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Comparative Study of Routing Protocol Performance in Mobile Ad hoc Network

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Abstract

Over the decades amazing progress has been observed in the world of wireless and mobile communication that ushers in the era in which laptops, smartphones and sensors have become pervasive, inexpensive and rapidly available. Due to the high mobility and dynamic nature of the network finding an effective and efficient routing protocol for a particular scenario is often a challenge. This paper basically focuses on the comparative study of the performance of the routing protocols (Ad hoc On-demand Distance Vector (AODV), Dynamic Source Routing (DSR), Optimized Link State Routing(OLSR)) using OPNET (Optimized Network Engineering Tool). Four scenarios were created, and each scenario with different nodes and run on three application services (HTTP, FTP and Video conferencing). The performance of the protocols was compared based on certain metrics (Throughput, end-to-end Delay, Load). The simulation results show that the AODV on the average performed better than OLSR and DSR, but OLSR will be preferred for real-time application and higher number of connected nodes in a MANET system.

Keywords: WLAN, AODV, DSR, OLSR, MANET, HTTP and FTP

1. Introduction

Over the decades amazing progress has been observed in the world of wireless and mobile communications that usher in the era in which laptops, smartphones and sensors have become pervasive, inexpensive and rapidly available (Ray, 2003). Originally the difference between wireless network and wired network is in term of their communication channel. In Wired network a physical medium exist while in wireless network there is no physical medium. Due to the rising of inexpensive and rapidly available wireless devices, a wireless network has gained popularity in different applications. Their deployment in those applications is based on certain factors such as ease of installation, security, reliability and network performance (Zasad & Uddin, 2010).However the communication between these wireless devices is often achieved by two approaches*: infrastructure based and infrastructure-less based*.

Infrastructure is the traditional wireless networks approach in which all the activities in the wireless network is being controlled by an infrastructure backbone, the devices communicate with the access point which could be a base station connected to a fixed infrastructure network. Example of this kind of network includes GSM, Wireless LAN (WLAN) (Hoebeke et al., 2004)(Hosek, 2011).

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Infrastructure-less approach is an important part of communication technology, devices communicate with each other and route information to a remote end without being supported by any fixed infrastructure network and performs self-configuration when needed. Example of this approach is MANET (Mobile Ad-hoc Network) (Hoebeke et al., 2004)(Manoharan et al., 2016) (Zafar et al., 2016).

However the operation of most wireless devices is often based on cellular or wireless area networks, not considering the advantage offered by mobile ad hoc networking. MANET is a self-organized network of mobile computing devices (laptops, smarts phones, sensors) that communicate with each other over a wireless links without a fixed infrastructure (Mohapatra et al., 2012) (Manoharan et al., 2016). Having no fixed infrastructures, the nodes cooperate in a distributed manner to provide the needed functionality. Due to its infrastructure less nature, MANET paves ways for exciting benefits such as access to information regardless of the geographic position, scalable network, and improved flexibility.

MANET being an autonomous network does not rely on any fixed infrastructure in which each user communicate directly with an access point or base station. However in MANET, nodes are responsible for dynamically discovering nodes within range. Intermediate nodes act as a router to relay information between nodes that are not directly connected (Aarti, 2013)(Hosek, 2011).

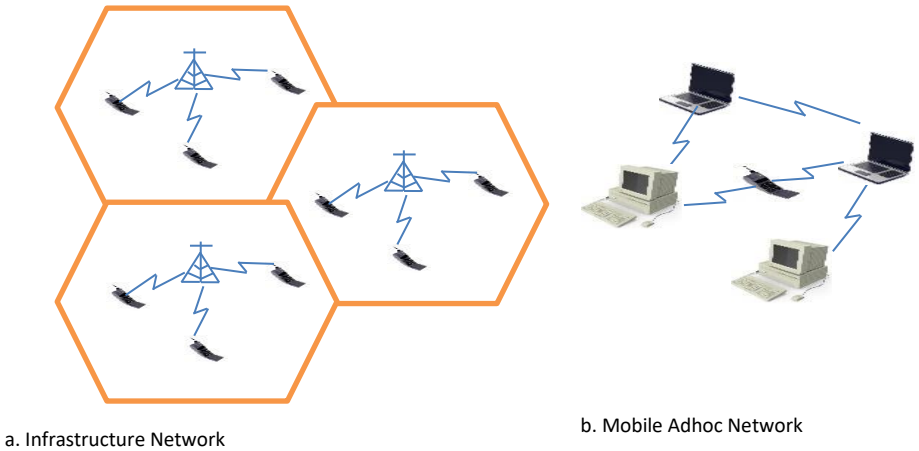

Figure 1: The architecture of cellular network and Mobile ad hoc network (Hoebeke et al., 2004).

In (Subramanya Bhat et al., 2011), they defined routing as the process of selecting a path in a network through which data can be sent. Since nodes in MANET act as a router relaying messages for other nodes within the network, an efficient routing protocol is needed to establish communication path between nodes without causing an excessive routing overhead.

