A Simulation Competition Study to Analyze and Evaluate the Performance of Five MANET Routing Protocols

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Abstract

Mobile Ad-hoc Network (MANET) was defined and known to be a collection of nodes that connected in a wireless manner without any infrastructures. Each of its mobile nodes is working as host and router. Such network can be deployed in an easy and quick manner. In order to send packets from source node to destination, Ad-hoc network needs to intermediate nodes to perform this task if its transmission range is less than the distance between these nodes. Many routing protocols were developed to be used in operating Ad-hoc networks. The purpose of this paper is to evaluate five used routing protocols (DSDV, OLSR, DSR, AODV and AOMDV) in terms of the dropped packets, the throughput, average end-to-end delay, average jitter, normalize routing load(NRL) and packet delivery fraction(PDF) under different speeds, nodes numbers, pause times and different simulation areas. The network simulator (NS-2) was used and applied to state the evaluation results and the effects of each factor on the others. From the results we found that DSDV and OLSR is the best in terms of average end-to-end delay and average jitter, DSR presents good results in cases of the PDF, NRL and dropped packets while the AODV is the best one in maximizing the network throughput.

***Keywords*:** MANET, NS-2, DSDV, OLSR, DSR, AODV, AOMDV.

INTRODUCTION

MANET represents a system of wireless mobile nodes that connected among each other in wireless manner without any prior organization or infrastructure devices. It relies on the cooperation principles to ensure its correct operation. The data packets can reach the destination directly or through multi-hops [3]. MANET has special features such as the limitation in the bandwidth, batteries and dynamic topology. The reason for the bandwidth constraint is the low transmission range. Dynamic topology happens due to the frequently and unexpected movement of its nodes with not constant speed [18]. The packets routing process are seemed to be complicated and requires specific policy. There are special routing Protocols were developed to be reactive, proactive and
hybrid [14]. The reactive routing protocols work when there is need for the route to the destination, For example: DSR (Dynamic Source Routing), AODV (Ad hoc On Demand Distance Vector) and AOMDV (Ad-hoc On-demand Multi-path Distance Vector). The proactive routing protocols that are periodically broadcasting to store in routing table view of the network and the correct route to each node in the network, such as DSDV (Destination Sequenced Distance Vectored) and OLSR (Optimized Link State Routing), and others. The hybrid routing protocols merge the advantages of the two above types of routing protocols in small domain. MANET is very appropriate in many situations such as Disasters, military and medical applications [16].

Related work

Ibrahim K. Tabash et al. at 2010 studied through NS-2 the effects of mobility on the throughput on different TCP (RENO and VEGAS), they used two routing protocols AODV and DSDV. From the results they concluded that AODV was the best in RENO and VEGAS when compared to DSDV [8].

The performance of (AODV, DSR and DSDV) were compared by Sabina Barakovi et al. at 2010 in NS-2 based on varying load and mobility using PDF (packet Delivery Fraction), NRL (Normalize Routing Load) and delay. They found that in low mobility and load the protocols react in similar way but when increasing the mobility DSR was the best [15].

Mohammed Bouhorma et al. at 2010 used NS-2 to present a comparison between AODV and DSR in terms of end-to-end delay and dropped packets ratio according to different speeds of nodes. They found that AODV was better than DSR when increasing the mobility [11].

The performance of DSR and AODV was studied by Rajesh Deshmukh et al. at 2011 by varying terrain rang according to dropped packet ratio, routing overhead and packet delivery ratio using NS-2. The simulation results stated that DSR was outperformed AODV for the large network area [13].

network simulator ns-2

Version 2 of the network simulator named as NS-2 was classified as event driven simulation tool and is discrete event simulator that used in many fields from the wire to the wireless networks. It can provide large support for many protocols such as (UDP, TCP, FTP and Telnet). NS-2 is more common due to its flexibility and easy as well as it is open source. It represents developable software by the users to perform a vital Simulation researches. NS-2 can be installed on Linux or windows environment. It was built by two programming language C++ and OTCL. OTCL represent fronted and contains the interpreter objects while C++ represents the backend and contains the corresponding hierarchical objects [17].

PERFORMANCE METRICS

There are many performance metrics were developed to evaluate the performance of the MANET. In this paper six metrics were used and utilized to compare and evaluate the effects and behaviors of five routing protocols under different MANET parameters and variables. These metrics are:

1. Throughput

Throughput represents the mount of data received by the destination nodes in some period of time [4].

