

Performance Evaluation of AODV, DSR, OLSR, and GRP MANET Routing Protocols Using OPNET

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Abstract—Routing is a critical issue in MANET and therefore, this is the focus of this paper, along with the performance analysis of its routing protocols. In this paper the performance of four MANET routing protocols (AODV, DSR, OLSR and GRP) are compared. To evaluate and validate the performance of these protocols, a feasibility study in the form of simulations were carried out. In these experiments, the four protocols were tested under different scenarios and circumstances using a simulation tool called OPNET. The performance of these routing protocols is analyzed based on two performance metrics: delay and through put. The simulation results have shown that on average, under heavy FTP traffic condition, the OLSR protocol outperforms the other three protocols with respect to the mentioned metrics under two scenarios (20 and 80 mobile nodes) that have been created in OPNET.

Index Terms—FTP, MANET, OPNET, routing protocols.

I. INTRODUCTION

The emergence of wireless networks has gone a long way in solving the growing service demands. The focus of research and development endeavor has almost shifted from wired networks to wireless **networks**. The limitations of wireless network techniques such as high error rate, power restrictions, bandwidth limitations and other constraints have not deterred the growth of wireless networks [1]. Mobile Ad-hoc network (MANET) is one of the most demanding field in the area of wireless network

MANET consist of mobile devices or users which are generally known as nodes, and each one of which is equipped with a radio transmitter and a receiver [2]. MANET is a temporary network of wireless mobile nodes which has no fixed infrastructure. There are no dedicated routers, servers, access points, base stations and cables [3]. The mobile nodes which are within each other's transmission range can communicate with each other directly; or else, other nodes in between can forward the packets if the source and the destination node are "out" of each other's range. Every node acts as a router to forward the packets to other nodes whenever required [4]. One of the main areas of research is the packet routing technology, which is the focus of this paper.

Mobile ad-hoc network is "infrastructure-less networks"

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having nodes which can act as a transmitter, router or receiver. MANETs have a dynamic topology where nodes are mobile. To monitor the workings of these nodes and the nature in which they behave while sending, receiving or forwarding data is classified by a set of rules known as routing protocols [5].

In this paper, four major MANET routing protocols (AODV, DSR, OLSR and GRP) have been evaluated. The evaluation process is based on the rate of FTP (High load) traffic; and also by increasing the number of nodes in different scenarios to assess the performance of each protocol. The performance is analyzed by means of delay and throughput using OPNET Modeler 14.0. The first two protocols are selected from Proactive category namely OLSR, GRP and the second set (of protocol) is selected from the Reactive category –AODV, DSR.

OPNET provides several MANET routing protocol models which are integrated with the IP and wireless LAN models. In addition, a MANET framework is available for rapid development of new MANET protocol models. Various dedicated routing protocols have been proposed to the Internet Engineering task Force (IETF) MANET Working Group. Some of these protocols have been studied and their performances have been analysed with details. OPNET support the following routing protocols (AODV, DSR, OLSR, OSPFv3, TORA and GRP).

The rest of the paper is organized as follows. In Section II, describes the related work. Section III illustrates the simulation environment. In Section IV, the selected performance metrics are described. Section V and Section VI, present the simulation scenarios and results respectively. Section VI analyze the results. Section VII concludes the paper.

II. RELATED WORK

Secondary research has been conducted to identify the gap that may exist in the literature regarding the performance of mobile ad-hoc routing protocols. This is done through investigating and evaluating several related academic research papers and studies in this area. To the best knowledge of authors, none of the addressed related work has investigated and produced quantitative results showing the performance of AODV, DSR, OLSR, and GRP under different number of nodes which make this research novel.

For instance, [6] presents Ad-hoc On Demand Distance Vector Routing (AODV), a novel algorithm for the routing operation of such ad-hoc networks. Their routing algorithm is quite suitable for a dynamic self-starting network, as required by users wishing to utilize ad-hoc networks. They show their algorithm can scale to large populations of mobile nodes

wishing to form ad-hoc networks. In addition, they present their evaluation methodology and simulation results to verify the operation of the proposed algorithm.