Routing protocols in MANET are broadly categorized into three: ***Proactive, Reactive and Hybrid*** (Ray, 2003) (Subramanya Bhat et al., 2011)(Mohapatra & Kanungo, 2012)(Aggarwal et al., 2011)(Ahmad et al., 2016).

Proactive routing protocol also known as table driven protocol is a modified version of the traditional link state routing protocol in wired network. Each node maintains two or more tables representing the topology information of the network, the table is updated on a regular basis to get up-to-date routing information of each and every

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node. As a result of this the routing overhead tends to be high; however routes are always available on request. Examples of proactive protocols include OLSR (Optimized Link State Routing), DSDV (Destination Sequenced Distance Vector) (Ray, 2003)(Aarti, 2013) (Subramanya Bhat et al., 2011) (Mohapatra et al., 2012) (Zasad et al., 2010)(Hosek, 2011).

Reactive or on demand routing protocol is a protocol that set up routes only when needed. Like when a node wants to send a packet to another node, the protocol set up a route request and establishes connection in order to transmit and receive packets. It set up routes by flooding the route request throughout the network. The advantage of this protocol is that the routing overhead is reduced at the same time the latency is increased, they do not maintain up-to-date information about the network. Examples of reactive protocols include Ad hoc On-demand Distance Vector (AODV), Dynamic Source Routing (DSR), and Temporary Ordered Routing Algorithm (TORA) (Ray, 2003)(Aarti, 2013) (Subramanya Bhat et al., 2011) (Mohapatra et al., 2012) (Zasad et al., 2010)(Aggarwal et al., 2011)(Hosek, 2011).

Hybrid routing protocol combines the advantages of reactive and proactive routing protocols. Nodes that are close to each other are updated proactively while routes that is far away are set up reactively. Example includes ZRP (Zone Routing Protocol) (Ray, 2003)(Aarti, 2013) (Subramanya Bhat et al., 2011) (Mohapatra et al., 2012) (Zasad et al., 2010).

Performance Matrix tools are used in evaluating or measuring the efficiency and effectiveness of a system and they are packet data ratio (PDR), throughput, end-to-end delay and jitter (Gulati et al., 2014)(Zafar et al., 2016)(Aggarwal et al., 2011)(Manoharan et al., 2016)(Mallapur et al., 2012).

Packet delivery Ratio (PDR) is the ration between the number of packets transmitted by a traffic source to the number of packets received by a traffic sink. *E2E delay* is the average delay time that the system experience from source to destination, when the E2E delay is low it is assumed that performance of the system is better. *Throughput* is the total packet that successfully delivers at the destination over a period of time. Jitter is the delay variation between each received packets. while Normalized Routing Load (NRL) is the number of routing packets transmitted per data packets delivered to the destination (Zasad et al., 2010) (Gulati et al., 2014)(Manoharan et al., 2016)(Zafar et al., 2016)(Aggarwal et al., 2011)(Ahmad et al., 2016). For an ideal system it is expected to have the following as shown in Table 1

Table 1: Ideal case of a MANET system

Performance matrix	**Indicator**
Packet delivery Ratio	High
End-to-End Delay	Low
Throughput	High
Jitter	Low
Normalized Routing Load	Low

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2. Related Works

Ray(2003) in his thesis considered OLSR, AODV and ZRP, each routing protocol representing the three types of routing protocols explained earlier. (Ray, 2003) focused on heterogeneous mobility behaviour of MANET by introducing GEMM (Generic Mobility Model) and simulated for 50 nodes between 0 – 300 secs at 30 secs interval. He discovered that OLSR out-performed the other two routing protocol in terms of packet delivery, routing overhead, number of dropped packet, speed variation and packet delivery for group mobility , while ZRP performed moderately than AODV (Ray, 2003).

Zasad et al.(2010) used OPNET simulation tool to evaluate the performance of AODV, DSR, GRP and OLSR on non-real time application (such as HTTP and FTP) traffic. They used 4 evaluation performance matrix (packet delivery fraction, normalized routing load, throughput and end to end delay) to study how the above mentioned routing protocol performed between 10 to 50 nodes and the simulation time was 150 secs. It was discovered that DSR performance was very low for non-real time application for all the four performance matrix while OLSR was considered as the most stable routing protocol (Zasad & Uddin, 2010).

Subramanya Bhat et al.(2011) conducted a simulation on hybrid, proactive and reactive routng protocols (AODV, DSR and LAR, ZRP and OLSR) and compared their analysis using Qualnet 5.0.2 simulator for mobile and stationary mode between 25 -250 connection using above menationed performance matrix (Subramanya Bhat et al., 2011). For Stationary mode, it was discovered that all AODV, DSR, LAR performed far better than OLSR, while ZRP performance was below average. For Mobile mode, using a scale of preference to indicate their performance LAR, AODV, DSR, out-performed OLSR and ZRP respectively (Subramanya Bhat et al., 2011). When the number of node was 50, all routing protocols mentioned except ZRP performance was above 95%. They concluded that DSR and AODV will perform better for applications that are not suceptible to jitter, and throughput on the average while OLSR will suit a large and dense environmen with random and sporadic changes between nodes (Subramanya Bhat et al., 2011)

Mohapatra et. al.(2012) conducted a performance analysis AODV,DSR OLSR and DSDV using NS2 Simulator. They used four performance matrix used in Zasad et. al. to explain their results. DSR performed excellently when packet data ratio was considered, while OLSR was performed better when mobility of nodes were considered, DSDV recorded the highest throughput when compared to DSR and OLSR that performed moderately when the network area is increased (Mohapatra & Kanungo, 2012).