2. Average end-to-end delay (average E2E delay)

It represents the time that spent by the packet to reach to the destination.

E2E delay [packet_id] = received time [packet_id] – sent time [packet_id]

The average end-to-end delay can be calculated by summing the times taken by all received packets divided by their total numbers [1].

3. Packet delivery fraction (PDF)

PDF can be measured as the ratio of the received packets by the destination nodes to the packets sent by the source node [5].

*PDF = (number of received packets / number of sent packets) * 100.*

4. Normalize Routing Load (NRL)

It is the number of transmitted routing packets per delivery data packets [12].

NRL = number of routing packets/ number of received packets.

5. Dropped Packets

It is the number of packets that sent by the source node and fail to reach to the destination node [1].

Dropped packets = sent packets – received packets.

6. Average Jitter

It is the absolute value of the difference between the end-to-end delays of two sequential packets [5].

Jitter = | (end-to-end delay (k+1)) - (end-to-end delay (k))|

The average jitter is obtained by summing the jitter of all received packets divided by the total number of the received packets.

RANDOM WAYPOINT MOBILITY MODEL

This model becomes suitable and essential in conducting simulation researches for Ad-Hoc networks. The location of each node will be initially selected in random manner. When the simulation is started, each host will be stopped at its current position for specified time called "the pause time" before selecting a new location. The node new location will be indicated randomly within the boundaries of the simulation area. This process of selecting the locations and stopping for some periods will be repeated until the simulation time is ended [9].

SIMULATION ENVIRONMENT

In this paper, a proposed MANET environment was suggested and implanted using NS-2. TABLEI represents the proposed simulation environment.

TABLEI
SIMULATION ENVIRONMENT

Parameter	Value
The simulator	NS-2.34
MAC	802.11
Propagation model	Two ray round
Routing protocols	DSR, DSDV, AODV, OLSR, AOMDV
Simulation time	75s
Traffic generation	CBR
Antenna	Omni Antenna
Packets size	512 bytes/packet
Transition rate	4 packets/second

Mobility model	Random way point model
Pause time type	Uniform distribution
Speed type	Uniformly distributed

THE EVALUATION METHODOLOGY

In order to conduct this simulation study to evaluate the effects of many routing protocols on the behavior of certain MANET under specified conditions with respect to the effective parameters and variables to find the best and may be the optimal routing protocol that can be preferred to be used in each MANET configuration. The following steps were suggested in certain sequence to represent the performance evaluation methodology using NS-2.

Step1: Start.
Step2: Create the traffic generation pattern (traffic file) using "cbrgen" file that was supported by NS-2.
Step3: set s = 0.
Step4: set k = 0.
Step5: Create MANET scenario (movement file) using NS-2 by the "setdest" file.
Step6: set i = 0.
Step7: Create "tcl" script that represent simulation environment of MANET with the routing protocol and invoke the movement and traffic files within the "tcl" file.
Step8: add this "tcl" file as input to the NS-2 in order to perform the simulation. The outputs will be the "NAM" file and the trace file.
Step9: use the "NAM" file to display the operation of all events occurred through the simulation as visualization review, while the trace file will be used in the process of the post analysis using AWK programming language that works strongly with text files.
Step10: increment i by 1.
Step11: if i < 5 (5 is the number of the routing protocols evaluated in this paper) then go to step7, at each time change the routing protocol and save the results of each state. Otherwise, k = k +1.
Step12: If k < 50 (50 is our suggested number of the simulation iterations of each case of the evaluation) then go to step5 (repeat this step in order to get more accurate results). Otherwise, s = s +1.
Step13: if s < m (m is the number of the evaluation cases. for example when the numbers of nodes are 20, 30, 40, 60 and 100 “then 5 will be assigned to m”), then go to step4, otherwise go to step14.
Step14: split the resulted file in to five separated files (each file represents the results of one routing protocol).
Step15: Calculate the average of the results of the performance criterion to determine the effects of MANET parameters on the performance of the routing protocols and decide which of them the best one is.
Step16: End.

CASE STUDY

The nodes number, nodes speed, pause time, and the simulation area were studied to indicate and state their effects on the performance of five different routing protocols. TABLEII shows these suggested scenarios and their values.

TABLEII
SUGGESTED SCENARIOS.