While [7] proposes an adaptive multi-mode routing framework that has multiple compatible modes of operation. Based on this framework, an adaptive protocol has been implemented with the novel feature that individual nodes can adapt their mode of operation at any moment, while an overall consistent state of the routing tables is maintained. Through simulation, the correct behavior of the protocol during mode switches is demonstrated and it is shown that the protocol is capable of minimally offering the performance of either proactive or reactive routing. Ref. [8] is focusing on energy aspect of mobile ad hoc routing protocols. This work discuss the power consumption aspect of the MANET routing protocols. A performance comparison of Dynamic Source Routing (DSR) and Ad hoc On-Demand Distance Vector (AODV) routing protocols with respect to average energy consumption and routing energy consumption are explained thoroughly.

Ref. [9] is performing a performance study for several mobile ad hoc routing protocols. Many routing protocols have been proposed like OLSR, AODV, DSR, ZRP, and TORA so far to improve the routing performance and reliability. The paper describes the characteristics of ad hoc routing protocols OLSR, AODV and TORA based on the performance metrics like packet delivery ratio, end-to-end delay, routing overload by increasing number of nodes in the network. The study concludes that AODV, TORA performs well in dense networks than OLSR in terms of packet delivery ratio.

III. SIMULATION ENVIRONMENT

OPNET modeller v14.0 has been used as a simulation tool to implement these sets of experiments as seen in Fig. 1. Two major scenarios have been created, one is for 20 nodes, and the second scenario is one for 80 nodes. These scenarios were used to assess the performance of these four routing protocols with different number of users with heavy FTP traffic for both scenarios. In addition, the delay and throughput are the key metrics given in these experiments.

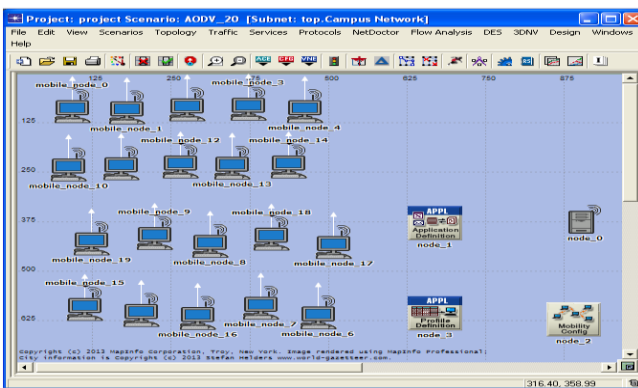


Fig. 1. Simulation environment.

In this experiment, the simulation time was set to 3600 second for each scenario. The required results were collected based on the selected metrics (Delay and Throughput). DES (global discrete event statistics) are collected on each scenario. Table I summarizes the various simulation

environment settings.

In this simulation the Random waypoint mobility was used as the model for simulation exercise. Random mobility used, shows more behaviour, good mobility and it was simple to use [10]. 100 m/s was used as a constant speed for mobile nodes movement until these nodes reached the destination, 200 second was used as a “pause-time” and after that it will search and choose a new destination randomly. Table I shows the simulation parameters.

TABLE I: SIMULATION PARAMETERS

Simulation Parameter	Value
Number of Nodes	20 and 80.
Simulation Time	1 hour (3600 (sec)).
Simulation Area	1000 × 1000 (m × m).
Routing Protocols	AODV, DSR, OLSR, GRP.
Mobility Model	Random waypoint.
Data Rate	11 mbps.
Application	FTP (High load).
Simulation Metrics	Delay and throughput

IV. PERFORMANCE METRICS

According to [4], [6]-[9] it is possible to evaluate the performance of MANET protocols with respect to several quality attributes, both performance-related attributes and the more general quality attributes, such as scalability. The following performance-related metrics have been identified as important for MANET routing protocols. These performance metrics will show the efficiency of MANET routing protocols. The performance is analysed by means of delay and throughput using the OPNET Modeler 14.0.

Delay (sec): It is the ratio of time difference between every packet sent and received to the total time difference over the total number of packets received. **Throughput** (bit/sec) is defined as the ratio of total data reaches a receiver from the sender – the time it takes by the receiver to receive the last message [11]. Throughput is expressed as bytes or bits per sec (byte/sec or bit/sec). Throughput can be mathematically expressed as in (1)

$$\text{Throughput} = \frac{\text{Number of delivered packet} * \text{Packet size} * 8}{\text{total duration of simulation}} \quad (1)$$

V. SIMULATION SCENARIOS

Various environmental scenarios, identified in Table II, will be used to measure the efficiency of the fourth routing protocols. This study compare four routing protocols, over extensive scenarios, varying node mobility and heavy FTP traffic load. All the traffic sources used in our simulations generated constant bitrate (CBR) data traffic.