In paper (Soliman, 2003), he focused on AODV strengths and weakness using above mentioned performance matrix using OPNET simulator. Soliman simulated for (3, 16 and 40) nodes and discovered that average E2E (End-to-End) delay increased exponentially initially but stabilized but high over time which implies that has the number of node increases with mobility of nodes the performance of AODV degenerates as a logarithm function (Soliman, 2003).

Gulati et al.(2014) conducted a simulation between AODV,DSDV and DSR using NS2 simulator, and used performance matrix to compare the analysis generated. AODV performed better on an average performance index but not the best (Gulati & Kumar, 2014).

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Carvin et al.(2002) considered the accuracy of popular simulators used in conducting MANET experiment which were OPNET(Optimized Network Engineering Tool) Modeler, NS-2 and GloMoSim respectively. Several scenarios were simulated considering random waypoint model for all the three simulators, it was discovered that all the three simulators had an antithetical results and concluded that there will be need to develop an hybrid simulator to close this gap (Cavin et al., 2002). Andel et al.(2006) concluded that the credibility of a MANET simulator is hard to detect but if the researcher conducting the simulation can take extra-mile to understand the documentation of the simulator and how it works, test the simulator beyond its operating capability and run multiple number of simulation and compare the output (Andel et al., 2006)

Zafar et al.(2016), analysed and compared throughput and delay in AODV, DSDV and DSR in a MANET using NS-2 simulator. They discovered that has the network topology and speed of the mobility are increased, DSR out performed AODV and DSDV performed leased. This indicate that when a MANET system has a large number of nodes it is preferred to use DSR (Zafar et al., 2016).

Motivation of this paper is to investigate the performance of MANET routing protocols using OPNET simulator and analyse their results based on performance matrix explained earlier. Literature shows that AODV has the best performance when compared to other types of routing protocol when non real-time applications services are used over the network. However, three different services were simultaneously transferred over the network which consisted of non-real time and real-time applications which was quite distinct.

3. Methodology

In this paper Optimized Network Engineering Tool (OPNET) was used to measure the performance of some routing protocols (AODV, DSR and OLSR) in MANET. Four scenarios were created, the first scenario consists of 10 nodes, the second scenario consists of 20 nodes, the third scenario consists of 30 nodes and the last scenario consists of 40 nodes as shown in Fig. 2 Each scenario was made to run three application services (HTTP, FTP and Videoconferencing). The data was analyzed using certain metrics- Throughput, network load, retransmission attempt, delay as shown in Table 2.

Table 2: Simulation Parameter

Simulation Parameter	**Value**
Area	Campus Network
Mobility model	Random waypoint
Number of nodes	10,20,30,40
Protocols	OLSR, AODV, DSR
Traffic Type	FTP, HTTP, Video Conferencing
Simulation time	1200 sec
Transmission power	16.99dBm
Date rate	11Mbps
Operation Mode	IEEE 802.11b
Performance Metrics	Traffic sent, Traffic received, Throughput, Delay

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4. Result Analysis

The simulation was performed in multiple for a period of 1200 sec (20 min), the metrics used for the performance comparison include: Data Dropped Rate (bits/sec), Delay (sec), Load (bits/sec), Retransmission Attempts (packets) and Throughput (bits/sec).Due to the user-friendly graphical interface of the OPNET we were able to overlay the three protocols on a single graph for easy analysis.

