The Impact of Routing Protocols on the Performance of a Mobility Model in Mobile Ad Hoc Network (MANET)

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Abstract. Mobile Ad Hoc Network (MANET) comprises a group of mobile or wireless nodes that are placed randomly and dynamically which causes the constant change between nodes. When considering a routing protocol to deploy in any given situation on MANET, factors such as the mobility model, mobility of nodes, the network size and packet size should be carefully considered because the routing protocols configured with the mobility model can highly affect the performance of MANET. This paper analysed the impact of two different routing protocols (i.e. Dynamic Source Routing (DSR) and Optimized Link State Routing (OLSR)) on the performance of Random WayPoint (RWP) mobility model. Three measures of performance metrics (i.e. average throughput, average delay and average traffic received) were used. In all three-performance metrics, the simulated results indicated that Random Way-Point (RWP) configured with OLSR protocol performed better than RWP configured with DSR protocol. This indicates that the choice of a routing protocol for a specific mobility model should be considered in a network design.

Keywords: MANET · Mobility model · Routing protocols
Pause time · Average delay · Average throughput · Average traffic received

1 Introduction

MANET consists of a group of mobile or wireless nodes that communicate together. This indicates that the mobiles nodes can communicate and share information without the help of any central device. On MANET, the network topology (i.e. the physical connectivity of communication in a network) changes frequently since nodes are mostly in motion [14, 16, 17]. The communication between active nodes is made possible through routing protocols. In other words, routing protocols determine the route(s) that packets need to follow from the source node to the destination node. The overall performance of MANET greatly depends on the communications and agreement between mobile nodes [1, 2, 7, 8].

The aim of a mobility model is to portray the movement pattern of mobile nodes in MANET under different network scenarios. Nodes can move in any direction and at any speed. During movement, mobile nodes can pause at regular intervals or may not stop at all. It is important to consider the movement patterns of the mobility models

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when analysing the performance of MANET. In Random WayPoint (RWP), mobile nodes normally wait for a period (pause time) before it moves to its destination at a given speed. Mobile nodes in RWP normally travel near the centre of the simulation area [9, 12, 15].

In this paper, OLSR and DSR were used because OLSR is a proactive routing protocol whiles DSR is a reactive routing protocol. The difference is that, DSR determines proper route when a packet is required to be forwarded whereas with OLSR, all nodes study the network topology before a forward request comes in. In situations like this, mobility model's role is very crucial because a mobility model specifically depicts the pattern of mobility and the features of real mobile nodes for particular scenario, and as such, this will be the dimension for accurately examining the effectiveness of a protocol for a particular scenario [2].

The aim of the paper is to analyze the impact that routing protocols have on the performance of Random WayPoint (RWP) mobility model. The objective of this paper is to examine routing protocols and their impact on the performance of MANET.

This paper is arranged as follows: Sect. 2: methodology, Sect. 3: results, Sect. 4: conclusion and Sect. 5: future work.

2 Methodology

OPNET is used as the simulation environment because of its ability to offer a complete modeling environment for unique design, simulation and analysis of the performance of any network [3, 4]. It also has the capability to model or modify MANET mobility models and routing protocols [5, 6, 13, 18, 19]. Two routing protocols and one mobility model are used in analysing the same network sizes, same speeds, pause time and traffic loads. The network standard used was 802.11 g and all the nodes are mobile. Scenarios are used to compare the performance of two different routing protocols in MANET. The OPNET simulation was carried out in an area of 500 m $\times$ 500 m and all the scenarios have an equal node size of 500 mobile nodes. The objects available in the simulation environment are mobile nodes, mobility, application and profile. For the configuration of node speeds, Random Waypoint model with Vector trajectory was used. The node speed of 5–10 m/s is also used. The used pause time is 5 s. File Transfer Protocol (FTP) and Electronic mail (E-mail) are the data types that generate traffic. The data rate that Media Access Control (MAC) uses to transmit data frames through the physical layer is 24 Mbps. Each scenario was simulated six times (to get more consistent and accurate results) [19] in a 3600 s simulation time. The general simulation parameters and the parameters for the chosen routing protocols are shown in Tables 1, 2 and 3.

Two scenarios are configured using DSR and OLSR protocols. The mobility configuration object is used for the configuration of mobility model, node's speed and pause time. Explanation of the network scenarios can be seen in Table 4.

