 200 nodes

For comparative study we also observed how the routing protocols perform under different simulators with effect and limitations of simulators. We have considered two parameters namely throughput and end to end delay. We have used NS2 and Qualnet for simulations. AODV and OLSR have been simulated to assess the performance. The channel frequency is set to 2.4 GHz for random waypoint mobility model. The simulations are carried out at node density of 0, 50, 100, 150, 200, 250, 500, 750 and 1000 with CBR traf ic and packet size of 512 bytes. The simulation parameters are listed in table 3.3.

Parameter	Value
Channel Type	**Wireless**
Radio Propagation Model	**Two ray ground**
Network Interface Type	**Phy. /Wireless**
MAC Type	**Mac/ 802.11**
Antenna	**Omni Antenna**
Maximum Packet	50
Area	**1500m x 1500m**
Number of Nodes	**0 to 1000**
Simulation Time	**500 sec**
Routing Protocol	**AODV, OLSR**
Speed of Nodes	**2 m/s**

Table 3.3: Simulation Parameters

We have evaluated throughput and end to end delay.

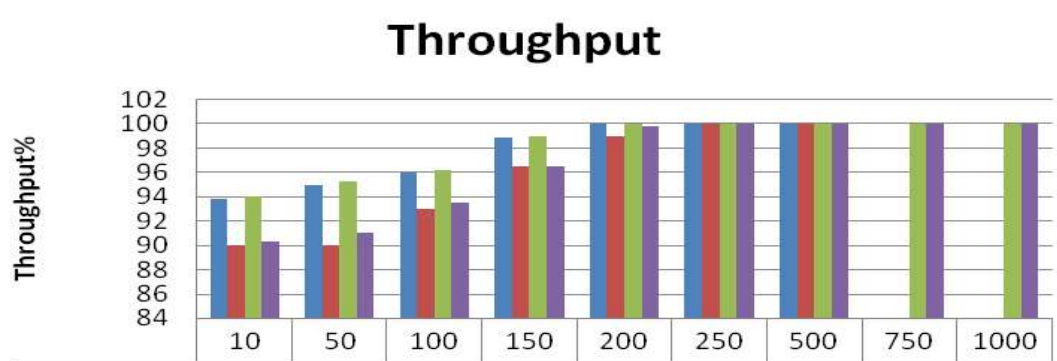
Throughput: It is de ined as the percentage of the number of packets that are received by the destination(s) against the number of packets sent by the source(s).

Throughput = (Data packets received / Data packets sent) x 100

End to end delay: It is the average amount of time that is taken by a packet to reach inal destination from source. It is the sum of delays at links.

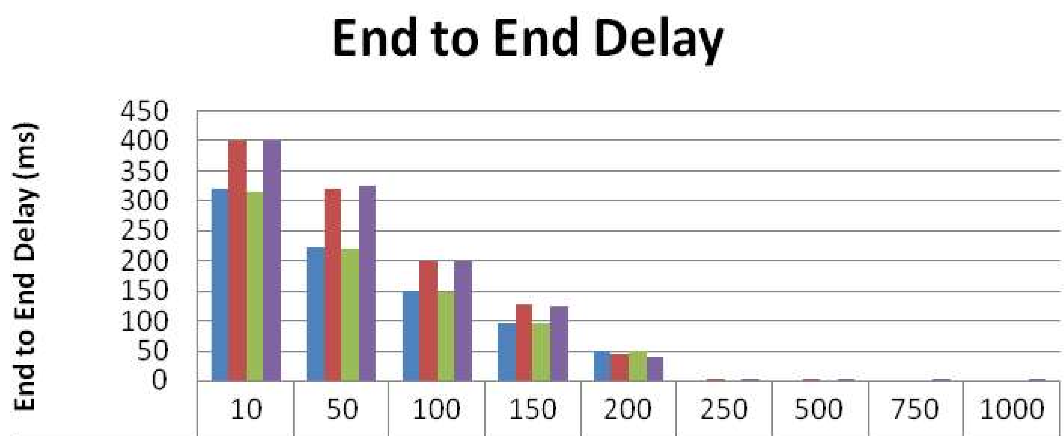
Average delay = Σ (tr - ts)/Pr, where ts is the packet send time and tr is the packet receive time.