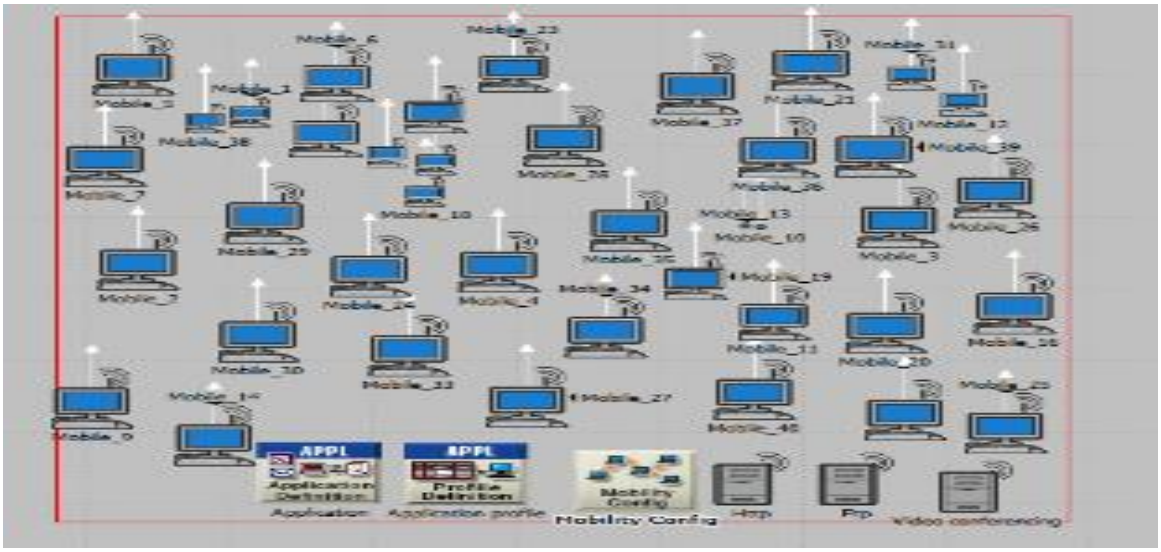

Figure 2: Network Topology of MANET

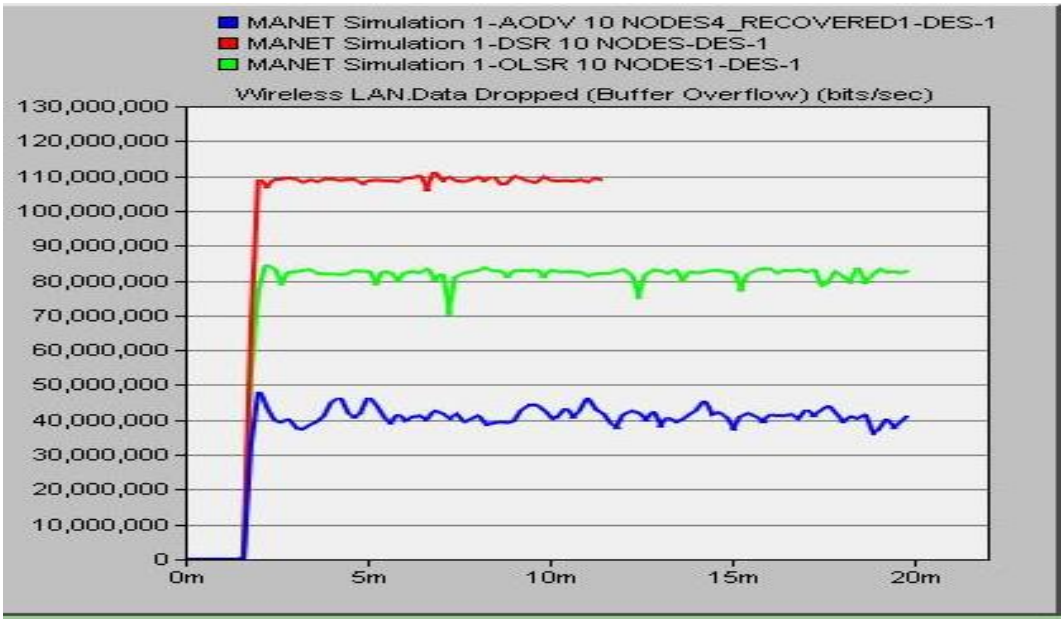

Figure 3 : Overall wireless LAN data drop performance at 10 Node

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However during our simulation something interesting was observed in the performance of Dynamic Source Routing (DSR) protocol. It was observed that DSR does not scale well in high network density as shown in Fig.4, this is due to the irregularities observed in its performance i.e when there was excessive data coming into the network such that it was not easy for the protocol to cope with such traffic the simulation stopped and this can be seen in its graphs compared to other protocols. We tried to prove this by first reducing the simulation time to 600 sec (10min) and still DSR was unable to complete the simulation.