Throughput, end to end delay and routing traffic received are the performance metrics used to measure the performance of MANET. **Throughput** is the average rate

Table 1. General simulation parameters

Parameters	Value
Number of nodes	500
Network area	500 × 500 square meters
Mobility model	Random WayPoint
Routing protocol	Optimized link state routing; Dynamic source routing
Speed	5–10 meters/second (m/s)
Pause time	5 seconds (s)
Traffic/data type	FTP; E-mail
Data rate	24 Mbps
Simulation time	3600 s

Table 2. OLSR parameters

OLSR	
Parameters	Values
Willingness	Default
Hello interval (sec)	2.0
TC interval (sec)	5.0
Neighbour hold time (sec)	6.0
Topology hold time	15.0

Table 3. DSR parameters

DSR	
Route expiry time (route cache)	300
Request table size (nodes) (route discovery)	64
Max Request retransmission (route discovery)	16
Max request period (sec) route discovery	10
Max buffer size for route maintenance (packets)	50
Maintenance hold time (sec)	0.25
Max maintenance retransmission	2
Maintenance acknowledgement timer (sec)	0.5
Route replies using cached routes	Enabled
Packet salving	Enabled

of data packets received successfully over a communication path and is measured in bits per second (bits/sec) [7]. Mathematically, Throughput (S) can be represented as in Eq. 1:

$$S = Number\_deliveredpacket * Packet\_size * 8/Total\_simulationtime \quad (1)$$

Table 4. Network scenarios

Network scenarios	
Scenario	Description
1: Random WayPoint OLSR	• This network has 500 nodes • It implements the OLSR protocol • Mobility speed is 5–10 m/s • Pause time is 5 s
2: Random WayPoint DSR	• This network has 500 nodes • It implements the DSR protocol • Mobility speed is 5–10 m/s • Pause time is 5 s

Delay (end-end) is defined as the time taken to pass through from a source to a destination node and is measured in seconds (s). These delays are caused by processing, queuing, transmission and propagation [7]. Mathematically, Delay (D) can be represented as in Eq. (2):

$$D_{end-end} = N\ [D\ trans + D\ prop + D\ proc] \quad (2)$$

where $D_{end\text{-}end}$ = End-End Delay, D_{trans} = Transmission Delay, D_{prop} = Propagation Delay, D_{proc} = Processing Delay and N = Number of Nodes.

Equations 1 and 2 will be implemented in Microsoft Excel to generate the correct results.

Routing Traffic Received is defined as the amount of routing traffic received in bits/sec in the entire network. For best effort traffic, throughput and end to end delay are the most essential metrics to take into consideration. Lower throughput and great delays may occur when there are large overheads. All the same, a short delay does not mean higher throughput because delay is only measured in data packets delivered successfully.

3 Results

The simulation results are grouped as follows: Random WayPoint (RWP) DSR versus Random WayPoint (RWP) OLSR.

Random WayPoint (RWP) DSR versus Random WayPoint (RWP) OLSR
Figure 1 shows that Random WayPoint configured with OLSR performed better in terms of average throughput by delivering 182321.0 bits/sec of data, which is 78% of the total data. Random WayPoint DSR had the lowest average throughput by delivering only 50455.9 bits/sec of data, which is 22%. The percentage value for RWP OLSR was calculated as follows:

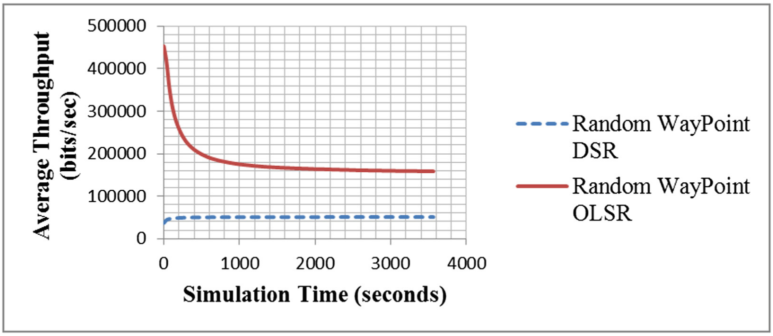

Fig. 1. Average throughput for RWP DSR & RWP OLSR

$$\text{Average throughput of RWP OLSR } \div \text{sum (RWP OLSR, RWP DSR average values)} \times 100$$

$$= 182321.0 \div (182321.0 + 50455.9) \times 100$$
$$= (182321.0/232776.9) \times 100$$
$$= 78.3\% \sim \mathbf{78}\%$$

This same formula was used to calculate the average percentages for all values in all scenarios.

Figure 2 shows that Random WayPoint OLSR recorded no delay at all. It had an average delay of 0.02 s. The highest average delay of 24.2 s was obtained by Random WayPoint DSR. This means that RWP OLSR had 0% delay while RWP DSR had 100% delay.