Scenario A investigates how these four MANET routing protocols behave under a heavy FTP traffic with respect to the delay and the throughput and 20 nodes.

Scenario B investigates how these four protocols perform under a heavy FTP traffic and 80 nodes with respect to the

delay and throughputs.

TABLE II: EVALUATION SCENARIOS

Nodes Num.	Traffic Setting (FTP Heavy Traffic)
	Scenario A (20 Nodes)
	Scenario B (80 Nodes)

VI. EXPERIMENT RESULT

The results have been divided into two sets based on the above scenarios as presented in Table II. The graphs of results are presented in a two-dimensional Cartesian plane where the x-axis represents the temporal progression of the simulation and the y-axis represents the relevant performance metric. Fig. 2 and Fig. 3 show the delay for the 20 and 80 nodes scenarios respectively.

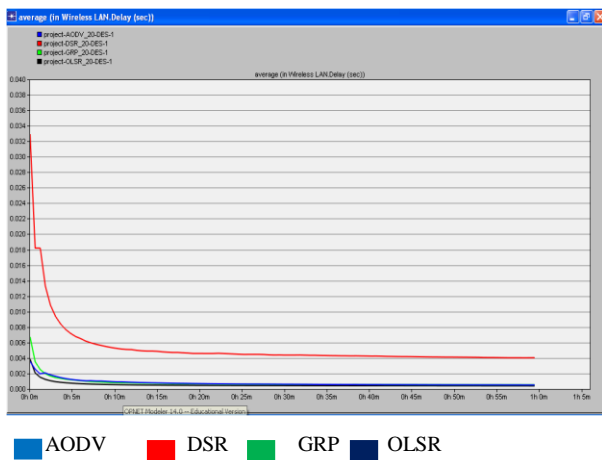


Fig. 2. Wireless LAN delay under 20 nodes.

As seen in Fig. 2, OLSR has the least delay while AODV has almost similar characteristic to OLSR but it is larger than OLSR in terms of value average; whereas GRP has a medium delay as compared to DSR which has the highest delay than the other routing protocols. This concludes that OLSR has the lowest delay and performs better than the other routing protocols.

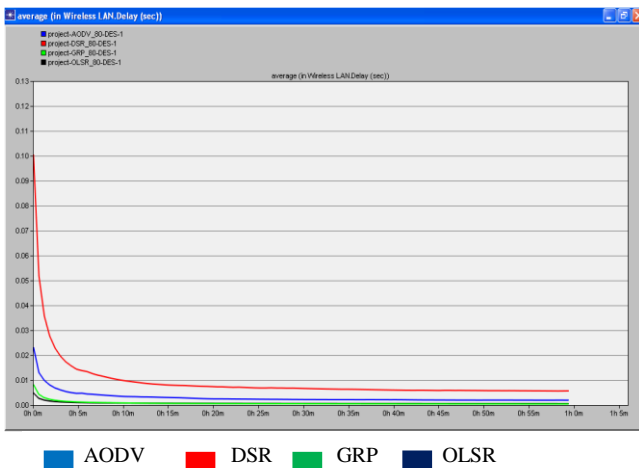


Fig. 3. Wireless LAN throughput under 20 nodes.

Fig. 3 shows that DSR has the highest delay during simulation time (ST). AODV shown here has a delay but less

than DSR, whereas GRP and OLSR have the least delay and showed little differences between them. Finally, it has been found that OLSR is the best protocol during the delay (beginning at the fifth minute after start). After that it can be seen that GRP and OLSR have the same values.

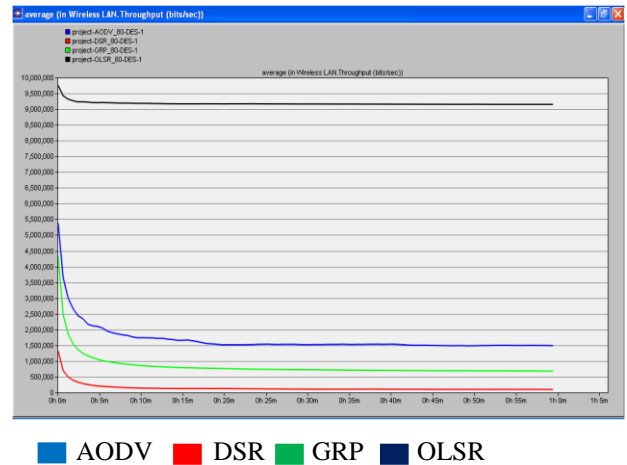


Fig. 4. Wireless LAN delay under 80 nodes.