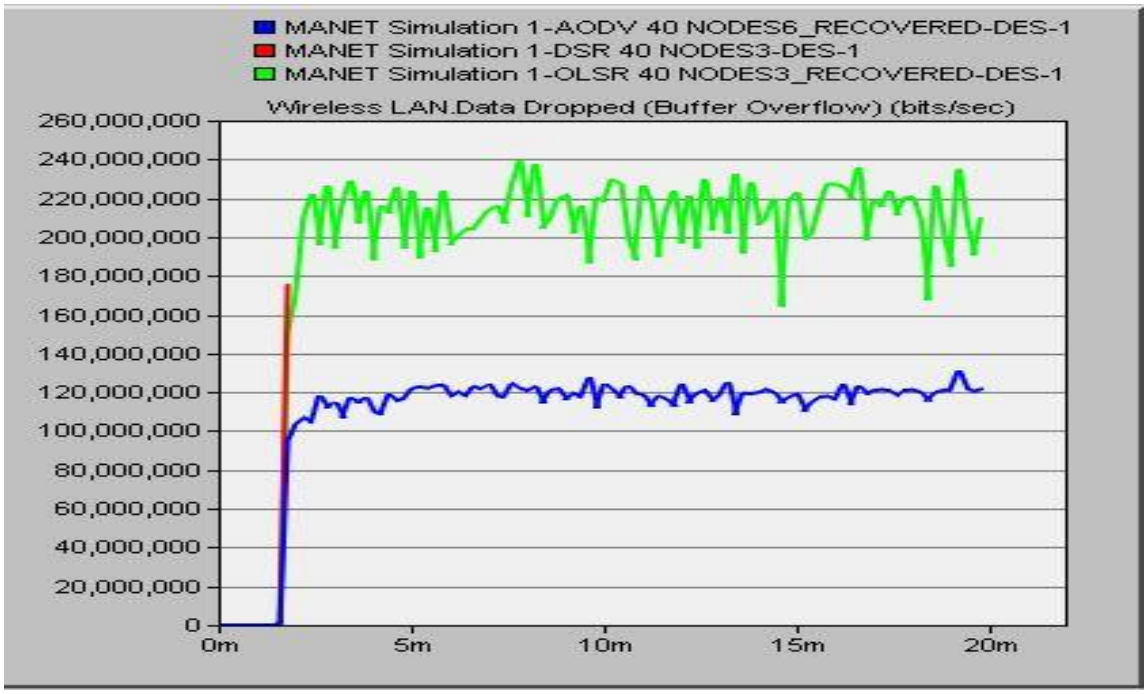

Figure 4: Overall wireless LAN data drop performance at 40 Mode

Then we reduced the simulation time again to 300sec (5min) and a slight improvement was seen in its performance like in the scenario of 10 nodes, the simulation did not stopped but as the number of nodes was increased, the network crashed again see Fig.4 ,Fig 5 and Fig. 6 respectively.

Then finally we decided to reduce the number of application services being run to two (HTTP & FTP / FTP & Video conferencing), since we are running three applications services initially (HTTP, FTP & Video conferencing) .This is contrary to most researches conducted by other scholars in which they either run two application services concurrently or one but it was rare to run three application services at once as we did in this project. This explains why a case like this was not recorded in the review. As the application services were being reduced, the performance of DSR also improved as the simulation time was completed without crashing.

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In Fig.6 it was shown that the more you load the wireless network the better OLSR performs. When the number

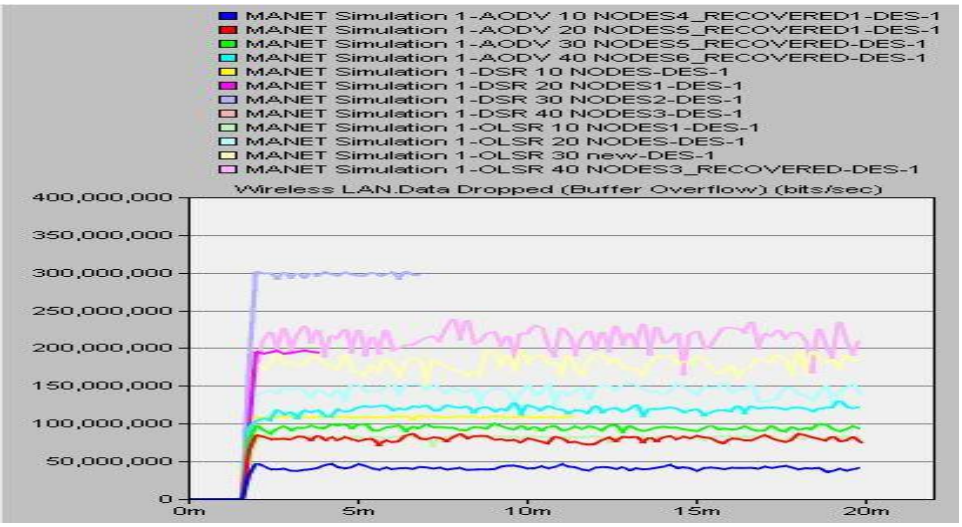

Figure 5: Overall data dropped for all the Scenarios (10 -40

of nodes are increased the least of OLSR i.e at 10 Nodes could accommodate more loads on the network than AODV and DSR between 10 -40 nodes.