Case number	Nodes number	Speed	Pause time	Simulation area
1	10, 20, 30, 40, 50	10m/s	10s	1000m*1000m
2	50	(5, 10, 20, 30)m/s	6s	1000m*1000m
3	30	10m/s	(0, 3, 6, 10)s	1000m*1000m
4	25	15m/s	8s	(500m*500m, 750m*750m, 1000m*1000m, 1250m*1250m)

IX. SIMULATION RESULTS

The simulation environments were ran for 50 scenarios with varying nodes number and speed. Packet delivery fraction, routing load, dropped packets, average jitter, average end to end delay and throughput were calculated for AODV, AOMDV, OLSR, DSDV and DSR. The results are shown in the following figures, each point in the graph represent the average of 50 scenarios.

Fig. 1 shows that the number of dropped packets is decreases with increasing the nodes number and the best routing protocol is DSR. Fig. 2 shows that the throughput is increases with high nodes number and the best routing protocol is AODV.

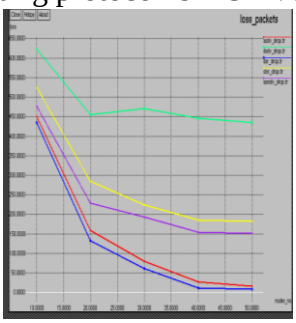


Fig. 1: Dropped packets Of case1

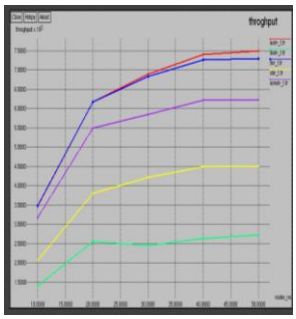
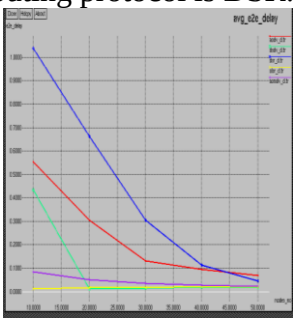


Fig. 2: The throughput of case1.

Fig. 3 illustrates that the average end-to-end delay is decreases with increase the number of nodes and the best routing protocol is OLSR. Fig. 4 shows that the NRL is large with high nodes number and the best routing protocol is DSR.



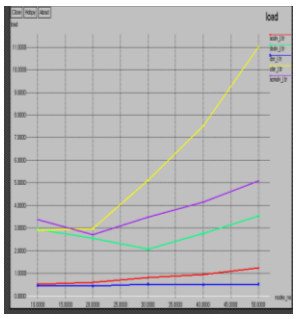


Fig. 3: Average E2E delay Of case1.

Fig. 4: NRL of case1.

Fig. 5 clarifies that the PDF is high with high number of nodes and the best routing protocol is DSR. Fig. 6 illustrate that the average jitter is decreases with increase the number of nodes and the best routing protocol are OLSR and DSDV.

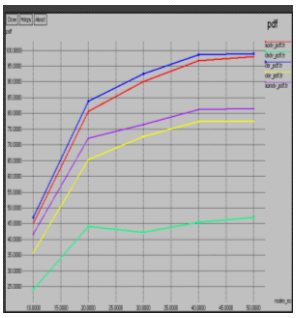


Fig. 5: PDF of case1.

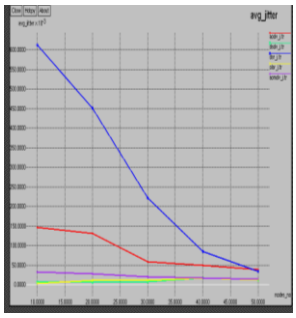


Fig. 6: Average jitter of case1.

Fig. 7 shows that the number of dropped packets is increases with increase the speed and the best routing protocol is DSR. Fig. 8 illustrates that the throughput is decreases with high speed and the best routing protocol is AODV.

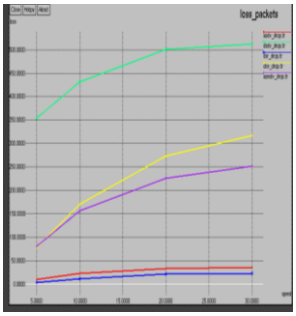


Fig. 7: Dropped packets Of case2.