Under the 20 nodes scenario and with regard to the throughput metric, the OLSR clearly has a highest throughput as seen in Fig. 4, Whereas DSR has the lowest, while AODV and GRP have a medium throughput. This result shows clearly that the OLSR outperforms the other protocols.

Fig. 5 shows clearly that OLSR has the highest throughput again under 80 nodes, so it is the best protocol compared to the other examined routing protocols. This is followed by AODV, then GRP and the least throughput is DSR (for this scenario).

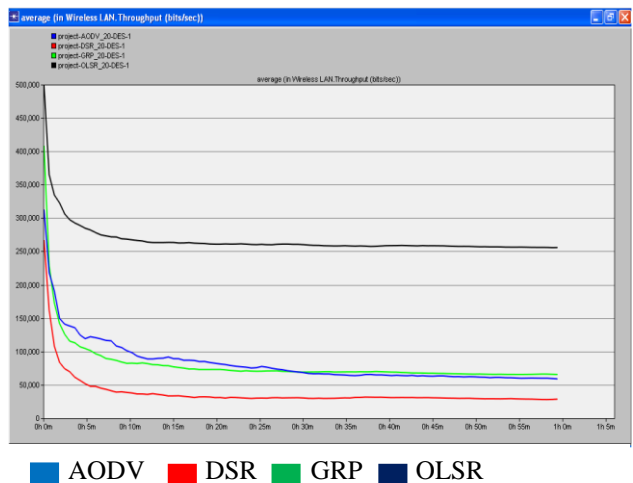


Fig. 5. Wireless LAN throughput under 80 nodes.

VII. RESULTS ANALYSIS

According to the obtained results, the authors were able to answer the question “which routing protocol performed the best?” – As can be seen from the above graphs and Table III, OLSR is the best protocol for all scenarios, during the delay and the throughput simulations for the 20 and 80 nodes scenarios. The four experiments yielded results of similar patterns and characteristics. The graphs of results are presented in a two-dimensional Cartesian plane where the x-axis represents the temporal progression of the simulation

and the y-axis represents the relevant performance metric.

As seen from the graph (Fig. 3), the OLSR protocol in general performs slightly better at reducing the delay for transmitting data packet than the other protocols. This reduction in the delay is due to the working mechanisms of the OLSR over the other protocols [12], which lead to a speeding-up of the content delivery process. This will

eventually be reflected in the reduction of the overall delivery time as indicated by the graph; which can be attributed to the fact that OLSR uses the concept of Multipoint Relays (MPR) to reduce the possible overhead in the network. Table III lists the obtained result which clearly indicates that OLSR protocol is given high throughputs and less delay over the other protocols.

TABLE III: SUMMARY OF EXPERIMENTAL RESULTS

Nod.	Metrics	AODV	DSR	OLSR	GRP
20	Delay(sec)	0.00206	0.00647	0.00135	0.00434
	Throughput (bit/sec)	301,146	214,124	456,106	299,136
80	Delay(sec)	0.00213	0.04267	0.00298	0.00198
	Throughput (bit/sec)	462,198	265,894	1,658,467	345,319

VIII. CONCLUSION

This paper presents an evaluation study of four major MANET routing protocols. It is necessary to provide the network operators and mobile applications developers with such a study to help them decide which MANET routing protocols can help to enhance the end-user experience. In addition, routing protocols have an important effect on the overall performance of the mobile applications which use MANET as a business network [13]-[15].

The simulation results have indicated that OLSR in general performed better than the other three protocols (ADOV, GRP, and DSR) with respect to delay and throughputs under heavy FTP traffic. In other words, OLSR can be considered as the best protocol in terms of bandwidth utilization. This characteristic is very much required for cutting-edge mobile applications that need high throughput and less delay. Furthermore, the results support the intuitive expectations of OLSR behaviour which has been proven in [12].

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