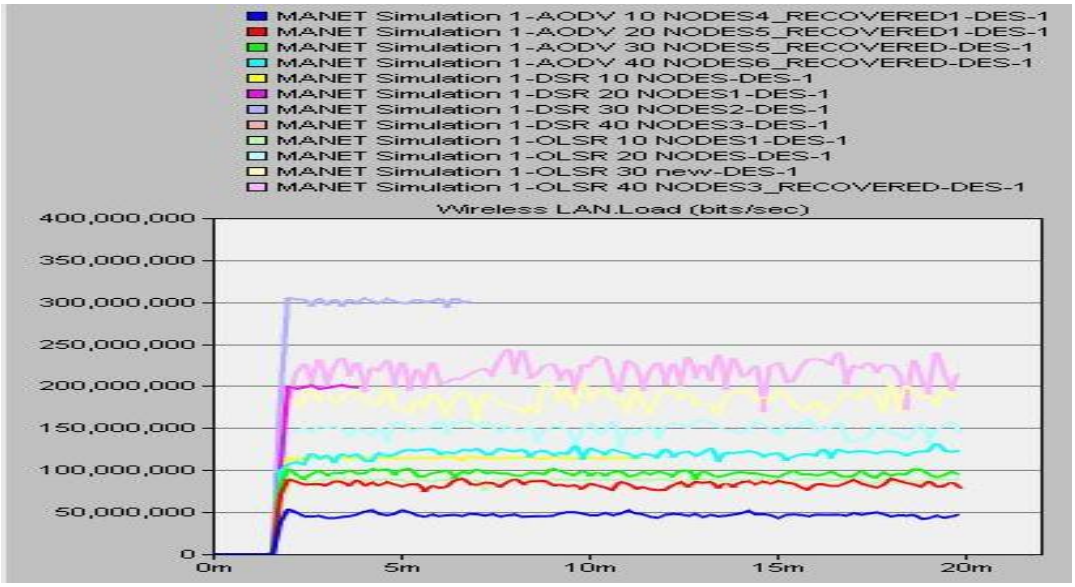

Figure 6: Wireless LAN Overall Load for all the Scenarios

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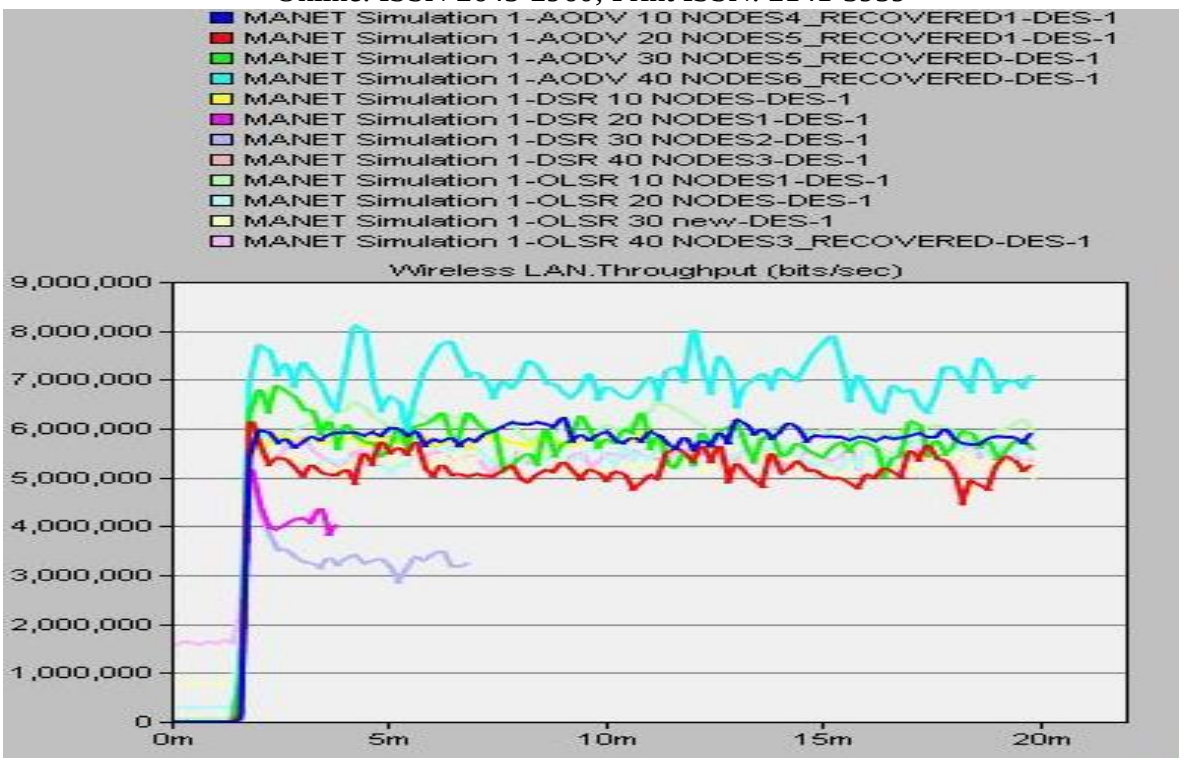