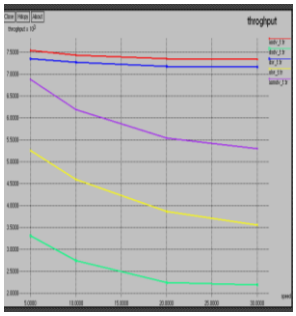


Fig. 8: the throughput of case2.

Fig. 9 clarifies that the average end-to-end delay is increases with increase the speed and the best routing protocol is DSDV. Fig. 10 shows that the NRL is large with high speed and the best routing protocol is DSR.

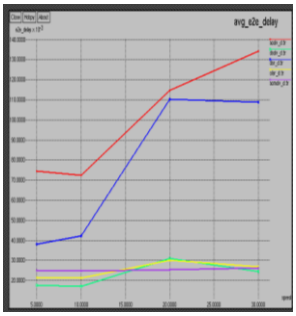


Fig. 9: Average E2E delay

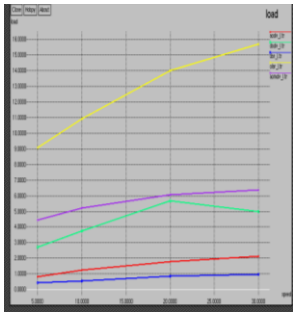


Fig. 10: NRL of case2.

of case2.

Fig. 11 shows that the PDF is decreases with high speed and the best routing protocol is DSR. Fig. 12 shows that the average jitter is decreases with increase the number of nodes and the best routing protocol is AOMDV.

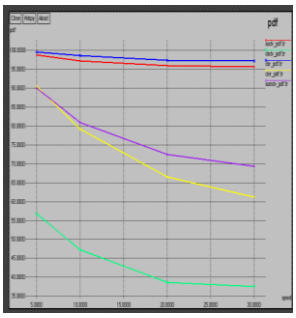


Fig. 11: PDF of case2.

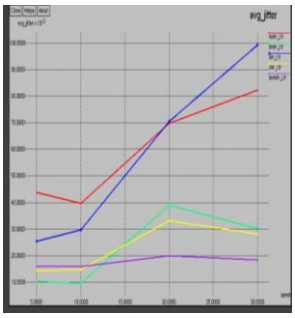


Fig. 12: Average jitter of case2.

Fig. 13 illustrates that there is a little increasing in the number of dropped packets when increases the pause time and the best routing protocol is DSR. Fig. 14 shows that the throughput is decrease in small range when increases the pause time and the best routing protocol is AODV.

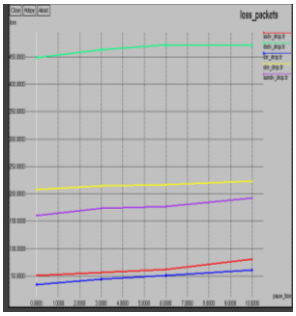


Fig. 13: Dropped packets Of case3.

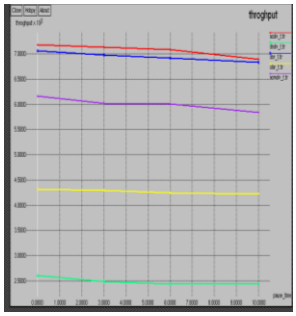


Fig. 14: the throughput of case3.

Fig. 15 illustrates that when the pause time increases the average E2E delay is decrease and the best routing protocols are OLSR and DSDV. Fig. 16 clarifies that with small increasing in the pause time the NRL is increase with small range and the best routing protocol is DSR.

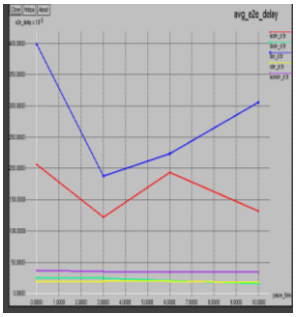


Fig. 15: Average E2E delay Of case3.

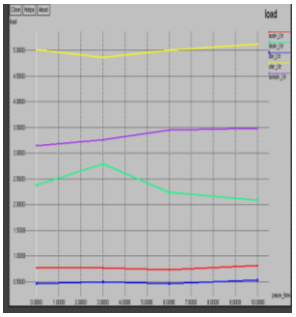


Fig. 16: NRL of case3.