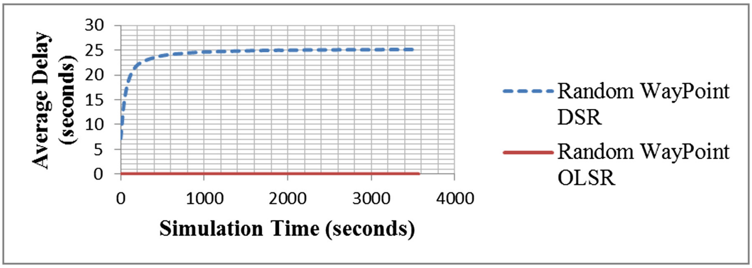

Fig. 2. Average delay for RWP OLSR & RWP OLSR

In Fig. 3, it could be seen that the average routing traffic received in Random WayPoint OLSR performed better in delivering 2110434.8 bits/sec of traffic or data, which is about 72% of total traffic. Random WayPoint DSR on the other hand delivered 812623.1 bits/sec of traffic, constituting only 28% of the entire traffic.

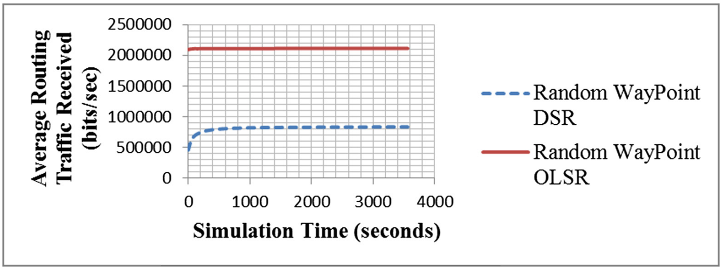

Fig. 3. Average routing traffic received for RWP OLSR & RWP OLSR

Analysis and Discussion of Results

This analysis and discussion was for the results obtained from Figs. 1, 2 and 3, which was, RWP DSR versus RWP OLSR. The pause time and speed for this scenario were 5 s and 5–10 m/s respectively. Once again, the analysis of different protocols with the same mobility model was made. RWP DSR obtained an average throughput of 50455.9 bits/sec whereas RWP OLSR delivered 182321.0 bits/sec. The average throughput in terms of percentage was 22% for RWP DSR and 78% for RWP OLSR. RWP DSR had an average delay of 24.2 s, which was 100% delay. RWP OLSR on the hand had 0.02 s and this was 0% delay. In routing traffic received, 812623.1 bits/sec of routing traffic was delivered by RWP DSR. This is equivalent to 28% of the total routing traffic delivered by the protocol. But RWP OLSR sent 72% of routing traffic, thus, delivering 2110434.8 bits/sec of traffic. The above analysis indicates that, RWP OLSR performed better than RWP DSR by providing 78% of throughput; no delay (0%) and 72% of routing traffic delivered.

The analysis showed that routing protocols can greatly affect the performance of MANET and the mobility model chosen. In all the performance metrics, that is throughput, delay and routing traffic received, RWP OLSR performed better than RWP DSR. This means that even when a network has the same mobility model and parameters, the routing protocol selected can have adverse influence on the network. The statistics showed that OLSR once again had 0% delay with RWP. OLSR use of the sensing of neighbouring nodes technique to set up a connection is the cause of its great performance. With this technique, it senses other nodes to verify their availability before sending a message that reduces packet drops and tends to increase performance. Throughput and routing traffic are also high in OLSR because it uses MPR nodes and these nodes works well in network where mobility speed is low, as it is in the case of this scenario, therefore, the possibility of OLSR maintaining a valid route is very high. DSR on the other hand, due to the availability of cache routes has high possibility of having expired routes and link failures. This is the reason why RWP DSR recorded 100% delay and fewer throughputs. With the reason given, the author could therefore say that RWP configured with OLSR improved MANET's performance than RWP configured with DSR. For this reason, the choice of a protocol for a specific mobility model should be considered in a network design [10–12].

Table 5 shows a summary of the performance results of the two routing protocol and mobility model discussed.

Table 5. Summary of performance results

Scenarios	Average throughput (bits/sec)	Average delay (sec)	Average routing traffic received (bits/sec)
RWP DSR	50455.9/22%	24.2/100%	812623.1/28%
RWP OLSR	182321.0/78%	0.02/0%	2110434.8/72%

4 Conclusion

In view of the simulated results shown above, it could be concluded that, OLSR protocol would perform better on MANET when used with RWP mobility model in an environment where the pause time is 5 s and mobility speed is 5–10 m/s. RWP OLSR had better performance than RWP DSR by providing 78% of throughput, no delay and 72% of routing traffic received. The simulation results prove that the choice of a protocol for a specific mobility model should be considered in a network design.

5 Future Work

In future, different mobility models, different routing protocols and different speed and pause time can be simulated to determine the performance of MANET. Future categories may include the following: MANET_Down_Left DSR versus MANET_Down_Left OLSR and MANET_Down_Left DSR versus Random WayPoint OLSR.

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