Figure 7: Wireless LAN Overall Throughput for all Scenarios

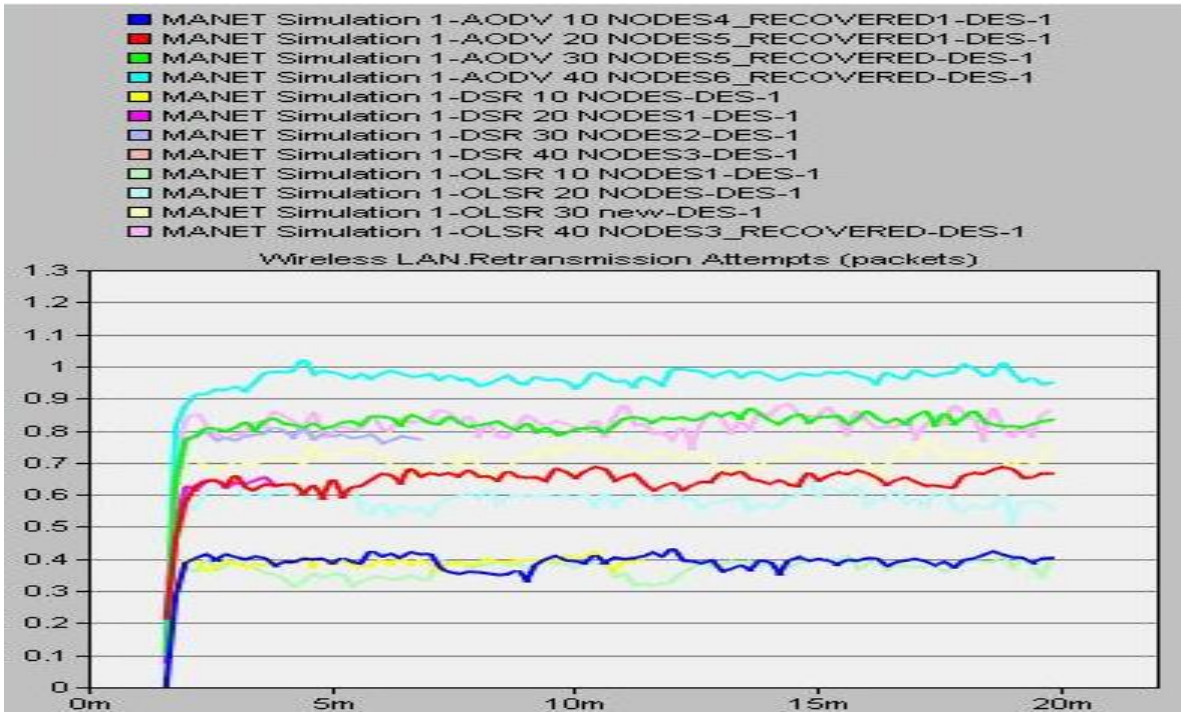

Figure 8: Wireless LAN Overall Retransmission attempt for the scenarios

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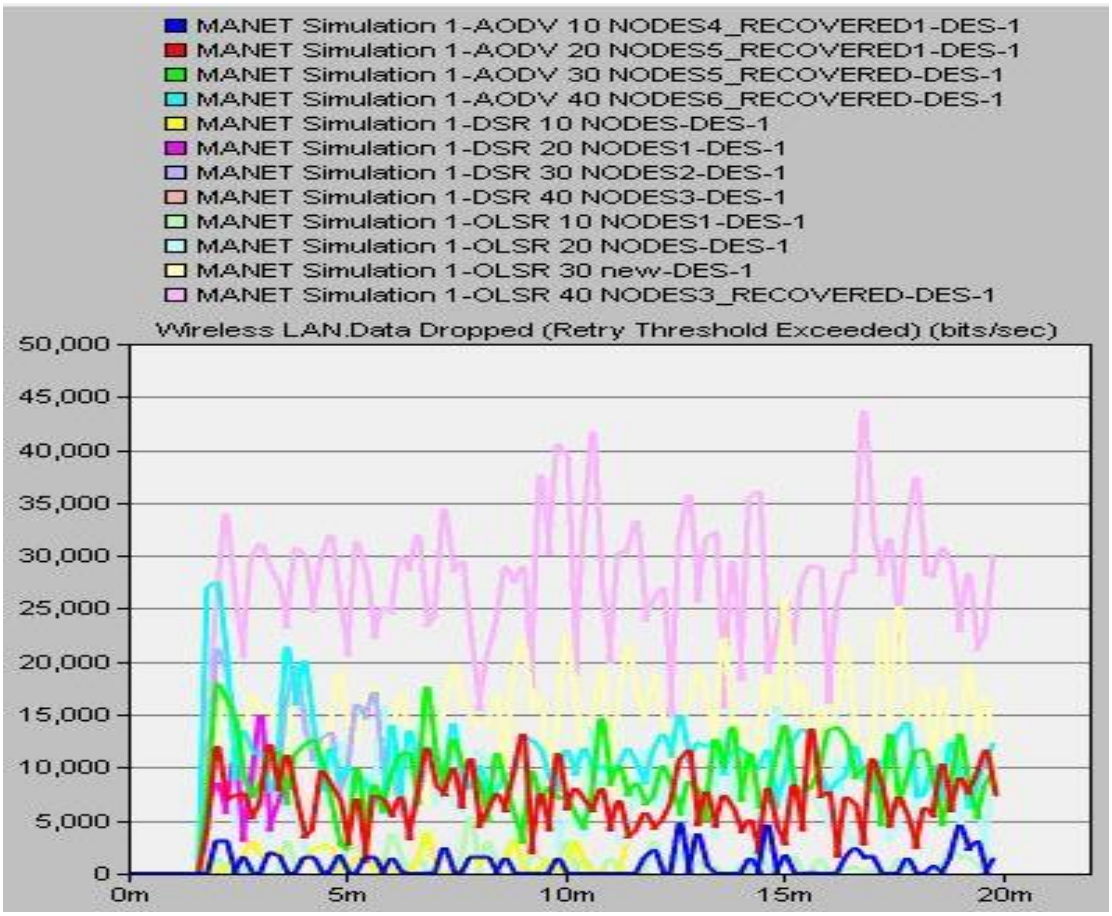