Fig. 17 clarifies that the PDF is decreases in small range with the increasing of the pause time and the best routing protocol is DSR. Fig. 18 shows that the average jitter is decreases when increase the pause time and the best routing protocol is OLSR.

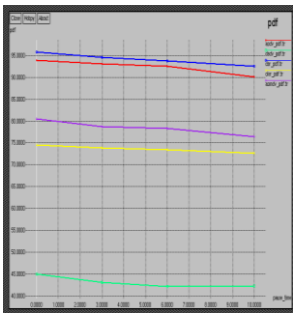


Fig. 17: PDF of case3.

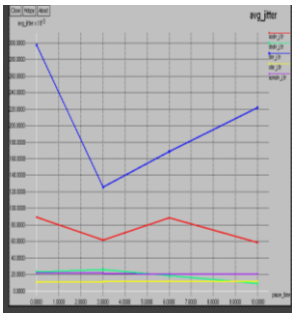


Fig. 18: Average jitter of case3.

Fig. 19 illustrates that the number of the dropped packets is increases with increase the area and the best routing protocol is DSR. Fig. 20 shows that the throughput is decreases when the area is increase and the best routing protocol is AODV.

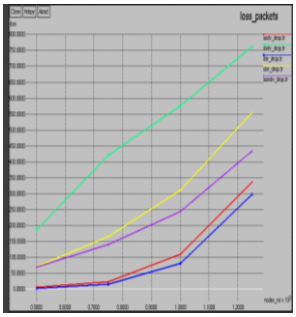


Fig. 19: Dropped packets Of case4.

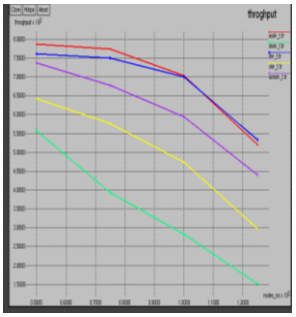


Fig. 20: the throughput of case4.

Fig. 21 illustrates that the average end-to-end delay is increases when the area is increase and the best routing protocols are OLSR and DSDV. Fig. 22 clarifies that the NRL is increase as the area is increase and the best routing protocol is DSR.

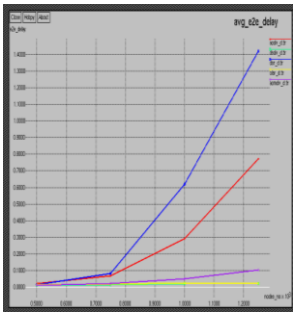


Fig. 21: Average E2E delay of case4.

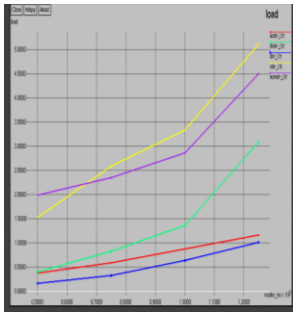


Fig. 22: NRL of case4.

Fig. 23 shows that the PDF decreases as the area is increase and the best routing protocol is DSR. Fig. 24 clarifies that the best routing protocols are DSDV and OLSR and the average jitter is increase when the area is increases.

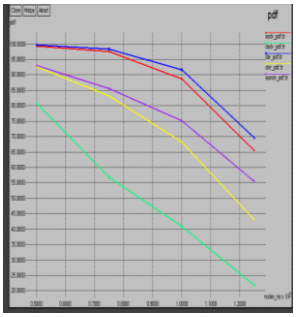


Fig. 23: PDF of case4.

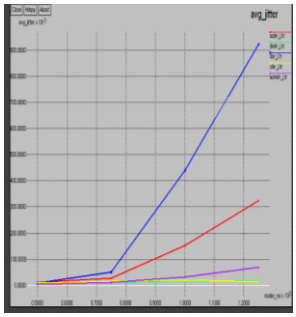


Fig. 24: Average jitter of case4.

X. CONCLUSION

In this paper, the performance of the five MANET Routing protocols was analyzed using NS-2 according to dropped packets, throughput, average E2E delay, normalized routing load, packet delivery fraction and average jitter. Often, when increases the nodes number, speed, pause time, and the simulation area, the DSR routing protocol is the best in terms of number of the dropped packets, NRL, and PDF. AODV routing protocol is outperforms than other routing protocols in the term of the throughput. The proactive routing protocols (DSDV and OLSR) are more suitable in cases of average E2E delay and average jitter.

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