Figure 3.10 shows the throughput for AODV and OLSR under both NS2 and Qualnet. Similarly, igure 3.11 and 3.12 shows the end to end delay. When node density increases, the throughput increases up to a certain point and then becomes constant. This is due to the fact that as density increases, more nodes become reachable. It happens because more nodes are covered by transmission range, so packets can be transferred with high success probability. Similarly, with increase in density the end to end delay decreases. OLSR performs better than AODV. This is due to the fact that, OLSR being a proactive protocol stores the whole route information before communicating packets. And with increase in density, the link breakage is not so often. Reverse is the case with AODV, as it is a reactive protocol. We observed that NS2 fails to simulate the network under heavy load, while Qualnet easily does the job.



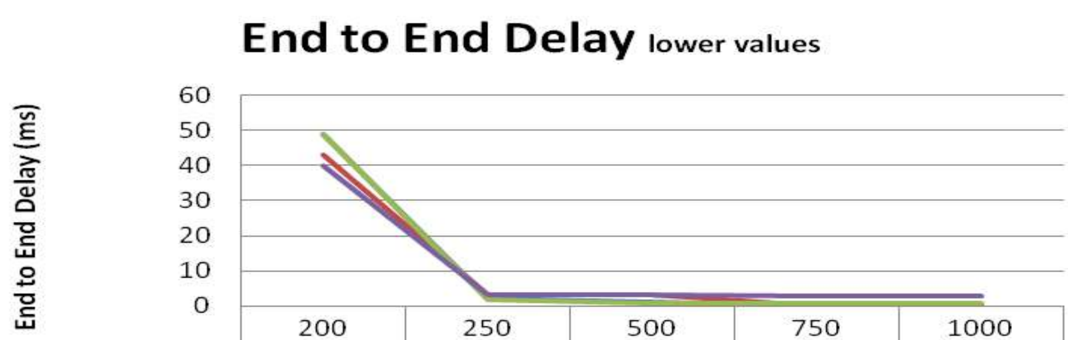
	10	50	100	150	200	250	500	750	1000
OLSR-NS2	93.8	95	96	98.9	100	100	100		
AODV-NS2	90	90	93	96.5	99	100	100		
OLSR-Q	94	95.3	96.2	99	100	100	100	100	100
AODV-Q	90.3	91	93.5	96.5	99.8	100	100	100	100

Figure 3.10: Throughput under variable node density



	10	50	100	150	200	250	500	750	1000
OLSR-NS2	320	224	150	96	49	2	1		
AODV-NS2	400	320	200	126	43	3	3		
OLSR-Q	316	220	148	95	49	1.9	0.7	0.7	0.7
AODV-Q	402	325	200	125	40	3.5	3.5	3	3

Figure 3.11: End to end delay for variable node density



	200	250	500	750	1000
OLSR-NS2	49	2	1	0	0
AODV-NS2	43	3	3	0	0
OLSR-Q	49	1.9	0.7	0.7	0.7
AODV-Q	40	3.5	3.5	3	3

Figure 3.12: End to end delay for variable node density (lower values)

3.3 Conclusion

In this chapter, we have compared basic features of Network simulators including NS2 & Qualnet. We investigated their performance and the scalability of the tools as well as we simulated two widely used protocols namely AODV (reactive) and OLSR (proactive) under varying node density. The same set of conditions was employed on two simulators Qualnet and NS2. OLSR was able to perform better. NS2 was unable to perform under heavy load. Our result shows that while both Ns2 and Qualnet are ef icient for carrying out small-scale network simulations: however for a moderate scaled network Qualnet has been found to be better in terms of network speed, memory consumption and for larger areas.