Figure 9 : Overall Data Dropped (Retry Threshold Exceeded) for all the scenarios

Data dropped was considered for buffer overflow and retry threshold exceeded as shown in Fig. 6 and Fig. 9 respectively. Data are dropped by higher layer data traffic as a result of constant failing retransmission of packet. The higher the number of node the higher the number of packet being dropped, AODV outperformed DSR while OLSR was least.

DSR had the highest value for E2E delay initially but stabilized over time as the number of node increased as shown in Fig. 10. In Fig. 10 it can be seen that at 40 nodes AODV had the highest value for E2E delay accounting for its nature i.e it establishes route only when needed but as the network size increases the time it takes during route recovery also increase therefore resulting in delay. OLSR performed better than AODV and DSR at 40 nodes indicating that OLSR can be used for low latency applications

Table 3 shows a summary of AODV, DSR and OLSR routing protocol performance at the peak of the simulations.

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Table 3: Summary of QoS Metric Performance

QoS metric			AODV	DSR	OLSR
Data dropped(Buffer Overflow)			Low	High	Moderate
Data dropped(Retry threshold Exceeded)			Low	Moderate	High
Delay			High	Moderate	Low
Load			Low	Moderate	High
Network load			Low	Moderate	High
Media Access Delay			High	Moderate	Low
Retransmission attempt			High	Moderate	Low
Throughput	High	Low	Moderate		

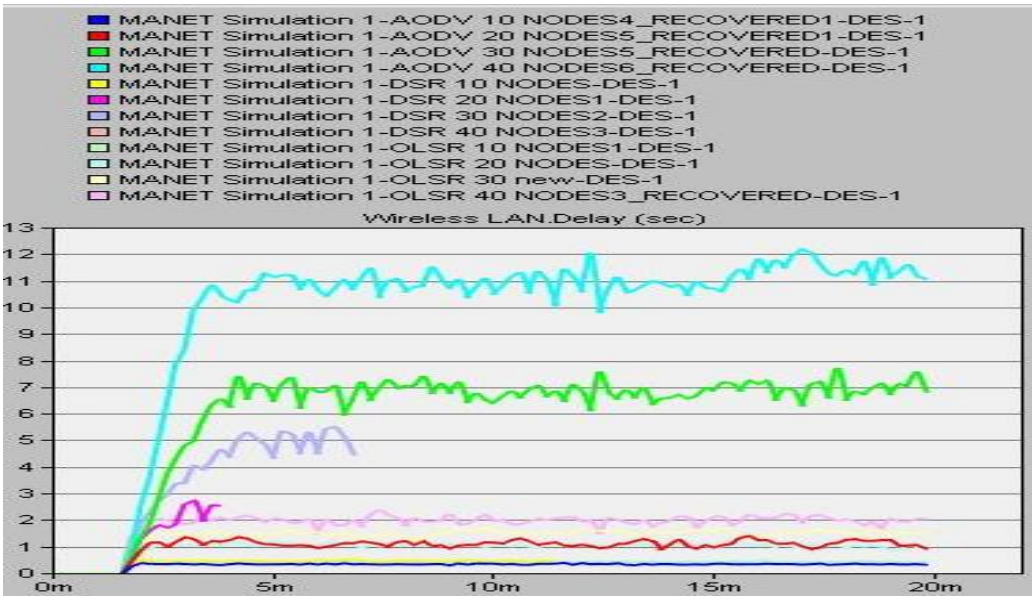

Figure 10: Overall Delay for all the scenarios

5. Conclusion

The analysis of the protocols was divided based on Simulation. Routing protocol selection must be dependent on the network environment. From the results of the simulation it can be concluded that AODV has a better all-round performance of all the three protocols, followed by OLSR and the performance of DSR can be said to be poor. The versatility of AODV is due to the fact that it is an improvement of DSR. It is also suitable in an environment where MANET has to be deployed in a large network for a small amount of time due to its low packet loss ratio. On the other hand the use of OLSR is recommended in a low mobile environment with small number of nodes and for real-time application. As shown in the simulation results there is probability that it would not obtain route quickly enough in a large network thereby increasing the overall convergence time and also resulting to delay while DSR is not efficient for large and high density network in terms of traffic and delay as observed during simulation in which the network crashed as the application services was too much for it to handle.

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